

**Epistemological access in a science foundation course:
A social realist perspective**

A thesis submitted in fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

of

RHODES UNIVERSITY

by

Karen Ellery

March 2016

Abstract

This dissertation examines how educational practices of a multidisciplinary, integrated science foundation course, Introduction to Science Concepts and Methods (ISCM), at Rhodes University in South Africa, enable and/or constrain epistemological access to a range of mainstream science disciplines. Students in the ISCM course are mainly African, working-class, first-generation higher education learners whose home language is seldom English. This study is motivated firstly by poor success of working-class African students in higher education in South Africa in general and in the sciences in particular, and secondly by the need for closely theorised, empirical work to guide necessary transformational change that will contribute to equity and, thus, to greater social justice. Since I teach in ISCM and coordinate the programme in which it is located, I also have a personal and professional interest in improving my own practice.

Conceptually the study draws on Morrow's (2007, 2009) and various literacy theorists interpretations of the concept of epistemological access, which in this study is about becoming and being a participant in an academic practice by virtue of learning both the knowledge as well as the norms, values and beliefs that constitute the practice. Theoretically and analytically the study draws on Maton's (2014a) Legitimation Code Theory (LCT) and on various aspects of Bernstein's (2000) code theory work. Codes are the organising principles or 'rules of the game' of practices and code theory is premised on the idea that power and control in education systems manifest themselves through the structural and interactional aspects of educational practices, and therefore have the capacity to include or exclude. Analysing educational practices using code theory enables characterisation of the practices, highlights their underpinning principles, and allows for their effects to be considered. This layered approach to analysis indicates that a critical realist depth ontology serves as an underlabourer to code theory. The desired 'effect' of educational practices in this study, is students gaining epistemological access to science, or science disciplines, in higher education.

The overall approach is a single, in-depth, qualitative case study with a primary focus on what is legitimated in ISCM educational practices (curriculum, pedagogy, assessment) and how students respond to these practices. A lesser focus is how ex-ISCM students are responding to educational practices in the first-year, first-semester Cell Biology, Chemistry, Earth Sciences and Physics mainstream courses, and whether they are attaining epistemological access. To examine educational practices in ISCM and mainstream courses data from document analysis, interviews, observations and critical reflections are analysed through developing external languages of description. The two LCT code dimensions of Specialisation (what or who specialises a practice)

and Semantics (how meaning relates to context and empirical referents) are used to examine curriculum, Bernstein's (2000) framing of the regulative and instructional discourses are drawn on in considering pedagogy, and an adapted cognitive process level model assists in analysing assessment practices. To examine student responses to educational practices Bernstein's (ibid.) concept of acquisition of recognition and realisation rules is used. Since ISCM serves the dual purpose of developing scientific conceptual knowledge, as well as supporting student learning in an academic context, a complex picture of practices and underpinning codes emerges.

Based on *epistemological concerns* of developing students as scientists, ISCM legitimates an epistemic-context knowledge code and a rhizomatic/worldly curriculum code. If students produce the legitimated epistemic-context scientific 'text', they have attained *epistemic access*. Based on *axiological concerns* of the learning context, ISCM also legitimates a learning-context knower code. By producing the legitimate learning-context 'text' of an autonomous, self-regulated science learner, students demonstrate they have attained *learning-context access*. Both forms of access are key for student success, and combined they constitute epistemological access. The findings of the study indicate that framing and legitimation of educational practices in ISCM, by most accounts, should be promoting epistemological access. When epistemological access is not attained in ISCM it is suggested this is likely due to both a code clash at the learning-context level and competing code demands between epistemic-context and learning-context concerns. Poor access in mainstream courses appears to be exacerbated by both a narrow-based knowledge code and little or no support for a learning-context knower code.

The study concludes by outlining a two-tiered conceptual model of epistemological access in the sciences based on the mutually integrative components of epistemic- and learning-context access. Because of inequitable outcomes in science mainstream courses at Rhodes University based on race and/or class I argue for far-reaching transformative pedagogies throughout the faculty, and in the broader South African science higher education sector, that address and accommodate issues of diversity and difference. This should include, amongst other things, a weakening of epistemic relations to create space for a strengthening of learning-context social relations. This is *not* a suggestion to move away from a science knowledge code, which I argue is based on powerful knowledge to which all students must gain access, but instead a shift in emphasis to better support previously educationally disenfranchised students and to understand in a more rigorous manner what epistemological access means to them as individuals. In light of the recent disruptive and angry student calls for decolonisation of the curriculum, this is an urgent imperative.

Acknowledgements

I wish to express my heartfelt thanks to a number of people who have helped make this journey possible:

My supervisor Chrissie Boughey who encouraged me to take on the study and provided stimulating and challenging feedback throughout. Particularly appreciated is the input and guidance in the last few months during what proved to be an extremely busy and taxing time.

The ISCM 'team' Jennifer Williams, Rosa Klein, Miriam Mattison, Steffan Büttner and Leela Pienaar who have been inspiring colleagues to work with and who participated willingly in interviews and discussions for the dissertation.

All staff (past and present) and students who gave of their time to be interviewed and have been so honest and engaging with my persistent questions and requests for information.

Rebecca Joubert receives very special thanks as she so enthusiastically and ably took up all teaching and other duties that go with running a high-input teaching programme.

Colleagues and friends Lynn Quinn, Jo-anne Vorster, Sioux McKenna, Sherran Clarence, Karl Maton, Sue Southwood and especially Carol Thompson (for the interview) who all gave of their precious time to provide thoughtful input and very useful feedback whenever I troubled them.

The Higher Education Doctoral Studies scholars who meet regularly at Rhodes University and engage so freely and helpfully with the work of others, including mine.

Susan Blair for her willing, efficient and engaging editing. Also Nikki, Miles and Fred who assisted with diagrams, editing and layout. Similarly, Claire, Michaela, Jesamé, Shannon, Sanett, Holly and Steven who so ably did first-pass transcriptions of numerous, long interviews.

My friends who have kept me sane through hiking, dining, wining, laughter and distraction. Special mention to Bev, Daniella, Pauline, Kate, Liz, Roger, Joyce and Jono.

My wonderful husband Fred who has been so patient during my 'absence' and who always believed I could cross to the dark side and do an 'education' PhD. He listened carefully and contributed thoughtfully to all my convoluted articulations, until it made sense, although I suspect only to me.

Our amazing sons Steven and Miles who in young adulthood both support and inspire me, and have also kept me sane through lots of hugs, tea chats, Sunday suppers and crazy card games.

The completion of this PhD project was made possible, in part, by generous funding from Rhodes University and the National Research Foundation.

Table of Contents

Abstract	i
Acknowledgements	iii
Table of Contents	iv
List of Figures	viii
List of Tables	viii
List of Boxes	ix
List of acronyms	x
Chapter 1: Study background	1
1.1 Introduction	1
1.2. Context of study	1
1.3 Research questions	4
1.4 Rationale for research	4
1.5 Outline of dissertation	5
Chapter 2: Contextual framework	7
2.1 Introduction	7
2.2. The higher education context	7
2.3 The South African higher education sector and policy influences	8
2.4 The academic development field in South Africa	12
2.5 Extended Curriculum Programmes	15
2.5.1 Rhodes University Extended Studies Programmes	17
2.5.1.1 Development of Rhodes University Science Extended Studies Programme	17
2.5.1.2 Current structure of RU SESP	18
2.5.1.3 Overall performance of RU SESP students in mainstream	20
2.5.1.4 The purpose of RU SESP	22
2.6 Introduction to Science Concepts and Methods (ISCM) course	23
2.6.1 Early development of ISCM	23
2.6.2 Current overall ISCM structure	25
2.7 Overview	25
Chapter 3: Conceptual framework	27
3.1 Introduction	27
3.2 Epistemological access: Origin and early development of the term	27
3.3 Academic literacies	30
3.3.1 Models and perspectives of academic literacies practices	31
3.3.2 Access to Discourses	32
3.3.3 Ontology and identity	34
3.4 Home and school contexts	36
3.5 Access to scientific Discourses	38
3.6 Conclusion	40
Chapter 4: Theoretical framework	41
4.1 Introduction	41
4.2 Critical realism as an underlabourer	41
4.3 Social realism and a focus on knowledge	46
4.3.1 Knowledge differentiation	48
4.4 Bernstein on knowledge, codes, coding orientations and pedagogic device	49
4.4.1 Discourses and knowledge structures	49

4.4.2 Classification, framing and codes.....	50
4.4.3 (Epistemic-)pedagogic device.....	52
4.4.4 Recognition and realisation: Student acquisition of codes.....	56
4.4.5 Limitations of Bernstein’s work	60
4.5 Maton’s Legitimation Code Theory.....	61
4.5.1 LCT(Specialisation).....	61
4.5.2 LCT(Semantics)	66
4.5.3 Epistemological and axiological charging (or concerns).....	68
4.5.4 Critique of LCT	68
Chapter 5: Methodology	70
5.1 Introduction.....	70
5.2 Qualitative case study approach	70
5.3 Data selection and generation	72
5.3.1 Interviews.....	72
5.3.2 Documentary evidence.....	75
5.3.3 Observations and critical reflections.....	77
5.4 Positionality and ethics.....	77
5.4.1 Positionality in insider research.....	77
5.4.2 Ethical considerations	79
5.5 Data analysis: Developing external languages of description	80
5.5.1 Curriculum: LCT(Specialisation).....	81
5.5.1.1 Epistemic relations.....	82
5.5.1.2 Social relations.....	85
5.5.2 Pedagogy	87
5.5.3 Assessment: Cognitive process levels	91
5.5.4 Student response: Acquiring recognition and realisation rules.....	94
5.6 Research quality	97
5.7 Direction in following chapters	98
Chapter 6: Knowledge and knowers in the ISCM curriculum	99
6.1 Introduction.....	99
6.2 Current ISCM purpose and course components.....	99
6.3 LCT(Specialisation) for ISCM.....	103
6.3.1 Developing an external language of description.....	103
6.3.2 ‘What is science?’ component.....	104
6.3.3 Physics component	105
6.3.4 Chemistry component.....	106
6.3.5 HKE component.....	108
6.3.6 Geology component	109
6.3.7 Independent research project component.....	110
6.3.8 Trends in knowledge differentiation: Knowledge code of ISCM.....	111
6.4 LCT(Semantics): A differentiated ISCM curriculum.....	114
6.5 Discussion.....	119
6.5.1 Overall ISCM course structure: Multidisciplinary, integrated and hierarchical	119
6.5.2 LCT(Specialisation): Knowledge and knower characterisation and legitimation	121
6.5.3 LCT(Semantics): Differentiated curriculum codes	122
6.6 Moving forward.....	124
Chapter 7: Legitimation and framing of ISCM pedagogy.....	125
7.1 Introduction.....	125
7.2 Regulative discourse	125
7.2.1 Regulation of axiological concerns	126
7.2.1.1 Staff-student relations: General ISCM ‘classroom’ conduct.....	126

7.2.1.2 Becoming and being autonomous science learners.....	128
7.2.2 Regulation of epistemological concerns: Becoming and being scientists	132
7.3 Instructional discourse	134
7.3.1 Framing of selection of knowledge.....	134
7.3.2 Framing of sequencing of knowledge.....	136
7.3.3 Framing of pacing of knowledge	137
7.4 Discussion on ISCM pedagogic practices.....	138
7.4.1 Framing of the instructional discourse.....	139
7.4.2 Framing of the regulative discourse	140
7.4.3 Overview of framing of pedagogic practices	141
7.5 Revisiting ISCM code legitimation.....	142
7.5.1 Social relations: Knowers and associated gazes	142
7.5.2 ISCM: Two kinds of codes.....	145
Chapter 8: Legitimation and framing of ISCM assessment practices	148
8.1 Introduction.....	148
8.2 Assessment practices in ISCM.....	148
8.3 Trends in assessment practices	151
8.4 Framing of evaluative criteria and feedback	155
8.4.1 Evaluative criteria	155
8.4.2 Feedback.....	159
8.5 Assessment practices discussion.....	165
8.5.1 Framing of assessment practices: Becoming and being a scientist.....	165
8.5.2 Framing of assessment practices: Becoming and being a science learner.....	167
8.6 Final comments on pedagogy and assessment	167
Chapter 9: Student response to ISCM educational practices.....	169
9.1 Introduction.....	169
9.2 Acquiring cognitive (epistemic-context) competence.....	169
9.2.1 Acquiring epistemic-context recognition and realisation rules.....	169
9.2.2 Acquiring epistemic-context knower dispositions and values.....	180
9.2.3 Producing legitimate epistemic-context text: Summary	182
9.3 Acquiring social (learning-context) competence.....	183
9.3.1 Acquiring learning-context recognition and realisation rules.....	183
9.3.1.1 Autonomous science learner recognition.....	183
9.3.1.2 Autonomous science learner realisation.....	185
9.3.2 Acquiring autonomous science learner dispositions and values.....	188
9.3.3 Producing legitimate learning-context (science learner) text: Summary.....	190
9.4 Good RC and RL at epistemic- and learning-context levels	191
9.5 Discussion.....	192
9.5.1 Epistemic-context RC and RL and knower dispositions for being a scientist.....	192
9.5.2 Learning-context RC and RL and knower dispositions for being a science learner....	193
9.5.3 Code clash and competing demands: Constraints on learning-context realisation	194
Chapter 10: Student response to first year mainstream science courses.....	197
10.1 Introduction.....	197
10.2 Four mainstream courses: Overall structure, content and assessment practices.....	197
10.2.1 Cell Biology 101	198
10.2.2 Chemistry 101	200
10.2.3 Earth Sciences 101.....	200
10.2.4 Physics 101.....	201
10.3 Student response to educational practices in four mainstream courses	202
10.3.1 Performance based on marks	202
10.3.2 Student experiences.....	204

List of Figures

Figure 2.1: Skills, concepts and content identified as needing attention in ISCM	24
Figure 4.1: Relationship between the three ontological strata in critical realism	44
Figure 4.2: Conceptual model for acquiring recognition and realization rules	58
Figure 4.3: The specialisation plane	62
Figure 4.3: The social plane	65
Figure 4.4: The semantic plane	67
Figure 6.1: Specialisation codes for ISCM based on curriculum documentation	114
Figure 6.2: Semantic codes for ISCM based on curriculum documentation	115
Figure 7.1: Expected classroom practice	127
Figure 7.2: Specialisation codes for ISCM based on pedagogy and curriculum	146
Figure 8.1: Percentage marks related to knowledge type in ISCM assessment	152
Figure 8.2: Percentage marks related to cognitive process categories in ISCM assessment	153
Figure 11.1: Elements of access in ISCM based on findings of study	226
Figure 11.2: Generalised conceptual model of epistemological access in the sciences	230

List of Tables

Table 2.1: Proposed model for the RU SESP	18
Table 2.2: Cohort analysis for SESP students: basic degree	21
Table 2.3: Cohort analysis for SESP students: time taken and for Honours degree	22
Table 4.1: A conceptual model of forms of knowledge	48
Table 4.2: Arena created by the pedagogic device	53
Table 5.1: Interviews conducted during 2014	75
Table 5.2: Knowledge in ISCM using LCT(Specialisation): External language of description	82
Table 5.3: Knowers in ISCM using LCT(Specialisation): External language of description	86
Table 5.4a: Framing of instructional discourse: ISCM pedagogic practices	88
Table 5.4b: Framing of instructional discourse: ISCM assessment practices	89
Table 5.5: Framing of regulative discourse: ISCM pedagogic practices	91
Table 5.6: Characterisation of ISCM assessment tasks	93
Table 5.7: Student acquisition of epistemic-context recognition and realisation rules	95
Table 5.8: Student acquisition of learning-context recognition and realisation rules	96
Table 6.1: ISCM course components: Timing, duration and staff involved	101
Table 6.2: ISCM Teaching Programme for 2013: Term 1	102
Table 6.3: Epistemic and social relations: ISCM knowledge and knower types	104

Table 6.4: Trends in valuing of knowledge and knowers in ISCM	112
Table 8.1: Cognitive process categories and knowledge in ISCM assessment	150
Table 8.2: Cognitive process categories in four major assignments	154
Table 9.1: Student perceptions: Differences between school and university learning	184
Table 10.1: Summary of main aspects of four mainstream courses	199
Table 10.2: Marks allocated to cognitive process levels: Assessment in mainstream courses	200
Table 10.3: Performance in four mainstream courses based on marks in 2014	202
Table 10.4: Performance in four mainstream courses based on marks by race: 2005–2014	203

List of Boxes

Box 8.1: Major assignment tasks in ISCM	149
Box 8.2: Use of structured questions to guide answering of a complex task	154
Box 8.3: Typical structured and unstructured questions in examinations	155
Box 8.4: Tutorial questions guiding critical reading of science in the media	156
Box 8.5: Tutorial questions related to describing trends in graphs	157
Box 8.6: Criteria used to guide production of an essay	158
Box 8.7: Suggested answers to questions from a lecture handout	160
Box 8.8a: First page of first draft of Ntombizodidi's essay with lecturer feedback	162
Box 8.8b: First page of final draft of Ntombizodidi's essay	163
Box 8.9: Lecturer feedback comments on students' reflective responses	164
Box 9.1: Student epistemic-context RC and RL: Recall of Physics knowledge	171
Box 9.2: Student epistemic-context RC and RL: Comprehension of Geology knowledge	172
Box 9.3: Student epistemic-context RC and RL: Application of Chemistry knowledge	173
Box 9.4: Student epistemic-context RC and RL: Analysis of scientific literacies knowledge	174
Box 9.5: Student epistemic-context RC and RL: Evaluation of scientific literacies knowledge	175
Box 9.6: Student epistemic-context RC and RL: Creation of scientific literacies knowledge	177
Box 11.1: African student voices in 2015	219

List of acronyms

AD	Academic development
ADC	Academic Development Centre
ADP	Academic Development Programme
APK	Academic practices knowledge
BScF1	SESP students in first year of study
BScF2	Ex-SESP students in second year of study (first year in mainstream courses)
BSM	Black Student Movement
C	Classification
CHE	Council on Higher Education
DET	Department of Education and Training
DK	Disciplinary knowledge
DoHET	Department of Higher Education and Training
DoE	Department of Education
DP	Due Performance (certificate)
DVC	Deputy Vice Chancellor
ECP	Extended Curriculum Programme
ER	Epistemic relations
ESU	Extended Studies Unit
F	Framing
HEQC	Higher Education Quality Committee
HoD	Head of Department
IR	Interactional relations
IRP	Independent research project
ISCM	Introduction to Science Concepts and Methods
Kn(ec)	Epistemic-context knower
Kn(lc)	Learning-context knower
LCT	Legitimation Code Theory
MCQ	Multiple-choice question
NLS	New Literacies Studies
NQF	National Qualifications Framework
OBE	Outcomes-Based Education
RA	Recontextualising agents (each staff member was allocated an RA number)
RC	Recognition rules
RC(ec)	Epistemic-context recognition rules

RC(lc)	Learning-context recognition rules
RL	Realisation rules
RL(ec)	Epistemic-context realisation rules
RL(lc)	Learning-context realisation rules
RU	Rhodes University
RUConnected	Rhodes University's web-based learning platform
RSA	Republic of South Africa
SAQA	South African Qualifications Authority
SD	Semantic density
SESP	Science Extended Studies Programme
SG	Semantic gravity
SLK	Scientific literacies knowledge
SR	Social relations
SRC	Student Representative Council
SR(ec)	Epistemic-context social relations
SR(lc)	Learning-context social relations
SubR	Subjective relations
TDG	Teaching Development Grant
UCT	University of Cape Town
+	stronger
-	weaker

Chapter 1: Study background

1.1 Introduction

When asked by a colleague nearly twenty years ago what work I did as an academic developer, my response was that I was trying to ‘teach students how the academic system works’. At the time of making this rather inarticulate statement I had an MSc in plant ecology and a general interest in student learning, and on that basis was employed as an academic development¹ tutor in a biology programme. Having stayed the course in the academic development field in the intervening years I can now answer more eloquently that I am attempting to ‘enable epistemological access’, but I am still trying to unpack what this *really* means in terms of what we as educators are offering students and, in turn, how and why students are responding.

Morrow (2009, p77) states that epistemological access means ‘learning how to become a participant in an academic practice’. I take the view that embedded in this deceptively simple statement are complex issues of power relations, socio-cultural theories of learning, academic language and literacies practices, knowledge, values, epistemology, ontology and student identity and agency, all of which should be taken into account when considering the manner in which educational practices enable or constrain such access. These are the issues of concern in this dissertation which asks whether and how educational practices in a particular science foundation course² (which forms part of a broader science foundation programme) can enable epistemological access to a range of mainstream science disciplines.

1.2. Context of study

Historically universities served the interests of an elite few from the middle and upper classes of society (Trow, 2006; Spielvogel 2010). Because of global economic and social justice drivers, the massification of universities in the last century has resulted in major transformations at all levels of the higher education sector (Calhoun 2006). A significant feature of the massification process has been the increase in diversity of the student body in terms of social and educational backgrounds. However, for many universities, the essential ‘culture’ in terms of teaching, learning and research has remained remarkably constant (Longden 2006) with the result that, despite widening participation, the system as a whole still favours certain social groups over others and is therefore inequitable.

Subsequent to the first democratic elections in South Africa in 1994 many higher education sector policies were implemented to address transformation issues such as increasing overall participation rates as well as redressing past racial and gender inequities. Despite this, recent

¹ Aimed at improving teaching and learning activities to better support student success.

² A stand-alone, year-long course preparing students for a range of mainstream disciplines.

cohort studies paint a dismal picture of a poorly performing system that still reflects extreme racial and other biases (Scott, Yeld and Hendry 2007; CHE Report 2013). The most recent data show both gross participation rates (total enrolment as a percentage of the 20–24 age-group) and cohort completion rates (completion of a three-year degree within five years) being well below targets and unacceptably low for Africans³ and coloureds compared with those of Indians and whites (CHE Report 2013). Acknowledging there are many subtleties in race–class categorisations, particularly in South African society (see Cooper 2015), it can be argued that because of the structuring policies of apartheid⁴ the majority of African and coloured students that have entered the university system post-1994 are from working-class backgrounds and, as such, an ‘elite’ system still exists today. Physical access without epistemological access is meaningless, and the emotional and financial toll on individuals and families makes equity of outcomes an urgent moral imperative. The broader-scale implications of perpetuating a system with a grossly unequal distribution of power and access to educational, social, and economic resources in our society add impetus to this imperative. Recent vociferous and angry student protests in this regard, captured by the slogan #RhodesMustFall⁵, are indicative of a disaffected student body that is impatient for real change.

With regards to these inequities, a national study points to overall systemic failure and calls for major curriculum transformation that would extend the length of a programme of study by an additional year for many students (CHE Report 2013). In a ministerial report on transformation of higher education, the call for curriculum reform includes understanding ‘how knowledge is conceived, constructed and transmitted’ (Report of Ministerial Committee 2008, p89, citing Hall 2006). This call for a stronger focus on knowledge in the curriculum has been made by a number of scholars both in the South African and broader context (Muller 2000; Moll 2004; Young 2008a, 2008b; Wheelahan 2010). In this regard, philosophical and theoretical frameworks, drawing on the sociology of knowledge from a social realist perspective, have been progressively developed by a range of scholars over the last few decades. Of particular interest in this study is the work of sociologists of education Basil Bernstein (see 2000) and Karl Maton (see 2014a), who have developed fine-grained theoretical and analytical tools that enable close-up study of curriculum, pedagogy and assessment. An underlying premise in their work is that

³ Race, as a social construct, continues to be a defining feature in South African society. Terminology in this regard is in keeping with the CHE Report (2013): African (black), Indian, coloured (mixed descent) and white.

⁴ A system of legislated segregation and discrimination in South Africa from 1948 to 1994 based on the grounds of race. The system advantaged whites and disadvantaged all other racial groups.

⁵ A collective protest movement of some students and staff mobilising for direct action against institutional racism at universities. The ‘fall’ (removal) of a statue of Cecil Rhodes at the University of Cape Town, a nineteenth century British imperialist businessman, is viewed as symbolic of the fall of racism and privilege at universities (<http://rhodesmustfall.co.za/>).

power and control in education systems manifest themselves through the organisational and interactional aspects of curriculum and pedagogy, and thus have the capacity to either reproduce educational inequity or transform it (Hoadley and Muller 2010, p71).

Central to their work are the concepts of codes and legitimation. Code 'shapes who we are, who we think we can become and what we think we can do' (McLean, Abbas and Ashwin 2013, p265). Since education is about specialising and changing consciousness of individuals, code theory provides a grammar or language for analysing how consciousness can be differentially specialised by different social groups in educational practices (Hoadley and Muller 2010, p69). In this regard Maton developed a conceptual framework called Legitimation Code Theory (LCT), which provides the means not only to make knowledge in educational practices more visible, but also to identify underpinning organising principles (codes) of the practices and indicate how they are being legitimated, as well as to explore their effects (2014a, pp2-3). Two commonly identified codes in education are a knowledge code, which has stronger epistemic relations and emphasises possession of specialised knowledge, and a knower code, which has stronger social relations and emphasises attributes of actors (ibid. p30), both of which are key in this study. The identification of both stronger epistemic *and* social relations in a science course could be considered unusual, and the effect of this on student access forms a main focus of this study.

In an attempt to address systemic inequities in the higher education sector in South Africa, the state has funded Extended Curriculum Programmes (ECPs) since 2004. These programmes extend the three-year degree by a year with courses in the first and sometimes second year being designed to align better with students' educational backgrounds and to allow for more time on task in both structured and independent study in a supportive environment. As a result of restricted funding the programmes do not make a huge impact on the sector in terms of gross participation rates, although they do offer physical access to students who otherwise may not have been able to enter the higher education system.

Rhodes University has three ECPs, one each in the Commerce, Humanities and Science Faculties. The Science Extended Studies Programme (SESP)⁶ is available to selected students who do not meet Faculty entrance requirements for the mainstream three-year degree. Because of a range of other criteria SESP students are usually African, from poor socio-economic backgrounds, have attended former DET or homeland schools⁷, are first-generation university learners and do not have English as their first language. In other words they mainly come from working-class

⁶ The ECPs at Rhodes University are called Extended Studies Programmes (ESPs).

⁷ Prior to democratic elections there were fifteen education ministries, based mainly along racial lines. The Department of Education and Training (DET) was the education authority for African scholars not living in homelands (partially self-governing areas). Most DET and homeland schools were characterised by poor infrastructure and inadequate resources and funding and their scholars were largely expected to enter the work force and not higher education institutions.

backgrounds⁸. In the programme students take three year-long courses: Mathematics, Computer Skills for Science and Introduction to Science Concepts and Methods (ISCM, which carries double the credits of the other two courses).

Of particular interest, and forming the main object of study in this dissertation, is the ISCM course. It is an integrated, multi-disciplinary, foundation course that currently focuses on the four main disciplinary areas of physics, chemistry, earth sciences and life sciences. Two permanently employed staff work with the development of scientific- and language-related literacies⁹ throughout the year in tutorials, whilst disciplinary input is provided by mainstream staff in lectures and practicals. I joined the programme in 2010 as coordinator and staff member responsible for working with the development of students' scientific literacies and in 2011 the programme was reviewed by the Science Faculty. One of the main findings of the review was the need for theoretically-grounded, research-informed curriculum development and pedagogy. This finding was one of the major reasons for the present study.

1.3 Research questions

Underpinned by the issues outlined in the previous section, this study seeks to address the following main research question:

How do educational practices of the Introduction to Science Concepts and Methods (ISCM) course enable and/or constrain epistemological access to a range of mainstream science disciplines?

The sub-questions supporting this main question are:

- 1) How are knowledge and knowers characterised and legitimated in the ISCM curriculum?
- 2) How are pedagogic and assessment practices framed and legitimated in ISCM to enable access?
- 3) How do students interpret and respond to ISCM educational practices?
- 4) In what way do ISCM and mainstream educational practices enable or constrain epistemological access?

1.4 Rationale for research

There are two main reasons for this research. The first is the social justice agenda that has been outlined in section 1.2. My own personal bias feeds into this agenda as, having taught in the academic development field for many years, I am constantly reminded of the enthusiasm,

⁸ Based primarily on income, occupation and lifestyle (Unisa 2011). In this study I assume most SESP students are from working-class backgrounds. This allows me to draw more seamlessly on the literature that refers to working-class students, without having to continually make the race-class link.

⁹ The approach to scientific and language literacies is informed by the New Literacy Studies movement (see Gee 2012) which acknowledges that literacy is a social practice and that there are multiple literacies in society and within an individual's repertoire.

resourcefulness, talent and innovation that students I teach have to offer society, most of whom could have used their circumstances as an excuse to lead a life different to the one they have chosen. In this regard, in a research project examining agential journeys of SESP students getting to university, Thando¹⁰ captured his agential project well: 'I don't believe in these laws that when you come from a poor background you become a tsotsi¹¹. I always want to defy them' (Ellery and Baxen 2015). However, I am also constantly frustrated at how our education system, and the political system underpinning it, fails these youngsters on a daily basis. I am therefore driven by the need to develop deeper explanatory understanding of both the broader academic development field and the narrower context in which I work if I am to contribute productively to the field and the courses in which I teach.

Linked to this is the second reason for this research, which is the need to develop a broad base of theoretically-informed work in the field of science access. There are studies that, drawing on the literature, report on innovative teaching strategies in South African science access programmes (see Holtman, Marshall and Linder 2004; Holtman and Marshall 2008; Kloot, Case and Marshall 2008; Holtman and Rollnick 2010) and on the relative success of such course and programme interventions (see Grayson 1996, 1997; RSA DoACST 1997; Downs 2005, 2010; De Beer 2006; Kioko 2009; Rollnick 2010). There are also empirical studies in these programmes that focus on cognitive aspects of acquiring science knowledge (see Rollnick, Lubben, Lotz and Dlamini 2002; Lubben, Allie and Buffler 2010), academic and scientific literacies and student identity (see Case and Marshall 2006; Ellery 2011), and student agency (see Kotta 2011; Case 2013, 2015). However, studies that draw on social realist code theory (as this study does) for developing understanding on access, exclusion and learning in science and science-related fields (such as engineering) are rare. This study will therefore contribute to what appears to be a small but emerging body of close-up empirical research in this regard (see Blackie 2014; Georgiou, Maton and Sharma 2014; Wolff and Hoffman 2014; Wolff 2015).

1.5 Outline of dissertation

This chapter has briefly contextualised the study, which is concerned with enabling epistemological access of working-class African learners to the sciences. The research questions relate to how educational practices are legitimated in ISCM, a year-long, university-level science access course, and how students respond to these practices. Chapter 2 provides more detailed contextualisation, firstly, by outlining global trends in the higher education sector and secondly, by focusing on South African trends in higher education policy, historical changes in the

¹⁰ Student names have been changed. For simplicity I have used isiXhosa pseudonyms, which is the dominant language amongst SESP students.

¹¹ South African word describing a disreputable character. Someone who steals, lies and generally is not to be trusted; a black township gangster (<http://www.urbandictionary.com/>).

academic development field, and the recent establishment of Extended Curriculum Programmes. Chapter 3 outlines the *concepts* on which the study draws, and therefore unpacks the notion of epistemological access, and locates it within the ideological and socio-cultural model of academic literacies. Although I do not draw on academic literacies work as my theoretical frame I contend in this dissertation, as does Jacobs (2013), that literacies work can have realist underpinnings (as opposed to the more traditional relativist underpinnings), and I therefore argue that the concepts in Chapter 3 align well with those in Chapter 4 which provides the *theoretical frame* of the study. Because the study draws on the objective, stratified ontology and constructivist epistemology, the tenets of critical realism are outlined first in Chapter 4. The second component is a social realist account of the importance of making knowledge an object of study. The third component outlines how code theory, as developed by Bernstein (2000) and Maton (2014a), can be used to develop explanatory accounts of knowledge practices and to consider effects of such practices. Chapter 5 is about methodology, in which the overall study design, approaches to data generation and analysis, and positionality and ethical considerations are provided.

Chapters 6 to 10 present the findings of the study. Chapter 6 focuses on the first research question, which relates to how knowledge and knowers are legitimated in the ISCM curriculum, and draws on the LCT concepts Specialisation and Semantics to do this. Chapters 7 and 8 centre on the second question, which considers how pedagogy and assessment practices respectively are legitimated and framed in ISCM. Pedagogy is examined through close consideration of framing of the regulative and instructional discourses. The assessment analysis focuses on cognitive complexity and knowledge types in ISCM assessment task questions as well as on framing of both the evaluative criteria, and of the feedback associated with the evaluative criteria. Chapter 9 concentrates on the third question, which relates to how students interpret and respond to ISCM educational practices. This is achieved largely through the lens of students' acquisition of recognition and realisation rules in order to be able to produce a legitimate text. In taking a slightly broader view by examining students' responses to four first-year mainstream courses, Chapter 10 provides insights into the last question on how both ISCM and mainstream educational practices enable or constrain epistemological access. This is achieved primarily through analysis of constraints and enablements of student acquisition of recognition and realisation rules. The final chapter synthesises the findings and develops a conceptual model of epistemological access. It also discusses the theoretical and practical implications of outcomes of the study in light of political and academic concerns in contemporary South African higher education.

Chapter 2: Contextual framework

2.1 Introduction

The purpose of this chapter is to outline the contextual landscape that underpins the main research question of how educational practices of the science foundation Introduction to Science Concepts and Methods (ISCM) course enable or constrain epistemological access to a range of disciplines in mainstream science courses. Firstly, the chapter provides a very brief description of the contemporary higher education landscape as well as an overview of policy influences in the South African higher education context, particularly those relating to participation, equity and redress. This is followed by descriptions of the South African academic development field in general and then the Extended Curriculum Programmes (ECPs) in particular, both of which are attempting to address these issues. Finally, the development and overall structure of the Rhodes University Science Extended Studies Programme (RU SESP, which is an ECP), and the ISCM course, in which this study is located, are outlined.

2.2. The higher education context

Historically the traditional university served the interests of an elite few (Trow 2006). The purpose was to produce, at least initially, cultivated gentlemen who would likely become leaders in society. In this context, teachers and learners were from the same social class and as a result the social 'gap' between them was small. After World War II, there was a move away from this elite system to one in which far greater numbers of learners, and from a much wider spectrum of social groups, were permitted access (Trow 2006). The original agenda of massification was social justice and equity, where widening participation was driven by the idea of universities serving a public good (Calhoun 2006). However, in more recent times this social justice agenda has been progressively sidelined by what has been termed the neoliberal agenda, where the purpose of the university has shifted to the production of appropriately-skilled, employable graduates, who can further economic growth in a burgeoning knowledge economy (Giroux 2002; Boughey 2003; Levidow 2005; Apple 2006; Santos 2010). These competing discourses, of equity, participation and collegiality on the one hand, and efficiency, performance and employability on the other, have been and still are playing out in the higher education sector (Boughey 2003; Nkomo, Akoojee and Motlhanke 2007; Santos 2010).

As mentioned, a significant feature of the massification process has been an increase in diversity of the student body in terms of social and educational backgrounds. However, many universities have not adapted their curricula or teaching approaches to accommodate this diversity. As a result, many who are entering the university system are not successful (Longden 2006). It is in this context that the international academic development movement, which is primarily intent

on improving teaching and learning, has emerged (Clegg 2009). How the global trends of massification and neoliberal agendas and the more local trends of academic development initiatives have played out in the South African higher education context are outlined in the following sections.

2.3 The South African higher education sector and policy influences

The policies and initiatives that are described in this section pertain mainly to the South African higher education sector, particularly where 'education' as opposed to 'training' is the imperative.

Because the Extension of Universities Act of 1959 legislated for separate universities for different races, there were 36 publically-funded universities and technikons¹ across South Africa prior to democratic elections in 1994. These institutions were controlled by eight different government departments, resulting in an unwieldy system with much unnecessary duplication. The newly-elected democratic government therefore inherited a higher education system that, reflecting its apartheid origins, has variously been described as internally divided, fragmented in structural and governance terms, globally isolated, racially inequitable, inefficient and unsustainable (CHE Report 2004, p230). A series of mergers and restructuring processes resulted in the 36 institutions being reduced to 23 by 2005 with 11 traditional universities² (of which Rhodes University is one), 6 comprehensive universities³, and 6 universities of technologies⁴. In 2014 two new universities were created to provide a better geographic spread of institutions across the country.

Policy analysts recognise three main periods in terms of higher education policy development. The few years leading up to democratic elections have been termed a 'symbolic policy-making' period during which the 'predominant concerns were principles, values, visions and goals, unconstrained by issues of planning' (CHE Report 2004, p231). However, following the elections of 1994 the 'framework development' period (1994–1998) recognised that principles, values and goals needed to be translated into policies. Discourses of meeting the needs of previously disenfranchised individuals through equity and redress competed with discourses of economic development and global competitiveness (ibid. p232). In linking the education project with the labour market, South Africa made the decision to focus on developing a skilled workforce.

¹ Offering technical and vocational education at tertiary level.

² Offering theoretically-oriented degrees.

³ Offering theoretically- and vocationally-oriented diplomas and degrees.

⁴ Offering vocationally-oriented diplomas and degrees.

Consequently, an Outcomes-Based Education (OBE)⁵ system was adopted with a supporting National Qualifications Framework (NQF).

The main outcome of this period for the higher education sector was the Education White Paper 3: A Programme for the Transformation of Higher Education (RSA DoE 1997) and its subsequent National Plan for Higher Education (RSA DoE 2001) in which the key proposals were for the planning, funding and governing of a single national co-ordinated higher education system, an integrated qualifications framework (the NQF, overseen by the South African Qualifications Authority, SAQA) and a quality assurance system (coordinated by the Higher Education Qualifications Committee, HEQC; RSA DoE 2001). Increased participation, equity of access, equity of outcomes and improving efficiency through increased graduate outputs were all key issues in these documents. One means of achieving some of the equity goals, and of relevance to this study, was the proposal to fund academic development work through extended curricula structures (RSA DoE 2001). These are discussed in section 2.4.

The third policy 'implementation' period since 1999 has been characterised by two trends. Firstly there has been increased input into and steering of university governance by the state to bring about the desired transformation. Secondly, and of particular interest in this study, the discourse of public accountability, efficiency and effectiveness has been dominant, although some analysts argue that the discourses of democratisation and equity and redress have remained clearly in sight (CHE Report 2004, p233) and are still very visible in the relatively recent White Paper for Post-school Education and Training (RSA DoHET 2013a).

Various studies in the last few years on the higher education sector indicate improvement in some areas and, more generally, poor progress in others. Whilst the sector has expanded considerably from 473 000 students in 1993 (CHE Report 2004) to just under a million in 2013 (RSA DoHET 2013a), the latter represents a gross participation rate⁶ of 17%, which is below the 20% benchmark of comparable countries in terms of economic development (Scott, Yeld and Hendry 2007). Whereas white students formed the majority group pre-1994, by 2010 Africans constituted 79% of the total student body (CHE Report 2013). Whilst this represents an enormous shift in overall demographics, of great concern are the inequities of gross participation rates by race, which in 2011 were only 14% for both Africans and coloureds, 47% for Indians and 57% for whites⁷.

⁵ 'Outcomes-Based Education' defines learning as 'what students can demonstrate that they know' and can do, and is not usually specific about content (McNeir 1993, p2).

⁶ The total higher education enrolment (of all ages) expressed as a percentage of the 20–24 age group.

⁷ To contextualize this, according to the 2011 census, the total population of South Africa is approximately 52 million, with 79% African, 9% coloured, 9% white, 2.5% Indian and 0.5% 'other'.

Cohort studies indicate similar poor and inequitable trends in throughput and graduation rates, with the following statistics coming from a recent CHE Report (2013). Of the students enrolling for basic three- and four-year degrees and diplomas at all universities in the 2006 cohort, only 27% graduated in regulation time. Breaking this down by race it represents 20% Africans, 24% coloureds, 28% Indians and 44% whites. In terms of first-year attrition for the same cohort as many as 33% of all students had left the system by the end of the first year of study. Again disparities are evident when this is broken down by race: African 34%, coloured 39%, Indian 34%, white 29%. In terms of overall attrition of this 2006 cohort a staggering 55% of the intake never graduated.

Since this study is located in the sciences, it is relevant to note that, in terms of the 3-year BSc degrees offered at contact universities⁸, 48% of the 2006 cohort graduated within 5 years (CHE Report 2013). In another cohort study starting in 2000, graduation after 5 years for the 3-year degree at contact universities in the life and physical sciences was 31% for Africans and 63% for whites, and in the mathematical sciences it was 35% and 63% respectively (Scott et al. 2007).

It is acknowledged that the school system that feeds into higher education shows similar inequitable trends, which gives rise to the unfortunate label of the 'underprepared student'. Whilst this may be true at one level, for example in science some base concepts are very poorly understood from school, it allows us to shift blame onto schools and students and away from the higher education system (Scott 2012). Yet, it is repeatedly emphasised in the literature that we need to 'teach the students we have, not the ones we wish we had' (Jones 1995) and this is particularly relevant in the South African context, where substantial improvement in the school sector is unlikely in the short- to medium-term (Scott et al. 2007; Fisher and Scott 2011). Rather than the 'fault' lying with the schools and students, it is instead argued that institutions are underprepared for the current diversity of students (Vilakazi and Tema 1985; Mehl 1988; Boughey 2007a; Scott et al. 2007; Dhunpath and Vithal 2012; Smit 2012; CHE Report 2013).

Whilst it is easy to recognise that change in higher education is needed, there is less consensus on what would be appropriate. Because this study draws on social theory, which acknowledges that students from working-class backgrounds are less likely to attend higher education institutions and also significantly less likely to persist to completion (see Tinto 2006; Arum, Gamoran and Shavit 2012; Soria 2014), it will be argued that institutional changes would need to take this into account.

The above therefore indicates an education system that is not only failing its students, but also failing to meet the economic and social development needs of the country (CHE Report 2013).

⁸ Excluding the one extremely large distance education institution (UNISA), which, if included, would most likely lower this number considerably.

The Council on Higher Education (CHE) appointed a task team to investigate the possibility of changing the undergraduate curriculum in order to substantially improve graduate output and outcomes. The report cites evidence of ‘systemic obstacles to access and success, particularly in relation to curriculum structure’ as well as an essentially unchanged curriculum from colonial times as reasons for focusing on teaching and learning processes in the undergraduate curriculum (CHE Report 2013, p15). The report concludes that ‘modifying the existing undergraduate curriculum structure is an essential condition for substantial improvement of graduate output and outcomes’ (ibid. p16). The report thus ‘presents a case for this systemic change, and makes a concrete proposal for a flexible curriculum structure for South Africa’s core undergraduate qualifications – based on extending their formal time by a year as the norm – designed to address effectiveness, efficiency, quality and responsiveness to diversity across the higher education sector’ (ibid. p16). These proposals would concur with social theory used in this study, which recognises that underlying structural constraints need to be identified in order to make necessary change.

Although it was originally envisaged that this study could contribute empirically and conceptually to the debate on the four-year flexible undergraduate curriculum, government support for adoption of this approach appears unlikely at this point in time. Instead, indications are that more funding may be made available to increase the number of places in Extended Curriculum Programmes until more research on the impact on student performance of other initiatives, such as those supported by the Teaching Development Grant (TDG)⁹, has been concluded.

In an effort to improve both efficiency and equity the higher education sector has changed considerably in the last two decades, especially at the broader structural levels. However, even before 1994 there were small-scale, institution-specific attempts to improve access and success for a diverse group of students, particularly those from socio-economic and educational backgrounds that may not have prepared them well for success at university. Such attempts were, at least initially, peripheral to mainstream academic activities, but they have become increasingly, although insufficiently, central in the higher education sector in the interim. Academic development initiatives are outlined in the following section as they form the contextual backdrop for locating work in this study.

⁹ The Teaching Development Grant (TDG), an initiative of the Department of Higher Education and Training, provides earmarked funds to enhance, amongst other things, curriculum development and teaching support initiatives in order to improve student performance (RSA DoHET 2013b).

2.4 The academic development field in South Africa

Academic development initiatives worldwide are generally aimed at improving teaching and learning activities to better support student success. As such, academic development in higher education institutions only emerged in the mid-twentieth century, largely in response to contemporary challenges of massification and widening participation (Clegg 2009). The drivers for academic development in South Africa were slightly different, at least initially, as the first initiatives established at four liberal 'white' universities (Cape Town, Natal, Rhodes and Witwatersrand) provided support to a small group of African students who had been exposed to poor-quality school education (Boughey 2007a). This section outlines these early and subsequent academic development initiatives and locates them in a national historical and political context.

Much of the research on teaching and learning in higher education in South Africa in the last thirty-or-so years has been conducted by a small group of educational practitioners who mostly have been associated with Academic Development Centres or Units (Boughey and Niven 2012). The term 'academic development' has been used variously to encompass aspects of student development (both learning and support functions), staff development, curriculum development, policy development, quality assurance, and the production of learning resources and research (Gosling 2009). The definition used in this study comes from that of Shay (2012), who broadly defines academic development as a 'range of development and research practices aimed at the professionalization of teaching and learning, most commonly associated with various forms of student, staff, curriculum and policy development' (p311). However, this study refers particularly to *student* academic development, which forms the focus of the following discussion.

The history of academic development in South Africa has been well documented (Volbrecht and Boughey 2004; Boughey 2007a) and a recent thorough analysis of structural, cultural and agential underpinnings of such shifts have added depth to this narrative (Boughey and Niven 2012; Boughey 2012). The brief overview that follows is based on these four articles, unless otherwise stated.

The academic development field in South Africa has seen three major 'phases' since the early 1980s, although it is acknowledged that there is considerable overlap between the phases and that aspects of each still continue today. The apartheid policies in South Africa, in place since 1948, ensured that the majority of African scholars in South Africa were exposed to a vastly inferior school education compared with their white counterparts, and those that did study further usually did so at 'African' higher education institutions with poor facilities and limited

opportunities for advancement¹⁰. By the early 1980s white liberal universities, in rejecting the separate educational facilities policies, were providing access to small numbers of African students. These students were in the minority and perceived as being 'disadvantaged' and 'underprepared' for higher education (Boughey and Niven 2012). In order to support them in their studies interventions were introduced, such as add-on, generic, practical, life skills and language courses (such as English for Academic Purposes, Communication Skills and Academic Literacy Life Skills) and tutorials. This has come to be termed the 'support' phase of academic development.

Although not often explicitly stated, the support phase drew largely on the field of cognitive psychology, which views learning as an intellectual activity undertaken by individuals. Knowledge is viewed as neutral and acontextual and its acquisition is usually seen as a process of transfer from expert to learner. Articulating norms, values and beliefs is unnecessary as these sit outside of the knowledge structures and therefore have no bearing on learning. As such, teaching within this discourse does not require a specific disciplinary context, and generic, add-on skills courses (teaching reading, writing, listening, numeracy, communication, etc.) which address knowledge gaps are viewed as sufficient to enable student success. In this discourse the capacity of the student to construct knowledge and make meaning rests within themselves, and responsibility for success therefore lies with the student and not with the teaching practices or the institution (McKenna 2003, 2010).

Interventions in the support phase were not always popular with students, mainly due to their suggestion of 'difference' as well as their lack of credit-bearing status. Consequently these interventions were often poorly attended and levels of motivation and participation were low. Lecturers involved in such initiatives were generally concerned with addressing past inequities from a social justice perspective and, because of social difficulties many African students encountered during this time, interventions often took on a pastoral role as well. However, the separation of these initiatives from mainstream teaching and learning meant that staff were marginal to the main academic project, often employed in separate units and programmes in temporary, short-term contract posts subsidised by donor funding.

The subsequent 'academic development' phase arose in the context of increasing political upheaval in the 1980s, where collapse of the apartheid state seemed inevitable, bringing with it major shifts in the political and educational landscape. The anticipation of a democratic dispensation meant that the idea of the 'underprepared' student would no longer be tenable, as Africans would be in the majority and educators would instead need to recognise and act on the

¹⁰ These were later referred to as Historically Disadvantaged Institutions (HDIs).

concept of 'underprepared' institutions (Vilakazi and Tema 1985; Mehl 1988; Boughey 2007a; Scott et al. 2007; Dhunpath and Vithal 2012; Smit 2012; CHE Report 2013). There was also some acknowledgement that learning is not neutral, and therefore needs to be embedded in a broader context. Instead of small-scale, marginal efforts aimed at addressing student 'deficit', broad-scale initiatives aimed at addressing curriculum and staff development were needed to bring about institutional change. During this phase different institutions used different approaches (Kloot, Case and Marshall 2008).

One approach was the 'infusion model' which existed at the University of the Western Cape (Walker and Badsha 1993) and in many other institutions. Academic development lecturers, either housed in departments or housed centrally in Academic Development Centres but working within departments, were expected to play a role in curriculum and staff development in the broader university context. Unfortunately the much anticipated shifts in mainstream curricula did not materialise through the infusion model. This was partly a result of many academic development lecturers still occupying marginal positions and lacking authority to have widespread influence. This was exacerbated by broader political and economic processes, which saw the collapse of the professional academic development association (South African Association for Academic Development, SAAAD) through the withdrawal of both government and donor funding. Many Academic Development Centres closed down in the late 1990s.

Another initiative that started during and emerged out of this phase was the development of 'foundation' programmes, which can be defined as 'special programmes for students whose prior learning has been adversely affected by educational or social inequalities' (Kloot et al. 2008, p800), whose purpose was to 'lay the necessary academic foundations for further study' (ibid. p801). In this regard Science Foundation Programmes were implemented at the University of Cape Town in 1986 (Kloot 2011) and the University of Natal-Pietermaritzburg in 1991 (Grayson 1996), a College of Science was initiated at the University of the Witwatersrand in 1991 (Rutherford and Zietsman 1992) and an Extended Degree Programme started at Stellenbosch University in 1995 (de Klerk, van Deventer and van Schalkwyk 2006).

Initiatives in this phase recognised the role of social context in learning. Some academic development practitioners drew on the idea that students from different socio-economic backgrounds bring different forms of social and cultural capital (Bourdieu 2010 [1986]) to the educational context, which needed to be accommodated. Others drew on Vygotsky's (1987) concept of 'Zone of Proximal Development' to support and scaffold learning. Many language academic development lecturers were influenced by the socio-cultural literacies work of Gee (1990, 1999) and Street (1984, 1993), which recognises teaching and learning as profoundly ideological and linked to issues of power (see Chapter 3). The literature on metacognition was

used by some to inform understanding on student awareness of learning (Kloot et al. 2008). Furthermore, during this phase many drew on the theory of constructivism to understand poor or wrong conceptions students had developed in school (Kloot et al. 2008).

Leading up to South Africa's first democratic elections in 1994 and beyond, there was a gradual change in student demographics, with increasing numbers of African and other previously disenfranchised students at higher education institutions. Capacity to bring about change in line with the newly implemented OBE post-elections was almost absent in mainstream disciplinary staff, and academic development professionals were increasingly called upon to assist in staff development in this regard. This heralded the third and current phase of academic development, termed 'higher education development', in which the focus has been on the development of mainstream staff, rather than of students. This has helped raise the profile of academic development lecturers and today many have tenure and permanent positions, with some occupying high and influential positions within the university.

Despite this general shift to working with staff and to overall curriculum development in this last phase of academic development, student development initiatives, some of which started as foundation programmes mentioned earlier, have continued mainly in the form of government-funded Extended Curriculum Programmes (ECPs). The following section briefly outlines the general structure and rationale of ECPs.

2.5 Extended Curriculum Programmes

As mentioned earlier the National Plan for Higher Education outlined its support for student academic development through extended curriculum programmes based on 'recognition that curriculum-related approaches are critical to dealing with educational disadvantage, rather than reliance on supplementary support mechanisms' (RSA DoE 2001, p27). Funding for Extended Curriculum Programmes (ECPs) has been made available since 2000, although the main three-year on-going funding cycles were initiated in 2004. Whilst some institutions such as the Universities of Cape Town, Stellenbosch and KwaZulu-Natal have used this funding to build on well-established programmes with permanent staff, other institutions are offering them for the first time with part-time staff on short-term contracts (CHE Report 2013).

Scott's definition of the undergraduate extended curriculum is as follows:

An extended curriculum is a first degree or diploma programme that incorporates substantial additional provision, over and above the coursework prescribed for the standard programme, that is (a) equivalent to one or two semesters of fulltime study, (b) formally planned, scheduled and regulated, (c) primarily foundational in nature, i.e. designed to enable learners to acquire basic knowledge and skills considered necessary for successful study in the relevant degree or diploma programme, (d) designed to

articulate effectively with the standard elements of the programme, and (e) primarily intended to enable learners who are underprepared for the standard programme to gain a sound foundation for successfully completing the programme (Scott 2001, p18).

The overall purpose of ECPs is to 'create the curriculum space needed to enable talented but underprepared students to achieve sound foundations for success in higher education' (CHE Report 2013, p70). The foundational provision can take the form of introductory disciplinary courses as well as courses in which academic literacies (in their broadest sense) and learning practices are developed. An essential feature of these programmes is to provide more time on task and more teaching of an appropriate nature (Kloot et al. 2008). Credit-bearing foundation provision is usually offered in the first year of study, but can be incorporated at other levels (RSA DoE 2006). The programmes therefore extend the length of the degree, usually by a year. The combination of courses in which this additional tuition is provided is known as the 'Integrated Foundation Phase' (RSA DoE 2006). The ECP model was favoured over other models in which support was concurrent with regular mainstream offerings, as the latter created an additional burden for students and in fact did little to address the articulation gap between school and higher education (CHE Report 2013).

ECPs are recognised as the only current major systemic attempt to address the so-called secondary-tertiary articulation gap (CHE Report 2013). Unfortunately, there was little formal guidance in terms of what was needed in these programmes in the RSA DoE report (2006), and as a result many of the programmes have not taken advantage of the opportunity to support students beyond their first year of study, and the 'student deficit' and 'skills' discourses still dominate in many (Boughey 2007b). In a more recent report it is suggested that the current limitations of ECPs include (a) an articulation gap between the foundation phase and mainstream phase of the programme, (b) being restricted to address only the secondary-tertiary articulation gap, (c) an intake of students that is often very poorly prepared for higher education studies, (d) a limited overall impact on student numbers as they tend to serve a minority of students, and (e) continued marginalisation from mainstream academia (CHE Report 2013). Whilst I agree with the issues related to overall impact and marginalisation, I think the concept of an articulation gap, which is generally viewed as a mismatch in knowledge or skills, needs to be problematised, or at least articulated better. Because I take the social theory view that underpinning structural, cultural and agential mechanisms affect student performance, simply improving students' knowledge and skills may not be sufficient. As this study will show, students' deep-seated orientations to ways of working and knowing need to be addressed to ensure success.

It is in this context of a continued need to address equity issues and poor student performance, as well as the provision of government funding supporting extended curriculum programmes, that Rhodes University established an Extended Studies Unit with three programmes under its umbrella. The following section outlines the overall Rhodes University extended curricula framework and focuses in particular on the Science Extended Studies Programme.

2.5.1 Rhodes University Extended Studies Programmes

An ECP, originally called the Commerce Foundation Programme, was initiated in the Commerce Faculty at Rhodes University in 1994, and still continues today as the Commerce Extended Studies Programme. Supported by the DoE Foundation Programme Grants in 2001 (Commerce) and 2004 (Science and Humanities), the Extended Studies Programmes were formally established and housed within an Extended Studies Unit (ESU). Whereas the foundation phase of the Commerce ESP runs over two years, for the other two faculties it occurs in a single year. The following sections will examine the development and current structure of the Science Extended Studies Programme (SESP).

2.5.1.1 Development of Rhodes University Science Extended Studies Programme

The structure and form of the Rhodes University Science Extended Studies Programme (RU SESP) was originally developed by Williams, a practitioner in the then Academic Development Centre (ADC). This was done in discussion with RU staff, and in consideration of foundation and/or access programmes in place in Australia, South Africa, the United Kingdom and the United States (Williams 2003). Williams speaks of the school–tertiary articulation gap as not simply a matter of students needing to gain more content and skills, but rather as a more complex issue related to the worldviews of students and the worldviews that underpin science (Williams 2003, p2, quoting Hand, Lawrence and Yore 1999):

It is essential that students understand that science is an intellectual activity requiring more than technical competence. Students must engage their own epistemological beliefs about knowing, scientific proof, justification, and logic with those central to scientific reasoning. Addressing the lack of congruence between the students' beliefs and the modern epistemological commitments of science is central to promoting student learning. Activities in the classroom should take on the authentic characteristics of scientific inquiry as students develop their epistemological commitments and understandings about the nature and rationale of science. Critical discussions of these inquiries can help students begin to understand science as a way of knowing related to, as opposed to distinct from, other ways of knowing (Hand et al. 1999, p1024).

In terms of the proposed overall structure three first-year courses were suggested: Introduction to Science Concepts and Methods (ISCM), Mathematical Literacy, and Computer Skills (Table

2.1). It was further envisaged that there would be language and information literacy tutorials and mentor support in the first year and that language and (disciplinary) content support would continue into the second and third years.

Table 2. 1: Proposed model for the RU SESP (adapted from Williams 2003, p8)

Year of study	Subjects/Courses	NQF credits*
4	Two '300' level majors	120
3	Three '200' or two '200' plus one '100' level course(s) allowed by Faculty <i>Language and content support in tutorials</i>	90
2	Two '100' courses allowed by the Faculty, plus either: Chemistry 1 OR Mathematics 1 <i>Language and content support in tutorials</i>	90
1	Introduction to Science Concepts and Methods Mathematical Literacy Computer Skills <i>Language and information literacy tutorials. Mentor support</i>	60 (plus foundation credits)

*1 credit requires 10 hours of learning

The following section outlines the current structure of the SESP, which essentially follows the model proposed by Williams, particularly in the first year of study. However, the proposed formalised tutorial support in years 2 and 3 was not implemented in the initial SESP as the 'final model was only concerned with the foundation phase' (pers. comm. Ms Wait (Biology teacher, UK), November 2014). I would suggest this focus on the foundation phase may be due to minimal input from those with teaching and learning expertise.

2.5.1.2 Current structure of RU SESP

Currently, the Rhodes University Science Extended Studies Programme (RU SESP) offers a four-year degree to selected students who do not meet the Faculty entrance requirements for the mainstream three-year degree. The criteria for admission to the RU SESP are that students should have at least 34 points based on the National Senior Certificate¹¹ code ratings, English Language (as a home or additional language), Mathematics and either Life Sciences or Physical Sciences all at a rating of 4 (50% to 59%) or above. Students must also be South African citizens, and preference is given to students who are first-generation university entrants, are from lower socio-economic backgrounds, have experienced educational 'disadvantage' (initially this was former DET and homeland schools but students from all schools are now considered as it is acknowledged that schooling alone does not develop capital necessary to succeed at university), and live in the Eastern Cape¹². Based on these criteria students from all races are eligible, but currently RU SESP has only been able to fill the places with African and, occasionally, coloured applicants. The programme, which is funded for 50 students, has had class sizes between 27 and

¹¹ The main school-leaving certificate in South Africa, commonly called the matriculation certificate.

¹² One of South Africa's nine provinces in which RU is located.

51 students since its inception¹³. Part of the difficulty in filling the programme is that students who meet the entrance criteria for RU SESP will often gain entrance to a three-year programme at another university and this influences their choice of whether or not they take up a place at RU.

The 'foundation phase' of the programme is the first year of study, in which students take three year-long courses: Mathematical Literacy (MAT 1L), offered by the Department of Mathematics, Computer Skills for Science (CSC 1S), offered by staff of the SESP, and Introduction to Science Concepts and Methods (ISCM), offered by staff of the SESP with input from mainstream lecturers in the Science Faculty.

Using the terminology of the Department of Higher Education (Boughey 2009), Mathematical Literacy and Computer Skills for Science are *extended* courses, which means the content and level are similar to mainstream, single-semester courses, but are run over an entire year with double the amount of tuition compared to regular courses. The Mathematical Literacy¹⁴ course helps develop appropriate mathematical tools and skills to develop meaningful ways of thinking, reasoning, and arguing with quantitative information in order to solve problems in different contexts (Rhodes University Funding Application Report 2012). The Computer Skills for Science course serves as an introduction to the modern computer environment, and allows students to develop basic computer skills as well as problem-solving techniques and principles, using integrated computer toolsets and programming (Rhodes University Funding Application Report 2012). ISCM is essentially a *foundation* course, as the course content is mostly not at a first-year level and students do not attend any first-year mainstream lectures, but instead attend sessions that have been specially designed to prepare them for mainstream courses in their second and future years of study at university. The ISCM course carries 30 credits (double the credits of the other two courses) and therefore has more contact teaching hours. Of these credits, 15 are 'foundation' credits and 15 count towards their degrees.

In addition to the above-mentioned courses, the students also attend Information Literacy sessions run by library staff in the first six weeks of the first semester. Furthermore, there is a well-developed mentoring programme, with each student being mentored by a former SESP student during the first semester.

The SESP has two full-time, permanent lecturers and shares a Computer Science lecturer with the two other ESPs. Other teaching input is provided by mainstream staff and senior post-graduate students. The Dean of Teaching and Learning provides guidance with regard to

¹³ The SESP is funded by the DoHET for 50 students.

¹⁴ Not to be confused with school level Mathematical Literacy in South Africa, which is substantially different in content and at a much lower level

Programme structure, funding, curriculum issues and day-to-day running whilst the Dean of the Science Faculty is responsible for the overall quality assurance and admissions.

In order to proceed into mainstream courses, students have to pass all three courses (with 50% or more) and obtain a minimum mean grade of 60%. It is a generic programme in that it allows students to proceed into any science discipline in the post-foundation phase of their degree. In their second year of study most students do not carry a full first-year mainstream load, but usually choose 6 (90 credits) instead of the full 8 (120 credits) courses on offer, providing time for them to adjust to the volume and pace of mainstream work. Although no formal support is provided by SESP staff in mainstream courses, a number of departments have traditionally had additional support structures, run by post-graduate students, which students can utilise. A recent additional support initiative that is currently being implemented is described in more detail in Chapter 10. In their third and fourth years of study students carry a full mainstream load, and finish with a slightly higher credit count than students doing a standard three-year degree. The overall performance of SESP students is outlined in the following section.

2.5.1.3 Overall performance of RU SESP students in mainstream

The cohort analysis presents data from 2005 until 2011, although it should be noted that the data for the latter years will likely still change as more students graduate (Table 2.2). The attrition at the end of BScF1¹⁵, which for the most part represents students excluded on academic grounds (although two or three may leave RU each year for other reasons), ranges from 7% to 57%. This latter unacceptably high figure has resulted in increased efforts in recent years to provide entry to students who are only just below the 'norm' for entry into mainstream based on matriculation (final schooling) results.

¹⁵ BScF1 is the first year of study in SESP, and BScF2 is the second year of study (first year in mainstream courses).

Table 2.2: Cohort analysis of BScF1, BScF2 and direct-entry African students for attaining degrees. Number and percentage of students graduating for (a) all BScF1 students, (b) all BScF2 students who enter mainstream, and (c) BSc direct-entry to mainstream African students (Data Management Unit, Rhodes University, February 2015)

Year started	BScF1 students				BScF2 students (only BScF1 students who enter mainstream)			BSc direct-entry African students		
	N enter	N grad	% grad	% attrit	N enter	N grad	% grad	N enter	N grad	% grad
2005	27	11	41	33	18	11	61	18	10	56
2006	31	14	45	10	28	14	50	19	9	47
2007	44	13	30	57	19	13	68	24	14	58
2008	46	17	37	30	32	17	53	35	19	54
2009*	35	17	49	43	20	17	85	91	40	44
2010*	32	11	34	38	20	11	55	38	25	66
2011*	27	9	33	7	25	9	36	55	30	55

*numbers will change as more students graduate; N=number; grad=graduating; attri=attrition after BScF1 (i.e. not entering BScF2)

The overall percentage graduation rates¹⁶ for SESP students are relatively low (although not necessarily so compared with overall sector statistics described in section 2.3). If we take into account all students who enter the SESP the graduation rate is between 30% and 49% (Table 2.2, BScF1 column). However, since there is some attrition at the end of the foundation year due to poor results and for social and economic reasons, when the number completing a degree is expressed as a percentage of those entering mainstream, the graduation rates are 50% or more (Table 2.2, BScF2 column). These latter percentage graduation rates compare favourably with BSc African students who entered mainstream directly with higher matriculation points than BScF students (Table 2.2, BSc direct-entry African students). These trends are better contextualised when examined in individual courses in Chapter 10.

Despite an extra year of study in the SESP, a relatively small number of students graduate in regulation time (37% or less since programme inception) with a number still requiring additional time to complete their degrees (Table 2.3). However, each year a number of ex-SESP students acquire sufficiently good marks to proceed into and graduate with an Honours degree. The best year so far was 2009 where 26% of the original cohort have achieved this so far.

¹⁶ Graduation rate refers to proportion of a given student intake or cohort that graduates.

Table 2.3: Cohort analysis showing number and percentage of BScF students graduating with BSc or BSc (Hons) (Data Management Unit, Rhodes University, February 2015)

Year started	N	Grad in 4 yrs	%	Grad in 5 yrs	%	Grad in > 5 yrs	%	Total BScF grads	%	Total Hons grads	%
2005	27	6	22	4	15	1	4	11	41	4	15
2006	31	7	23	6	19	1	3	14	45	4	13
2007	44	8	18	5	11	0	0	13	30	6	14
2008	46	7	15	9	20	1	2	17	37	9	20
2009*	35	13	37	4	11	0	0	17	49	9	26
2010*	32	8	25	3	9	0	0	11	34	6	19
2011*	27	9	33	0	0	0	0	9	33	0	0

*numbers will change as more students graduate; N=number of students; Grad=graduating; Hons=Honours (a single year of post-graduate study)

It is difficult to make comparisons across programmes as the context in each case is so different. Nonetheless, in order to provide some contextual backdrop, it is useful to provide statistics on student performance in other science extended-curricula programmes at other institutions. In this regard published reports from the University of Witwatersrand, University of Natal (now University of KwaZulu-Natal) and the University of Stellenbosch provide some insight. Since the shift from the successful but expensive 2+2 to the 1+3¹⁷ model at the University of Witwatersrand in 2003, only 26% of the 2002–2005 College of Science intake graduated (Matlou 2009). Kioko, Barnsley and Jaganyi’s (2012) article on the 1991–2000 cohorts in the Science Access Programmes at University of Natal using the 1+3 model indicate that the BSc4 (Augmented Programme) on the Durban Campus, with no exclusion after the first year, had graduation rates ranging from 21% to 58%. The four-year Science Foundation Programme (SFP) on the Pietermaritzburg Campus, which had an option for exclusion after the first year, had completion rates ranging from 20% (likely to change with longer-term data) to 95%. In a third example, the overall completion rate of the Science Faculty Extended Degree Programme (1995–2004 data) at Stellenbosch was 16% (de Klerk et al. 2006).

2.5.1.4 The purpose of RU SESP

In a relatively recent review of the Rhodes University ESU, teaching staff employed in the unit articulated the overall purpose of the programme as being ‘to provide epistemological and ontological access to students from designated groups whose cultural, socio-economic or educational conditions could inhibit their success in a university with western academic

¹⁷ 2+2 indicates two of the four years of study are highly supported. 1+3 indicates only one year of support.

traditions' (ESU Review Purpose Statement 2011, p1). The stated goal of ISCM, which is the focus of this study, is also to enable epistemological access (SESP Review Report 2011). The following sections provide a brief overview of necessary background information for the ISCM course.

2.6 Introduction to Science Concepts and Methods (ISCM) course

2.6.1 Early development of ISCM

In the original SESP proposal it was suggested that a range of science disciplines should contribute to the ISCM course, and that a problem-based approach, and/or a theme-based, multidisciplinary, integrated approach, would enhance transfer across disciplines (Williams 2003). The ISCM course was first introduced in 2005 and the primary course developer was the SESP coordinator, Ms Wait. She had a strong background in the sciences and admitted to being somewhat uncomfortable moving away from a content-based approach to a broader concepts- and skills-based approach to teaching (Wait 2008).

In the development process Ms Wait consulted generally with the original committee, particularly Mr Williams and the Dean of Science, and specifically asked mainstream staff from eight science disciplines to identify **content, concepts and skills** that were problematic for first-year students (Curriculum Development Report 2007). Their responses, summarised in Figure 2.1, formed the basis for course planning. In terms of content, staff mentioned stoichiometry, concentration, density, moles, evolution, cell chemistry and processes, diversity of animals, structure of the earth, maps, chemical nature of earth, calculus, vectors – reflecting the needs of respondents from individual disciplines. In terms of more general understanding of science, concepts such as hierarchies and connections, spatial awareness, logical construction, scale, diversity of things, change over time, accuracy and precision were suggested. The skills that staff identified related to time planning, literacy and reporting, numeracy including graphs and analysis, drawing and diagram construction, critical awareness and problem solving. Most of these suggestions were included in some way or another in the curriculum (although without a current Botany/Zoology component, aspects of diversity and evolution are not currently covered).

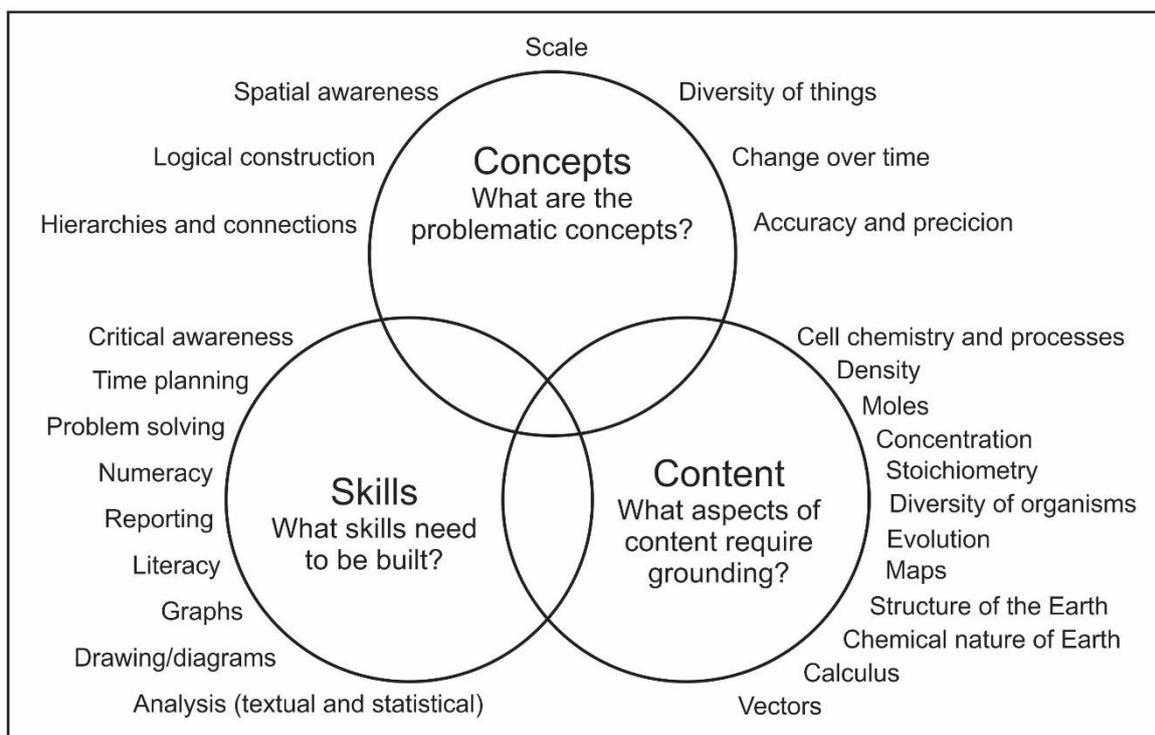


Figure 2.1: Skills, concepts and content identified by disciplinary staff as needing attention in ISCM (Curriculum Development Report 2007)

At that time the stated aims of ISCM were (a) to provide the concepts and skills [practices] required by first-year students in a science degree and (b) to prepare students for success in mainstream (Curriculum Development Report 2007). It was envisaged that the content would expose students to core concepts and methods in a number of disciplines in the Faculty of Science (Botany, Chemistry, Geography, Geology, Human Kinetics and Ergonomics, Physics, Statistics and Zoology; Curriculum Development Report 2007). The course had three interwoven strands linked to the original questions asked of disciplinary mainstream staff. The first involved the disciplinary lectures and practicals in which **content** (aimed at or close to a first-year level but mostly not what is currently first-year content) was covered. The second and third strands were 'skills-based activities' (Wait 2008, p15) and included 'science **concepts** and methods background and numeracy' that were planned and taught by Ms Wait and 'linguistic **skills** and analysis' that were planned and taught by Ms Platt (Curriculum Development Report 2007), the second contributor to course development who had an MA in Linguistics and Applied Language.

The current 'language-related literacies' practitioners in ISCM was appointed in 2009. Her academic background is in education and English with an MA in English Language and Linguistics. I was appointed as the SESP coordinator and 'scientific literacies' practitioner for ISCM in 2010. At that stage I had a Masters degree in the plant ecological field and another in

Higher Education, had worked in student support and academic development at a number of tertiary institutions for over 15 years and was doing research in the educational rather than the science field. Although the overall multidisciplinary nature of the ISCM course was maintained with three interwoven strands, many subtle changes have been instigated, most of which have been aimed at shifting from essentially (although not entirely) a skills-based approach to a literacies-based approach to teaching and learning. The overall current ISCM structure is briefly outlined in the following section.

2.6.2 Current overall ISCM structure

ISCM is an integrated multidisciplinary course designed to develop students' understanding of scientific knowledge and concepts, and to introduce them to methods, practices, competencies and literacies needed to communicate and construct knowledge in the sciences. Currently four mainstream academic staff, one from each of Physics, Chemistry, the life sciences (Human Kinetics and Ergonomics) and the earth sciences (Geology) contribute to the course by lecturing and running practicals on mutually-agreed aspects of their particular discipline.

Two full-time ISCM lecturers (a 'scientific literacies' practitioner (myself), and a 'language-related literacies' practitioner) ensure continuity within and between disciplinary themes throughout the year and run numerous tutorial and enrichment sessions with the students. The tutorial sessions are used to augment the content provided by the disciplinary lecturers as well as integrate scientific and academic literacies and practices¹⁸ into the offerings of each component. The purpose of the enrichment sessions is to expose students to new and interesting science ideas and to broaden their frame of reference. Whereas some sessions are linked to the current content theme others can simply be topical ideas that encourage critical reflection on the relationship between science and society.

Assessment in the course is continuous and serves both a formative and summative function. There are minor weekly assignments (for the practicals, tutorials and enrichment sessions), both a larger assignment and a test each term, and two exams.

2.7 Overview

This chapter has briefly described political and other influences that have driven change in the higher education sector in South Africa over the last 40 or so years. Based on the notion of long-term, systemic disparity in the quality of schooling in South Africa a range of higher education academic development initiatives have been implemented to address these challenges. Nonetheless, inequity in student performance based on race has persisted and, as has been

¹⁸ The differences between practices and literacies knowledge, as used in this study, are outlined in Chapter 5.

intimated, I believe that this focus on school deficiencies does not sufficiently acknowledge the roles of the working-class background (both home and school and other social contexts) in student performance in the sector.

In an effort to address performance inequities the current government-funded ECPs, of which the RU SESP is one, are aimed at addressing these issues of participation, equity and redress. As such, this provides the contextual backdrop to the ISCM course within the RU SESP, which has as its primary aim the enabling of epistemological access to students who come from backgrounds that may not have prepared them well for success in a higher education institution. The following two chapters consider the conceptual and theoretical ideas respectively required to examine whether the course is meeting this aim.

Chapter 3: Conceptual framework

3.1 Introduction

As indicated already, this study examines the way educational practices (curriculum, pedagogy and assessment) in a science foundation course enable or constrain epistemological access. This chapter aims to explicate the conceptual aspects of epistemological access that frame the study and the following chapter unpacks the theoretical aspects of the educational practices in terms of how knowledge, knowledge practices and knowers are legitimated and framed, and the resultant social effects.

This chapter begins by examining the origin and development of the term 'epistemological access'. Because, in South Africa, the concept of epistemological access historically has been linked to academic literacies work, I draw on this literature, in particular Street's (1984) ideological model of literacies and Gee's (2005, 2012) theory of Discourse, for its interpretation. It is also argued that epistemological access is about taking on new identities, and in this regard work related to the ontological turn (Barnett 2000, 2004, 2007; Dall'Alba and Barnacle 2007) is also discussed. This conceptual work is particularly useful in contextualising how prior forms of socialisation and current forms of social practices can serve to exclude particular groups of students, which is a strong theme that runs throughout this dissertation. In this regard, this chapter therefore also briefly examines home and school contexts of Science Extended Studies Programme (SESP) students, as well as aspects of access to scientific Discourses.

3.2 Epistemological access: Origin and early development of the term

The concept of epistemological access is increasingly encountered in the South African higher education context in policy and planning documents. In the most recent CHE document on the second cycle of quality assurance in the higher education sector, one of the stated objectives is to 'support epistemological access and student success', and in relation to this it is added that the 'HEQC¹ will pay attention to institutions' approaches to helping students develop the range of academic literacies which enable them to be part of disciplinary and professional discourses' (CHE Report 2011, p15). This statement indicates that developing academic literacies and enabling access to discourses are both considered key to facilitating epistemological access. A similar argument of a close relationship between academic literacies and epistemological access is made in this chapter.

During political upheavals in South Africa in the 1980s the University of the Western Cape (UWC), in opposition to laws restricting access to certain race groups, opened its doors to all

¹ Higher Education Quality Committee

and students flooded in. Being confronted with huge class sizes not previously encountered, Wally Morrow, a professor of teacher education, gave pause to reflect on the concept of access to tertiary education, not only in the physical sense but also in the epistemological sense. The term 'epistemological access' was thus coined by him and first mentioned in a public forum in his 1992 address at the University of the North (published in Morrow 2007, chpt1²). He subsequently alludes to and explains the term a number of times in his writing. This and the following sections serve to unpack the term from Morrow's perspective as well as outline the development and use of the term in the broader education literature.

From the outset Morrow (2007) distinguished between formal access and epistemological access. Formal access relates specifically to physical access to an institution (ibid. p2). However, as reported in Chapter 2, despite large increases in university participation by all racial groups since 1994, success in terms of throughput and graduation rates has continued to favour certain racial groups, and whites in particular (Scott, Yeld and Hendry 2007; CHE Report 2013). Therefore, although physical access may have improved for those in previously excluded racial groups, it appears that epistemological access and success for many has remained elusive. As alluded to in Chapter 1, race can be used as a crude proxy for social class in South African society, which means that the majority of students still unable to succeed in higher education institutions are likely working class.

The term epistemology stems from the Greek word *episteme*, which means knowledge. In 1992 Morrow first speaks of epistemological access within an education institution as being a form of access to 'the goods that it distributes'. He explains that, since the main good distributed in higher education institutions is knowledge, this is a convenient and appropriate term to use (Morrow 2007, p39). In his footnote clarification of how knowledge should be understood, he rather vaguely comments on 'all kinds of knowledge', but gives explicit examples of procedural knowledge such as how to weld, care for the ill, solve a mathematics problem and conduct research (Morrow 2007, p9). Muller (2014) suggests that Morrow's focus on procedural rather than propositional or principled knowledge was likely linked to his primary concern, which was for teacher professionalism. However, in stating 'all kinds of knowledge' it would be fair to assume that this would include principled knowledge too.

In subsequent writing in 1993 Morrow expands on the concept when he states that epistemological access is learning 'how to become a participant in *an academic practice*' and that this requires learning 'the intrinsic disciplines and constitutive standards of the practice'

² Where chronology of Morrow's ideas is important dates have been incorporated into the text, but the citations are mainly from two texts *Learning to teach in South Africa* (2007) and *Bounds of democracy: Epistemological access in higher education* (2009), both of which are collections of his past writings.

(2009, p77; my italics). Morrow is unclear on the boundaries of this statement, but by referring to 'an academic practice' I assume he is referring to a discipline (or field), and this includes the disciplinary (or field) principled and procedural knowledge mentioned in the previous paragraph, and its constitutive practices. If this is the case he would thus be saying that disciplines (and fields) have particular ways of working and doing things and in order to be successful learners need to understand the underpinning logics and canons to become a participating member of a disciplinary (or field) community.

In outlining his conception of practice, Morrow states that 'practices are shared activities that constitute our human lives' (2007, p132). He further contends that practices are social ('invented'), they have histories, and judgment of excellence in the practice is based on the norms and standards of achievement for the practice. Based on this description Le Grange (2010) and Slonimsky (2010) posit he was referring to a 'normative' conception of practice, broadly corresponding to use of the term in philosophy by Kant, Heidegger and Wittgenstein, which contends that actors share a practice if their activities are underpinned by and answerable to norms of the practice (Rouse 2001, pp198–199). This is in contrast to the 'regularities' view of practice, based on the social theories of Durkheim, Weber, Oakeshott and Winch, which conceives practice as a range of activities and focuses on the commonalities in behaviours and activities of social groups (ibid. p198). The main distinction between the two is that the former is practice underpinned by normative, internal rules such as the 'epistemic values' (Morrow 2009, chpt3) of a field or discipline and the latter is practice simply based on common activities that have no warranting epistemic logic. This distinction shapes the conceptual model of epistemological access that is developed in the final chapter of this dissertation.

The fact that these academic practices can often be opaque is highlighted in a later argument, where Morrow makes the distinction between the explicit (official) curriculum and the hidden curriculum (Morrow 2009, chpt3). The former is that part of the curriculum that is formally stated in objectives or outcomes and can relate to content, practices and attitudes. However, he acknowledges that the curriculum has 'a tacit framework of meaning, a grammar seldom explicitly spelled out', which encompasses norms, values and beliefs of a particular field or discipline (Morrow 2009, p31). He suggests that these epistemic values and norms, which have gradually developed over time through constant adaptation and amendment, are much more enduring and resistant to change than the content-related explicit curriculum. He further suggests that students need to not only learn about, but also care about and *commit to*, these epistemic values (Morrow 2009, p11).

This idea of students caring and committing to epistemic values grants agency to students in terms of gaining access. In his 1994 paper on 'Entitlement and Achievement in Education' Morrow asserts that epistemological access cannot be supplied or done or transmitted to students (2009, p78). He suggests that the students have to not only recognise the requirements of the practice, but also actively participate in order to gain access to the practice. The following section of this chapter shows that literacy theorists too ascribe to this notion. He makes these comments in light of what he perceived at the time to be a breakdown in the culture of learning where students, with a strong sense of entitlement, are negatively disposed towards working to achieve. He argues that agency of the student is key but if the agent as novice participant is either ignorant of, or refuses to acknowledge, or rejects the requirements of the curriculum, then epistemological access and success is unlikely to be realised (ibid. p79). He also maintains that, if epistemological access is attained, full participation in an academic practice grants students the space and capacity to critique the practice and become fully emancipated.

It is understandable that many South African academic development practitioners, who have as their primary concern the success of a previously disenfranchised sector of the student body, have drawn on the concept of epistemological access to frame their work. However, since the founding logic of academic development work is pedagogic rather than epistemic, many have focused on procedural or 'know how' knowledge, which arguably has resulted in an unfortunate trend of much academic development work being reduced to a set of generic 'know how' skills (Muller 2014, p4) such as provision of decontextualised reading, writing, language and numeracy skills that are perceived to be important for enabling access and success at university (Boughey 2003).

A 'procedural' approach based on skills does not align well with Morrow's view on epistemological access. When he speaks of access to knowledge, participating in academic practices, understanding and uptake of norms and values, and exercising agency and developing a new identity, he is essentially describing a practice with a knowledge base and with a literacies approach that draws on a socio-cultural view of learning. I therefore now turn to the academic literacies literature to better unpack the concept of epistemological access.

3.3 Academic literacies

This section discusses aspects of academic literacies literature relevant to his study, paying particular attention to New Literacies Studies which draw on Street's (see 1995, 2006) ideological model of literacies and Gee's (see 1999, 2012) Discourse theory, as well as to issues of ontology and identity.

3.3.1 Models and perspectives of academic literacies practices

As intimated in the previous section, there are two competing understandings of epistemological access: either as the development of a set of skills or as the development of new identities (Boughey 2003, p70). This polarised view aligns with the two competing literacy models. The first is the autonomous model of literacy which views literacy as a technical and neutral skill and it follows that literacy 'events' too are neutral and universal (Street 2006). This view of literacy means that lack of appropriate acquisition can be attributed to deficiencies in the learners and that addressing these can be achieved in acontextual settings such as add-on and separate language proficiency and skills courses (Boughey 2003; McKenna 2010). The autonomous label is based on the understanding that literacy itself is viewed as having an effect (autonomously) on other cognitive and social practices, meaning that once literacy has been acquired it is assumed, for example, that cognitive skills (and economic prospects) will automatically be enhanced (Street 2006, p1).

Critique of the autonomous model gave rise to the later ideological model of literacy, which assumes literacy is neither a technical nor neutral skill but instead a set of multiple social practices that are embedded in socio-cultural contexts which have 'socially constructed epistemological principles' (Street 2006, p2). This social practices view of literacies means that meanings and practices can be contested. It is therefore ideological and the possibility of marginalisation of certain groups is strong (Gee 1990, Street 2006). Acquisition of literacies practices would thus require an understanding of the context in which the literacies have developed and the norms and values that underpin them.

This ideological model of literacy developed during the time when theorists in the humanities and social sciences were moving attention away from individual to social practices. This social turn gave rise to the broad field, based on many movements from different disciplines, referred to as New Literacy Studies (NLS; see Barton 1994; Street, 1984, 1995; Gee 1999, 2012) under which the ideological model falls. New Literacies Studies, which focuses on literacies in the everyday as well as in specialised contexts, recognises that 'meaning and context are mutually constitutive of each other' (Gee 1999, p8). In referring to more specialised, educational contexts, it is recognised that 'reading, writing and meaning are always situated within specific social practices within specific discourses (Discourses)' (Gee 1999, pp7-8). Gee's ideas on d/Discourses have influenced the development of NLS and being relevant to this study are explained in the following section. However, before moving on it is useful to indicate a distinction of underpinning values.

Lea and Street (2006) talk of three perspectives related to writing and literacy practices: 'study skills' (individual cognitive activity and transfer of atomised skills), 'academic socialisation'

(induction into a new homogeneous, uncontested 'culture'), and 'academic literacies' (literacies as social practices concerned with making meaning, identities, power and authority; pp368–369). They maintain that the academic literacies model is very similar to that of the socialisation model except that the latter 'views the processes involved in acquiring appropriate and effective uses of literacy as more complex, dynamic, nuanced, situated, and involving both epistemological issues and social processes, including power relations among people, institutions, and social identities' (ibid. p369).

Whilst the study skills perspective currently dominates in higher education and is usually set in opposition to the academic socialisation and academic literacies perspectives, Lea and Street (2006) maintain that the three perspectives exist in a hierarchical relationship, whereby academic socialisation takes into account study skills, and academic literacies encapsulates both the socialisation and the study skills approaches. It is worth noting that the skills (although I refer to them as 'academic practices' in this study; see Chapter 5) and socialisation aspects of literacies are most visible in ISCM curriculum and pedagogy in this study.

3.3.2 Access to Discourses

Returning to d/Discourses, Gee distinguishes between discourse (small d) having a narrow meaning of 'language-in-use or stretches of language' (2005, p26) and Discourse (capital D) being associated more broadly with 'ways of being in the world' (ibid. p7), which in his earlier work he refers to as ways of 'thinking, feeling, believing, valuing, and acting' (1990, p143). In his later work he provides a more full definition of Discourse as:

. . . a socially accepted association among ways of using language and other symbolic expressions, of thinking, feeling, believing, valuing and acting, as well as using various tools, technologies, or props that can be used to identify oneself as a member of a socially meaningful group or 'social network', to signal (that one is playing) a socially meaningful 'role', or to signal that one is filling a social niche in a distinctively recognizable fashion (Gee 2012, p158).

Language (and therefore discourse) is an integral part of Discourse, but other 'non-language' aspects make up a particular Discourse for a particular context (Gee 2005, p7). To be a full participating member of a Discourse requires one to not only speak and read and write but also act and be and value and use tools and symbols in similar ways to other members of the Discourse. From Gee's definition the 'boundary' of Discourse is not entirely clear and in higher education it could be interpreted as Discourse of disciplines or, more broadly, as Discourse of academic or learning context. Both interpretations are used in this study.

Gee maintains we have one primary Discourse, which is developed through our home socialisation. We draw on this primary Discourse to make sense of the world and to take up secondary Discourses such as those of school, church, social groups, university, etc. (Gee 2012). Academic Discourses are therefore secondary Discourses, and Gee contends that early socialisation at home with practices that resonate with later school or academic Discourses can make acquisition of such secondary Discourses easier. He further suggests that this is not necessarily achieved through gaining skills, but rather through acquiring 'values, attitudes, motivations, ways of interacting and perspectives' (Gee 2012, p155). Empirical studies seem to support the notion of early socialisation practices (Boughey 2002, 2008) and prior educational experiences (Chen 2010; Niven 2011) significantly enabling or constraining access to and uptake of tertiary academic Discourses.

Gee defines literacy as 'mastery of a secondary Discourse' (2012, p173). Since there are many Discourses, there are always multiple literacies. The question arises, how then do we attain such mastery? In this regard Gee (2012) distinguishes between acquisition and learning. Acquisition is a process of acquiring something and we achieve this through a process of enculturation within a particular social setting – by being exposed to behaviours, models, and language appropriate to the context. Learning is instead a process involving conscious gaining of knowledge and can be taught through the breaking down of things to be learned into component parts, providing 'meta-knowledge' on the context (ibid. p167). Although Gee is adamant that you cannot overtly teach someone a Discourse (for example you cannot overtly teach someone to 'be a scientist'), he acknowledges that both tacit acquisition and to a lesser extent explicit teaching (and therefore learning) are both aspects of Discourse uptake, but that explicit teaching should be preceded by implicit acquisition (ibid. p168). He also suggests that critique of a Discourse can be enabled through teaching. This distinction between acquisition and learning is useful in this study as it helps explain difficulties students encounter in taking up norms and values not previously encountered.

Using overt approaches (such as explicit instruction) as a means of enabling acquisition of a Discourse are increasingly mentioned in the literature (Ballard and Clanchy 1988; Boughey 2002, 2005; Marshall and Case 2010). Boughey argues that in order to acquire a Discourse and thus enable epistemological access we need to focus on 'making the rules and conventions of academic ways of thinking, valuing, acting, speaking, reading and writing overt to students' (2002, p306). In higher education, disciplinary lecturers are the inside experts and Gee would see it as their role to induct or socialise students into the disciplinary Discourses. However, since much of the knowledge of the Discourse (ways of valuing, believing, acting) is in fact tacit and very difficult for insiders to articulate, studies have shown that collaborative work between

academic literacies experts from outside the discipline with disciplinary experts is an effective means of making the rules of the game overt (Jacobs 2007; Allie et al. 2009; Chanock, Horton, Reedman and Stephenson 2012). In this study, the four mainstream lecturers who both lecture and run practicals throughout the year in ISCM are considered the disciplinary 'experts' and the 'scientific literacies' lecturer (myself) and especially the 'language literacies' lecturer (my colleague who is not a scientist) are playing 'interpreting' and mediating roles in this regard. Since ISCM is a general science course, I discuss the 'rules of the game' for science in section 3.5. Before I do that, however, I wish to come to a logical end-point on my discussion of access to Discourses by talking about taking on new identities.

Since acquiring academic literacies is about taking on norms, values and practices of academic Discourses, where one is required to not only know, but also to act and behave in ways that are appropriate for the context, it is also about taking on new identities (McKenna 2004). The idea of identity development, and ontological becoming and being, is therefore an integral part of academic literacies work, and as a result also of epistemological access work, and is discussed in the following section.

3.3.3 Ontology and identity

In a review of conceptions of identity in literacies studies, Moje and Luke (2009) use five metaphors to conceptualise identity: (1) difference, (2) sense of self/subjectivity, (3) mind or consciousness, (4) narrative, and (5) position. This study draws primarily on the identity-as-difference metaphor, which focuses on 'how people are distinguished one from another by virtue of their group membership and on how ways of knowing, doing, or believing held or practiced by a group shape the individual as a member of that group' (ibid. pp419–420). This concurs with Gee's statement that developing an identity amounts to becoming 'a certain 'kind of person' in a given context' (Gee 2001, p99).

In the ISCM course we are expecting students to become and be scientists and science learners in an academic context. To become scientists, they not only need to acquire the requisite scientific knowledge, literacies and practices, but also need, amongst many other things, to be honest, critical, objective, precise, and accurate, as well as value empirical evidence, observe carefully, and reason deductively and inductively. These are not merely intellectual or epistemological pursuits, but rather reflect ontological aspects of developing an embodied way of being. By the same token we also require students to become science learners, for which they need to be, amongst other things, independent, autonomous, self-regulated, self-reflective and critical.

In recent years there have been calls for an ontological turn in our thinking of student learning in higher education (Barnett 2000, 2004, 2007; Dall'Alba and Barnacle 2007). Dall'Alba and Barnacle state that 'learning is not confined to the heads of individuals, but involves integrating ways of knowing, acting and being within a broad range of practices' (2007, p683). They further contend that because knowing is always situated in a social context it 'transforms from the merely intellectual to something inhabited and enacted: a way of thinking, making and acting. Indeed, a way of being' (ibid. p682).

The linking of 'knowing' and 'being' in the above quotations indicates a close relationship between epistemology and ontology that is increasingly being recognised in empirical (Ellery 2011) and other studies on learning (Barnett 2007, 2009; Blackie, Case and Jawitz 2010; McKenna 2012). Barnett (2009) draws on the human attributes of dispositions and qualities to develop the idea of a reciprocal relationship between knowing as 'an individual's hold on the world' (ibid. p432) and being as 'what it is to be in the world' (Barnett 2007, p3). Dispositions are 'those tendencies of human beings to engage in some way with the world around them' and include a will to learn and engage, a preparedness to listen, explore and hold oneself out to new experiences, and a determination to keep going forward (Barnett 2009, p433). In contrast, qualities are the 'manifestations of dispositions in the world' and form part of an individual's character (ibid. p433). He states that qualities such as courage, resilience, carefulness, integrity, self-discipline, restraint, respect for others, openness, generosity, and authenticity can be engendered through one's efforts to know the world (ibid. 434). The earlier mention of science students in ISCM needing to be, for example, honest, critical, objective, precise, and accurate would equate to Barnett's notion of qualities. It is timeous to note that, since I am using Legitimation Code Theory (LCT) as the main theory framing this study, Barnett's dispositions and qualities appear to be encapsulated into what LCT refers to as knower dispositions. For example, Barnett's quality of 'self-discipline' would simply be referred to as a knower disposition of 'being self-disciplined'. Knower dispositions are discussed more fully later in Chapter 4.

Barnett remarks on how little insight we have on this 'extraordinary and intimate' relationship between knowing and being and becoming (2009, p435) or, said slightly differently, between epistemology and ontology. Although we can directly assess student knowing, and perhaps even tacitly student being (Barnett 2007, p110), this gives us little insight into processes of coming to know and coming to be that occur in the spaces between the two. These processes can only be made partially visible by close engagement with students. Although not the main focus of the study, the student interviews on their responses to educational practices provide some insight in this regard.

Mastery of literacy practices and therefore of accessing Discourses is about developing new identities. Because the norms and values underpinning these practices are seldom made overt, this identity work is not easy. In this regard McKenna (2012, p59) states that:

. . . students find it hard to take on new ways of being as the expectations seem to be mysterious and, being largely unspoken, they seem to be beyond critique. Students, particularly the students in extended curriculum programmes, often feel alienated by the institutional culture and literacy practices of the academy. They feel as if the ways of being expected of them are uncertain (McKenna, 2004) and may come at the cost of their existing identities (De Kadt & Mathonsi, 2003).

Pym and Kapp too acknowledge the ambivalence, conflict and emotion work involved in taking on a new identity that requires 'considerable symbolic resources' and they argue that we need to 'foster students' investment in their learning and sense of belonging within the institution' (2011, p3). We thus need to support identity change work, and recognise the extent of difficulty for those from background contexts that differ from the university context. Just how different the background and university contexts can be for SESP students is briefly outlined in the following section.

3.4 Home and school contexts

It was stated above that early socialisation and prior educational experiences can significantly enable or constrain access to and uptake of tertiary academic Discourses. The effects of apartheid mean that the majority of Africans continue to be structured into working-class positions and, because of poverty, geography and numerous other structural factors, are denied engagement with many of the things would which have prepared them for higher education. It is worthwhile at this stage to briefly consider the literacy and numeracy and other practices of school and home contexts from which the majority of SESP students come. Although what follows is only a brief, selective and generalised 'snapshot' in this regard, it provides some context for understanding the extent of change required of SESP students, and likely many other African students, if they are to gain epistemological access to the university system.

As mentioned previously, the New Literacy Studies perspective recognises that literacy practices are about constructing knowledge, values, attitudes and beliefs through language and other symbolic expressions, and cannot be regarded as objective or ideologically neutral. The literacy and numeracy practices that students bring to university are to some extent a product of social and cultural interactions in the home environment and form part of their primary Discourse. Since SESP students are working-class, first-generation learners their home literacy practices will be very different from those of middle-class, second-or-more generation learners. As such, many literacy theorists prefer to speak of 'different' literacy practices rather than

'deficient' practices (Heath 1983; Ballard and Clanchy 1988; Boughey 2000; Bradbury and Miller 2011).

Drawing on South African work in this regard Dison (1997) and Niven (2005) provide illuminating accounts of home reading practices of foundation students at Rhodes University, whose backgrounds were very similar to those in the SESP. Their research indicates print-impooverished homes (except most had a Bible); little recreational reading and, if any, it was usually communal; an environment unconducive for quiet reading; and a propensity for oral stories, usually with the purpose of developing moral behaviour. In her description of the early school environment, Niven (*ibid.*) states that reading is mainly associated with repetition and memorisation and tends to be a communal activity where meaning is developed orally with teacher assistance.

In a study conducted at the University of Zululand in South Africa, Boughey (2000) provides close-up insights into school writing practices of first-year philosophy students from similar socio-economic circumstances to SESP students. Boughey indicates that students view writing as an act of repeating correct knowledge, to write as if speaking, and as a result do not contextualise or make explicit links, and assume 'common' knowledge does not need to be justified (*ibid.* p287). Both Niven (2005) and Boughey (*ibid.*) indicate that, whilst these literacy practices were and are relevant for students' particular home and school contexts, difficulties encountered in reading and writing at university stem mainly from unfamiliarity with norms and values of the new context.

In this regard, a number of authors make the distinction between 'content' and 'form' of academic knowledge, and suggest that students from poor educational backgrounds in the South African context have particular problems with form of knowledge (Craig 2001; Slonimsky and Shalem 2004; Bradbury and Miller 2011). As such, Slonimsky and Shalem suggest there are regularities in the way students respond to forms of knowledge in academic texts and writing, and point towards a tendency to reproduce verbatim or plagiarise in essays, present illogical arguments and claims, describe rather than analyse, focus on examples (tokens) rather than on principles (types), write from a highly subjective viewpoint without depersonalizing, use apparently unrelated anecdotes, and are prescriptive or normative when asked to be analytical (2004, p86). Other close-up studies have highlighted school-developed literacy practices such as superficial engagement with texts and knowledge, shallow conceptual development, over-reliance on procedural rather than declarative knowledge (CHE Report 2013, p61), and underdeveloped capacity to read independently (Mgqwashu 2012, p240).

In terms of school-based numeracy and mathematical practices in South Africa that are different from those at university, mention is made of practices that encourage rote performance of

measurements and algebraic manipulations (Rollnick, Lubben, Lotz and Dlamini 2002; Engelbrecht, Harding and Phiri 2010), that do little to develop understanding of verbal descriptions of quantitative concepts, and that seldom use mathematical techniques to solve a problem (Frith and Gunstone 2011, p21).

This section has very briefly shown that SESP learners likely enter university with a range of literacy, numeracy and other practices that are very different from the open-minded, analytical, creative, and critical approaches required when working with the high levels of conceptual knowledge in the sciences in higher education³. The larger the 'gap' between the primary (home) and secondary (school) Discourses and the new secondary (university) Discourse, the more difficult the uptake (Gee 2012).

3.5 Access to scientific Discourses

ISCM is a science course and it is useful to briefly indicate what is meant by science and the resultant effect this may have on course structure, curriculum, and pedagogy, as well as on student learning.

Science in this dissertation is about study of the natural world. Scientists assume that universal 'principles' and 'laws' govern the way in which the natural world works, and through comprehensive and systematic study we can come to understand this world. For example, the principle of motion is used to explain the motion of sub-atomic particles in nuclear physics as well as the motion of craft in outer space. Scientific theories usually represent the best explanation based on current knowledge, but these theories may change and develop over time as new knowledge comes to light. This is particularly true currently in the biological field, where exciting molecular technologies are either confirming previous theories, or allowing us to refine them based on new information, or even allowing us to explore previously 'unthinkable' ideas such as mapping the human genome. Although most scientists acknowledge it is not possible to come to absolute truths, we are developing increasingly accurate approximations that account for how the world works. Therefore, although we have some confidence in our scientific understanding and predications, we also are always tentative as we acknowledge our understanding can change.

Even though science is made up of disciplines, they all share a fundamental reliance on and valuing of evidence, use of hypotheses and theories, and use of certain kinds of logics. Empirical evidence can be obtained through careful observation and measurement, or through

³ Bernstein (2000), whose work I draw on extensively in the theoretical framework in the following chapter, suggests that home and school socialisation of many working class learners results in a 'restricted code' in which meaning remains largely rooted in context. Higher education works with an 'elaborated code' in which meanings are elaborated, abstract and largely context independent.

experimentation where conditions are controlled to verify a predicted outcome based on theories and/or hypotheses. Inductive logic is common in science, where a 'pattern' is observed and a possible explanation (hypothesis) is proposed. However, validation through deductive inference is the logical next step and is highly valued in science. For example, scientists have long used inductive logic to hypothesise that the 'pattern' of extensive soil erosion in South Africa is due to poor land-management practices. Recent work, however, using a deductive approach to test this theory, indicates that a current 'dry' cycle in long-term weather patterns is the most likely cause. Other values that underpin science are accuracy, precision, testability, reliability, generality, heuristic power, predictability and simplicity of concepts.

One of the common misconceptions is that science is about neutral and known 'facts' relating to the natural world, and that we come to know these facts through disinterested, objective inquiry, which means a priori personal biases, values or emotions do not form part of the inquiry (McComas 2002). It is possible to conceive that, by being truly objective and working in ways that support these values, a person's race, class, identity, or religion should not influence the validity of conclusions. However, this idea of absolute objectivity is problematic. Although scientists may advocate for unqualified objectivity, increased rigour and 'organised scepticism' (Merton 1973 [1942]; May 2011), it can be argued that, since science is essentially a social enterprise, it will always be influenced by social values. There are many well-known instances of how cultural beliefs and values of scientists have profoundly influenced their findings. In a contemporary example, research on possible harmful effects of genetically-modified organisms (GMOs) on health and environment indicate little agreement in findings between opposing pro- and anti-factions of scientists, despite having access to identical data.

The question is, how does the 'nature of science' as outlined above relate to learning and epistemological access? If one holds a value-free, fact-bound view of science, teaching is likely also viewed as a neutral conveyance of these 'facts'. This can conceivably be achieved through direct transmission of decontextualised, disembodied knowledge from teacher to learner. Whilst this is a legitimate view of learning, the primary focus is on knowledge and not on the learner or learning processes. Teachers or lecturers therefore put considerable effort into *what* is taught, but not necessarily on *how* or *why*. Content-laden, overloaded science curricula are common in university contexts despite there being much evidence to suggest that they are inadequate in promoting student learning (see Brown and Glasner 1999; Ramsden 2003; Case 2013).

However, if one holds the view, as I do in this study, that science is inherently social in nature with underpinning values, and that learning is a social process, then curricula and pedagogic practices need to take this into account. This requires consideration of how learning is not only

about acquiring science knowledge, but it is also about acquiring ways of thinking, valuing and being – in other words it is about taking on new and different scientific identities in scientific Discourses. The argument in this dissertation is that, in so doing, a learner would be gaining epistemological access.

One underlying notion needing problematising in this dissertation is that a generalised science course can promote access to a range of science disciplines. This is based on the assumption that science and science disciplines all share a hierarchical knowledge structure (as outlined in the following chapter) and ‘common attitudes, common standards and patterns of behaviour, common approaches and assumptions’ (Snow 1959, p9). For example, both the chemist and the botanist would recognise the strength of a scientific argument based on empirical data collected through an experimental procedure and, although there would be some subtle disciplinary differences, would even convey these in a relatively standard format (such as in a scientific report) using relatively common forms of expression (such as direct, accurate impersonal, and objective expression). Whilst teaching in ISCM is always located within a particular discipline (such as chemistry or earth sciences) the focus is on underpinning science values. The appropriateness of this approach, which assumes transfer of generalised values and concepts from one context to another, is addressed in the final research question, which asks whether a general science course such as ISCM can in fact enable access to a range of science disciplines.

3.6 Conclusion

Attaining epistemological access to any educational field (or Discourse), including science, is about acquisition of knowledge *and* becoming a participant in practices that encompass particular ways of doing, thinking, valuing and being. It has been outlined in this chapter that attaining such access is a profoundly ideological act underpinned by complex socio-cultural, epistemological and ontological issues.

The concepts outlined in this chapter are rooted in and inform this study, but are not the main theoretical or analytical frame that is being used. Since I argue in that the ‘academic practice’ that Morrow speaks of is in fact a knowledge practice with a knowledge base, I have made knowledge and knowledge practices the theoretical object of study to frame understanding student access in this study. This is the topic of the following chapter.

Chapter 4: Theoretical framework

4.1 Introduction

In order to understand how ISCM educational practices can serve to include or exclude I wanted to develop depth understanding of the issue. This required drawing on theoretical ideas that would enable a layered interpretation that took into account not only student experiences but also the structural and social aspects of the educational practices that give rise to these experiences. This study therefore draws on critical and social realist frameworks that enable study of practices at different ontological depths.

This chapter firstly describes, amongst other things, the layered ontology of critical and social realism, which creates space for unpacking possible generative mechanisms that underpin ISCM educational practices, and student responses to these practices. Secondly, since one of the main underpinning structural aspects of educational practices is knowledge itself, the chapter speaks to why it is important to make knowledge an object of study. This leads to the third component of the chapter, which is concerned with substantive social realist theories of knowledge.

Legitimation Code Theory (LCT) is an explanatory framework that enables characterisation of knowledge and knowledge practices, elucidation of organising principles of the practices, and examination of their effects (Maton 2014a, p3). As a theory it builds partly on the work of Bourdieu, whose 'social field' approach examines 'relations to' knowledge, and principally upon the work of Bernstein, who focuses on 'relations within' knowledge by using codes to theorise the underlying structuring principles (Maton 2010, p41). In this regard this study, which focuses on examining legitimation of knowledge, knowledge practices and knowers in the ISCM course, and student response to these practices, draws on four main areas of Bernstein's work: the structure of knowledge, key concepts of classification and framing and their link to codes, acquisition of recognition and realisation rules for a particular coding orientation, and the (epistemic)-pedagogic device. The aspects of LCT that take Bernstein's work further and are used in this study are the two legitimation code dimensions of Specialisation (what specialises the practices) and Semantics (how meaning relates to context and empirical referents). The concepts of epistemological and axiological charging of educational practices also help frame the study.

4.2 Critical realism as an underlabourer

Research is about constructing new knowledge. In so doing, we are making claims to the 'truth' based on our understanding of reality (ontology) as well as of how we gain knowledge of what

exists (epistemology). Our ontological and epistemological assumptions will have a direct effect on how research is conducted and the claims we can make as a result.

Prior to this doctoral study I never gave much consideration to epistemology or ontology, nor did I really understand the words themselves. In my scientific research, which was mainly on plant-environment interactions, I used an inductive approach to seek patterns of both plants and environmental factors in nature and, based on correlations of patterns, proposed causal links between the two (see Ellery, Ellery, Rogers and Walker 1991). This was grounded in an empiricist view that there was an objective reality (of plant distribution being caused by environmental factors), based on regularities (patterns of plant growth), and that my knowledge of this reality was limited by what I experienced (observed or measured). In summary, I was drawing on what Maxwell (2012) would call an empiricist approach that has a realist ontology and an objectivist epistemology based on what could be objectively experienced.

In contrast, in my earlier educational research I generally used an approach that Maxwell (2012) would describe as an interpretivist approach, which has a relativist ontology and subjectivist (socially constructed) epistemology. In this view, because there is no objective reality, there are multiple realities depending upon the perspective, situation or context, and we can only come to understand the contextual reality through social dialogue. Therefore, when trying to understand the influence of assessment feedback on student learning using mainly interviews and text analysis, I was developing a dialogue with students to generate meaning and understanding of a particular context. Issues that emerged from the research were as follows: the importance of timing of feedback (for influencing whether students engage); the use-value of verbal (for dialogue), written (for persistence) and global (for better emphasis) feedback; and the value of formative stages with no grades attached (for better engagement; Ellery 2008a). The subjective experience of the students was therefore the 'reality' in this research and as a result generalisation was not appropriate beyond the context, although I did in fact make generalised claims in this research.

This interpretivist approach to social research left me vaguely uncomfortable, but I was unable to articulate why at the time. In later research, when trying to understand undergraduate plagiarism in an essay assignment, again using mainly interviews and text analysis, issues related to writing-as-process, knowledge-as-constructed and the establishment of authorial voice emerged as a means of understanding student (plagiarism) actions (Ellery 2008b). This indicates I was attempting to move beyond student experiences as the basis for reality through surfacing underpinning discourses or causal mechanisms, but did not articulate it as such and still referred to it as interpretivist research. It was only when I was recently introduced to

critical realism, with its depth and realist ontology and constructivist epistemology, that I realised that my discomfort lay in the flat ontology I was using in my earlier educational research to interpret data; my findings in the 'feedback' study had been based purely on student perceptions. It is therefore with quite a sense of relief that I have finally found a 'philosophical' home for my educational research, which today is framed by critical realism.

This study therefore draws on critical realism, which is a philosophical 'underlabourer' (Bhaskar 2008 [1975]) that provides a framework for a range of substantive social theories (Sayer 2000). Critical realism has a realist ontology, which recognises that a real world exists independent of our beliefs and constructions of the world (Danermark, Ekström, Jakobsen and Karlsson 2002). Bhaskar (ibid.) refers to this as the intransitive dimension and contrasts it with the transitive dimension, which relates to our socially-determined notions of reality, or our epistemology. Critical realism therefore has a constructivist epistemology, which recognises that our knowledge of this world is based on our own constructions and we can never produce a completely objective account (Danermark et al. 2002). By making a clear distinction between ontology and epistemology, the 'what is' questions do not get reduced to the 'how do we know what is' questions, and we circumvent the 'epistemic fallacy' (Bhaskar ibid.) that is common to much education research – and as indicated in my research on assessment feedback mentioned in the previous paragraphs. In order to avoid this conflation between what we observe empirically (in other words our own experiences) in the world and the external reality that exists, Bhaskar (ibid.) argues for a stratified and differentiated reality. In this regard critical realism offers a world which has three ontological strata: the real, the actual and the empirical.

The real is what exists in the world regardless of our knowledge of it. The domain of the real includes objects, their structures, and their powers and mechanisms (Sayer 2000, p11). If objects or structures, such as an institutional structure, a language, knowledge, a discourse, and values have causal effects, they are located in the domain of the real. These structures and mechanisms are always present, whether or not they are observed or activated. When activated they give rise to events in the domain of the actual, which is the second stratum of reality. Our experience and observations of these events is the third stratum of reality: the empirical. The empirical is often the starting point from which we can understand the other strata.

The three strata of reality can be usefully represented in a 'nested' arrangement which indicates the empirical domain (what we observe or experience) being embedded in the actual domain (events that take place regardless of whether we observe or experience them), both of which are influenced by the real domain (which are the underpinning structures and causal mechanisms; Figure 4.1). The concept of emergence is important here as properties and mechanisms in one stratum emerge from those underpinning them (Danermark et al. 2002). In

the above example of student plagiarism, the essay-writing task was an event at the level of the actual, and students' understandings of the task (in relation to plagiarism) were at the level of the empirical. In this regard the interviews revealed particular student understandings on the concept of plagiarism despite explicit instruction. For example they perceived the following: changing a few words was acceptable; only needing to acknowledge a source if it was a direct quotation; not knowing the need to reference off the internet; lecturers wanting 'facts', which meant it could not be in students' own words. In an attempt to unpack their 'misconceptions' on plagiarism, poor engagement with the discourses of writing-as-process and knowledge-as-constructed were suggested as underpinning influences (which operate at the level of the real). In a more careful and thorough analysis it is likely many other structures and generative mechanisms, such as, for example, students' home and educational backgrounds or perhaps lecturers' stance towards plagiarism, may have been surfaced in the study.

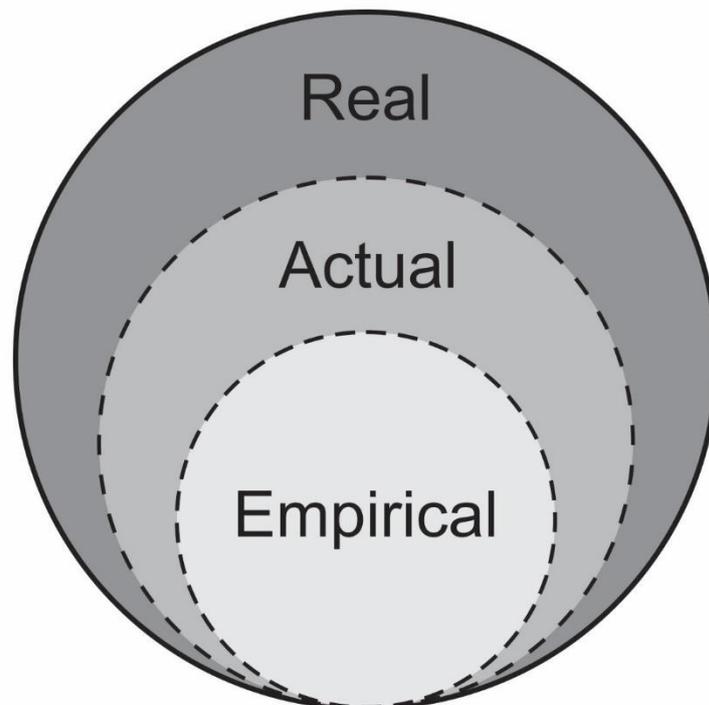


Figure 4.1: Relationship between the three ontological strata in critical realism

Causality is an important concept in critical realism. Although Bhaskar (2008 [1975]) referred to effects being tendential rather than causal, the term causal mechanism is commonly used in a critical realist context. In a closed system, such as in a controlled experiment, if a regular pattern or succession of events is observed it is possible to propose cause and effect relations with some degree of certainty. However, very few closed systems exist, even in nature. Social systems are open and Sayer thus warns against proposing causation based on regularities, but instead

suggests looking for ‘candidates for causal mechanisms’ (2000, p14). He further indicates firstly that a particular causal mechanism may result in different outcomes depending on context, and secondly that seldom is there a single mechanism resulting in a particular outcome. Furthermore, the fact that our knowledge of these underpinning mechanisms is socially constructed means that our knowledge will always be fallible (Sayer 2000). This paints a multifaceted picture of a complex set of interactions of mechanisms that characterise social systems.

Maxwell (2004, p254) claims that developing causal (tendential) explanations in the social sciences is hard work and requires intensive, long-term involvement, gathering rich data and identifying connections between events and processes. Bhaskar suggests that choosing between claims requires drawing on rational criteria for such choices, which he refers to as ‘judgmental rationality’ (2008, pxix). My knowledge of ISCM and position as lecturer and coordinator over a period of a number of years has contributed towards being able to make rational judgments for developing such causal (tendential) explanations. In this regard Maxwell (2004) suggests that it is necessary to develop plausible alternatives to maintain causal validity, and Sayer (2000) emphasises acknowledgement of fallibility, both of which this study attempts to do.

A final comment on critical realism is relevant here. Danermark et al. (2002, pp200–201) state that the ‘critical’ aspect of critical realism is a critique of various aspects of social science research such as ‘flat’ empiricism, conflation of structure and agency, and universalist claims to truth. They take this further, as do other authors (Bhaskar 1998; Sayer 2000; Fairclough, 2005; Boughey 2012), and suggest that, in the same vein as other critical research, the focus on depth understanding should promote an emancipatory critique for social justice and equality. These authors argue that understanding developed through identifying likely causal structures and mechanisms may make it possible to bring about appropriate transformational social change – either through enabling actions or absencing causal factors constraining actions (Bhaskar 1998). This study considers necessary transformational changes to better enable access for students, specifically in a science foundation course as well as in science higher education more generally.

In order to locate the work in this study in the critical realist frame, student and staff experiences operate at the level of the empirical. Curriculum, pedagogic practices and assessment practices are mostly events that function at the level of the actual. Knowledge, knowledge structures, discourses, codes, rules or logics of codes, all of which will be described in more detail later in this chapter, operate at the level of the real and act as mechanisms influencing events and experiences at the level of the actual and the real.

4.3 Social realism and a focus on knowledge

In order to answer the central question on how educational practices, which are underpinned by knowledge and knowledge practices, influence epistemological access, I now turn my attention to knowledge. This section briefly outlines the calls for a stronger focus on knowledge as an object of study in educational research, and subsequent sections outline theoretical and analytical concepts that are used in this study to analyse ISCM knowledge and knowledge practices.

The question is, why look particularly at knowledge? Teaching in the academic development field in the sciences has been influenced primarily by two opposing understandings of meaning-making based on the differing views towards reality of knowledge as outlined in the previous section and mentioned in the previous chapter in section 3.5 on scientific Discourses. The empiricist approach, with its realist ontology and objectivist epistemology, views knowledge as being objective, de-contextualised and certain. Knowledge therefore tends to be seen as an authoritative view on the world, rather than a system of knowledge about the world (Maton 2014a, p5). As mentioned, this view is very common in science disciplinary courses. The interpretivist approach with its relativist ontology and (social) constructivist epistemology, associated more commonly with academic development practices that have a stronger concern for learning processes, views knowledge as being individually (or socially) constructed in particular contexts and is thus only visible in relation to an individual's cognition (or socially in a community of practice). In this view, knowledge is reduced to *knowing*. In both of these stances the intrinsic properties and powers of knowledge itself are ignored (Muller 2000, p57), which precludes any consideration of 'knowledge as a category in its own right' (Young 2008a, p19). This creates, as Maton terms it, a 'knowledge-blindness' (2014a, p7).

In the previous section it was indicated that critical realism, with its ontological realism and epistemological relativism, lies between the two extremes of empiricism and (social) constructivism along the continuum of what can be considered 'real'. Social realism, a practical explanatory social theory that is based on the same philosophical underpinnings as critical realism, can be seen as the 'sociological and methodological complement' of Bhaskar's critical realism (Olvitt 2012, p37). Social realism is a practical explanatory social theory that has as its focus social phenomena (Archer 1998), and in the educational field it calls particularly for a focus on knowledge as an object of study. To quote Maton and Moore (2010, p10; original italics):

Knowledge is the very basis of education as a social field of practice; it is the production, recontextualisation, teaching and learning of *knowledge* that makes education a distinct field . . . social realism puts *knowledge as an object* centre-stage in thinking about education.

Social realism offers a new way of looking at knowledge that overcomes the knowledge-blindness mentioned earlier. It recognises the *social* nature of knowledge production but also allows for knowledge to have an *objective reality* and thus cannot be completely reduced to the social. Knowledge viewed in this way allows it to be an object of study that has structure, emergent properties, tendencies and powers of its own, all of which can have consequences for learning (Archer 1998).

A call for a stronger focus on knowledge in the curriculum has been made by a number of social realist scholars both in the South African and the broader context (see Muller 2000, 2014; Moore 2000; Maton 2000, 2014a; Moore and Maton 2001; Young 2008a; Wheelahan 2010). One underlying premise for these calls is that not all knowledge is equal. For example theoretical knowledge, which is produced and acquired differently and has a different basis for validity compared with everyday knowledge, is a more socially-powerful knowledge. The social power of theoretical knowledge, which relates to the intellectual power it gives to those who have it (Young 2008b, p14), lies in its abstract nature which allows us to think beyond current context and personal experience to think the 'unthinkable' and the 'yet to be thought' (Bernstein 2000, p30). It also allows us to make connections between seemingly unrelated events or objects and to predict the future (Young 2008a, pp41–42).

Theoretical knowledge is thus important as it provides access to 'society's conversation about itself' (Wheelahan 2010, p2), and students of higher education should certainly be contributing to and ultimately driving these conversations. Wheelahan argues that in order to do this students need to develop 'disciplinary styles of reasoning' on how knowledge is used and on what basis arguments are made (ibid. p2). For example, to be able to properly assess and critique scientific arguments on global warming, an understanding of the scientific method and the basis on which claims can be made would be essential in order to contribute meaningfully to the debate. The fact that we live in an increasingly complex and uncertain world strengthens these calls for theoretical knowledge.

From the above arguments it is clear that access to powerful theoretical knowledge is a matter of distributional social justice (Wheelahan 2010). Only through attaining such access will the educationally disenfranchised be able to join society's conversations and also have the capacity to disrupt existing power relations (ibid. p145). 'Knowledge' scholars thus propose that theoretical knowledge should be central to all higher education qualifications and courses (Wheelahan 2010; Shay, Oosthuizen, Paxton and van der Merwe 2011; Muller and Young 2014). In this regard they would argue that foundation courses, which traditionally do not necessarily have strong allegiance to any particular discipline, should pay particular attention to theoretical knowledge if their primary purpose is inclusion and epistemological access.

Based on the above arguments scholars have critiqued policies in which theoretical knowledge has been removed in some vocational education curricula (Young 2006; Wheelahan 2010) and academic development curricula, or subordinated to outcomes in outcomes-based education curricula (Muller 2000). However, theoretical knowledge is not the only form of knowledge in curricula and it is the vocational theorists, who consider both theoretical and practical knowledge and the interrelatedness between the two in a curriculum, that have been theorising knowledge differentiation. The next section briefly outlines aspects of knowledge differentiation that have formed a useful frame to examine knowledge and knowledge practices in this study.

4.3.1 Knowledge differentiation

Gamble (2006), in an article on theory and practice in the vocational curriculum, develops a conceptual dichotomous model on different forms of knowledge. The first distinction is based on knowledge having two fundamentally different kinds of meaning: that which is linked to a specific context and that which is not. She refers to these as context-dependent (or particular or practical) and context-independent (or general or theoretical) knowledge (Table 4.1). These have variously and respectively been referred to as, amongst other categories, profane and sacred knowledge (Durkheim 1959 [1912]), concrete and abstract knowledge (Vygotsky 1962), and mundane and esoteric knowledge (Bernstein 2000).

Table 4.1: A conceptual model of forms of knowledge (adapted from Gamble 2006, p92)

	First level of distinction	Second level of distinction
Forms of knowledge	General/theoretical (context-independent)	Principled (conceptual*)
		Procedural (proceduralised conceptual*)
	Particular/practical (context-dependent)	Principled (principled procedural *)
		Procedural (procedural *)

*from Shay et al. 2011

Within each of these two categories both principled and procedural knowledge are recognised at the second level of distinction (Table 4.1). We are familiar with the ideas of principled (often called propositional) and procedural knowledge in a theoretical academic context, and the terms used by Shay et al. (2011) of 'conceptual' and 'proceduralised conceptual' knowledge respectively (Table 4.1) capture this distinction well as they indicate that procedures are based on underpinning conceptual knowledge.

Gamble (2006) argues that the distinction of principled and procedural knowledge also occurs in practical knowledge (Table 4.1). Using the example of craft workers she suggests that the

production of a craft article (such as a wooden cabinet) is a tacit process requiring an understanding of the relationship between parts of the whole and the 'essential principle of arrangement' (Gamble 2004, p196). In other words craft work (and other work associated with practical knowledge), which is highly proceduralised, is underpinned by principles derived from practice and they are usually tacit and embodied. The principles are the codification of practice. Again the terms of Shay et al. (2011; Table 4.1) of 'principled procedural' and 'procedural' knowledge capture these two concepts well. This study draws on knowledge differentiation as proposed by vocational curriculum theorists Gamble (2004, 2006, 2009) and Shay et al. (2011), but adapts their ideas for use in a foundation course context in which literacies practices form an important part.

The following sections describe the theoretical concepts of Bernstein and Maton that are used in this study to help characterise and explain the different forms of knowledge, knowledge practices and knowers in ISCM, and their subsequent effects on student access.

4.4 Bernstein on knowledge, codes, coding orientations and pedagogic device

Basil Bernstein was a British sociologist who for over four decades was interested in social justice in education, or, to use his words: 'preventing the wastage of working class educational potential' (1961, p308). To this end he developed a theory of social and educational codes, with codes referring to the regulative principles that underpin message systems, especially curriculum, pedagogy and assessment, to help examine power relations and their effect on learning and social reproduction (Sadovnik 2001). This work however, did not take into account the *form* of discourses or knowledge structures that were being subject to pedagogic transformation and this therefore became the focus in his late-career work. The aspects of Bernstein's work applicable to this study are outlined below.

4.4.1 Discourses and knowledge structures

The first of Bernstein's concepts used in this study are those of discourses¹ and knowledge structures (Bernstein 2000). Bernstein recognised two different forms of discourse: horizontal and vertical. Horizontal discourse refers to the everyday, highly-contextualised, segmented knowledge that we acquire in everyday contexts. Two examples are washing dishes and plaiting hair, where acquisition of competence or knowledge in the one, usually informal, context does not necessarily bear relation to, or aid success in, the other. In contrast, vertical discourse is the

¹ Bernstein uses the term discourse to mean fields of social activity. This is dissimilar to Gee's (2012) use of discourse (language in use) or Discourse (interrelated ways of thinking, feeling, believing, valuing and acting)

specialised, conceptual, organised, more abstract knowledge that is context-independent, and it is the discourse that is most valued in formal educational settings.

Bernstein further differentiates vertical discourse into horizontal and hierarchical knowledge structures. A hierarchical knowledge structure is one that has 'a coherent, explicit, systematically principled and hierarchical organisation of knowledge' which 'attempts to create very general propositions and theories, which integrate knowledge at lower levels, and in this way show underlying uniformities across an expanding range of apparently different phenomena' (Bernstein 1999, pp161–162). This is usually represented by a triangle (Δ) where the base of the triangle relates to the broad base of fundamental knowledge, and the upper peak of the triangle represents the overarching theory/ies that can explain the base phenomena. In a hierarchical knowledge structure, new knowledge is thus developed by integrating and subsuming previous knowledge. Typically, the field of science, as well as disciplines within the sciences such as Chemistry and Botany, exhibit hierarchical knowledge structures.

In contrast to a hierarchical knowledge structure, Bernstein claims that a horizontal knowledge structure has a 'series of specialised languages, each with its own specialised modes of interrogation and specialised criteria' (1999, p162). This is usually represented by a series of segmented sections ($I_1 I_2 I_3 I \dots I_n I$) where each segment relates to a separate category (such as a field or discipline) and integration of knowledge across the segments requires acquiring a new language each time (*ibid.*). Disciplines in humanities and social sciences, such as Philosophy and Sociology, typically have horizontal knowledge structures.

Hierarchical knowledge structures develop through the integration and subsumption of old ideas into new and have an epistemic/empirical base. In contrast horizontal knowledge structures develop through competing claims that have an ideological base and are thus much more dependent upon *who* is making the knowledge claim, rather than on *what* is the claim (Maton and Muller 2007, p27). The idea of a person's claim having legitimacy has resulted in the development of the concept of a knower code (Maton 2014a), as opposed to a knowledge code, which is discussed in section 4.5 of this chapter.

4.4.2 Classification, framing and codes

The second facet of Bernstein's work relevant to this study is on the concepts of *classification* and *framing* and how these contribute to different codes. Bernstein is concerned with how issues of power and control regulate the reproduction or transformation of social contexts. Although he maintains that power and control are analytically distinct, he claims they are also 'embedded' within one another (Bernstein 2000, p5). In distinguishing them, he suggests that power relations create, legitimise and reproduce boundaries between different categories (or

contexts), and power therefore operates at the level *between* categories. In this regard, categories can be any social or educational context; for example academic disciplines, pedagogic practices, discourses, or agents. In contrast, control establishes legitimate forms of communication *within* categories. In order to analyse how power and control relations are realised, Bernstein developed the operational concepts of classification and framing, which can be used in a wide variety of contexts.

Classification (C), which is linked to power, is an indication of the relative strength of the boundaries, and extent of insulation, between categories (Bernstein 2000, p6). For example, if the topic of photosynthesis in a Botany curriculum draws on aspects of chemical reactions, this would represent a weakening of disciplinary boundaries. In contrast, if the topic is about plant structure and function and speaks to aspects of leaf shape and form, this would represent a strengthening of disciplinary boundaries. Stronger boundaries are indicated with a plus sign (+C) and weaker boundaries with a minus sign (-C). In the case of stronger classification, 'each category has its unique identity, its unique voice, its own specialised rules of internal relations' (ibid. p7).

In contrast, framing (F) is an indication of the relative strength of control on communication *within* categories. In pedagogy this relates to the locus of control between transmitters and acquirers of knowledge and is linked to selection, sequencing, and pacing of knowledge, and criteria (of assessment) and 'control over the social base which makes the transmission possible' (Bernstein 2000, pp12–13). A +F symbol indicates the transmitter has stronger control within the category and -F indicates the transmitter has weaker control. For example, if a lecturer uses a transmission mode of teaching with little or no student interaction, and what is taught and the pace at which it is taught is determined by the lecturer – this represents stronger framing. However, in an interactive class where the lecturer engages with and draws on student questions to help develop understanding, students have some influence over the pace and perhaps even the content – representing weaker framing.

Classification and framing can independently weaken or strengthen depending on the context, giving rise to four modalities of +C,+F; +C,-F; -C,+F and -C,-F. These modalities reflect the underlying, structuring principles of the social context and can be encompassed in a code. A code is essentially an 'orientation to meaning' (Maton and Muller 2007, p16) or a set of regulative or structuring principles of a context or practice (Bernstein 1990, p101). Codes have frequently been referred to as the 'rules of the game', which implies tacit or unwritten principles that shape practice. They also serve as a means of analysing the structuring of contexts, and have proved to be particularly useful in developing understanding of educational and social practices.

By way of example, in relation to curriculum and pedagogy, Bernstein (2000) developed two main educational knowledge codes: 'collection code' and 'integrated code'. A collection code represents a context with stronger boundaries and control (+C,+F), and the integrated code represents a context with weaker boundaries and control (-C,-F). For example science disciplinary courses often exhibit a collection code, as the boundaries between disciplines are often clear exhibiting stronger classification (+C) and the pedagogy and assessment criteria are often explicit and visible exhibiting stronger framing (+F). However, since Bernstein's curriculum-related collection and integrated codes focus only on how knowledge specialises educational practices (i.e. epistemic relations) and not on how dispositions of actors can specialise practices (i.e. social relations), later work by Maton (2014a) in LCT using the Specialisation dimension has essentially superseded these two codes. Likewise, Bernstein's well-known elaborated codes (in which context-independent meanings are prioritised) and restricted codes (in which context-dependent meanings are prioritised) are now better articulated in LCT using the Semantics dimension. These two dimensions are elaborated on in section 4.5.

4.4.3 (Epistemic-)pedagogic device

As mentioned, codes are the organising principles that structure practice. While the concepts of classification and framing provide a means to analyse these codes, Bernstein's work on the pedagogic device provides a means to understanding how these codes are established, maintained and transformed in different fields of practice (Maton 2014a). This is the third aspect of Bernstein's work relevant to this study.

The pedagogic device comprises three fields of practice: the field of production, where knowledge is produced, the field of recontextualisation, where knowledge is transformed into pedagogic discourse, and the field of reproduction, where pedagogic practice occurs (Bernstein 2000; Table 4.2). The three fields are hierarchically related, as indicated by the arrows (Table 4.2), with reproduction of educational knowledge being reliant on recontextualised knowledge, which is in turn dependent upon produced knowledge. Nonetheless, Bernstein maintains that each field has its own structure and associated set of rules.

Table 4.2: Arena created by the pedagogic device (adapted from Maton and Muller 2007; Maton 2014a)

Field	Field of practice	Typical sites...	Regulative rules	Symbolic structure	
Intellectual (production)	production	..where knowledge is created (research publications, conferences)	distributive	knowledge structure	
Educational (reproduction)	↓ recontextualisation	..where knowledge is selected, reorganised, transformed to become pedagogic discourse (curriculum policy, documents, textbooks)	recontextualising (hierarchy, discursive)	curriculum	pedagogic discourse
	↓ reproduction	..of teaching and learning (lecture theatre, laboratories, tutorials, assessment)	evaluative (criteria)	pedagogic practice	

The *field of production* (Table 4.2, column 2) is where specialised (as opposed to everyday) knowledge is created, positioned and modified; processes that usually take place in universities or other research institutions. The organising principle in this field is knowledge structure (hierarchical or horizontal), which has been discussed already in this chapter. The distributive rules of this field ‘regulate the relationships between power, social groups, forms of consciousness and practice’ (Bernstein 2000, p28). In other words, Bernstein claims that the distributive rules determine who has access to what knowledge and under what conditions, and establish the ‘limits of legitimate discourse’ (Robertson 2007, p79). By way of example, Bernstein suggests that the specialised ‘esoteric’ or ‘unthinkable’ knowledge in small-scale non-literate societies could be controlled and distributed by clerics, whilst in modern literate society it is controlled by the producers of knowledge, mostly in higher education institutions (2000, p29).

The *field of recontextualisation* is where intellectual knowledge from the field of production is transformed into pedagogised knowledge (Table 4.2). This field has the curriculum as its structure and the recontextualising rules that:

... selectively appropriate[s], relocate[s], refocus[es], and relate[s] other discourses to constitute [their] own order ... the recontextualising functions then become the means whereby a specific pedagogic discourse is created (Bernstein 2000, p33).

In this quotation the 'other discourses' can relate to disciplinary discourses (such as Physics or Biology) as well as educational discourses (relating to theories of teaching and learning). The resultant unique *pedagogic discourse* is created by recontextualising agents based on their practising ideologies for a particular context. By way of example, Bernstein states that the physics that is taught at school is an 'imaginary' physics, it has been transformed from a 'real' discourse to a pedagogic discourse of physics (2000, p33). The form this pedagogised physics takes will depend upon the values and beliefs of the recontextualising agent; for example, a theoretical physicist will likely teach an abstract and mathematically-based physics course compared to a practical, problem-solving course of an experimental physicist.

Bernstein (2000) argues that the pedagogic discourse comprises two discourses: a discourse of social order referred to as the *regulative discourse* and a discourse of skills and knowledge referred to as the *instructional discourse*. The regulative discourse is always dominant and the instructional discourse is embedded within the regulative discourse. He further argues that these two discourses are underpinned by three sets of internal rules: rules of hierarchy of the regulative discourse, rules of discursive order of the instructional discourse and rules of criteria of both the regulative and instructional discourse (ibid. p13). These discourses and their associated rules are discussed in turn below.

The regulative discourse is the discourse of moral and social order (Bernstein 2000, p13). Its underpinning rules of hierarchy regulate the interactional relationship between transmitter (lecturer) and acquirer (student), thereby influencing acquisition of rules of social order, character, and conduct in the pedagogic context. For example, in a university context stronger framing of hierarchy could be a lecturer only allowing entry into the lecture theatre if students arrive on time, and weaker framing of hierarchy perhaps an open-door policy for student consultation. In this study a distinction is made between two sets of hierarchical rules – those associated with the learning context and those with the epistemic context, the reason for which will become clear later in the dissertation.

The instructional discourse is underpinned by rules of discursive order that regulate selection, sequencing and pacing of knowledge, and these can be based on the *epistemic norms* and values of the intellectual field or discipline or on the *pedagogic norms* and values of the classroom. To give an example in terms of sequencing in a physics course based on epistemic norms: an understanding of the sub-atomic structure of particles and their associated forces would need to be addressed first as this is a prerequisite for proper comprehension of processes and harmful effects of radioactive decay. To give an example in terms of pacing, this time based on pedagogic norms: if it is considered more important to develop deep understanding rather than 'cover content' in a foundation course, pacing would be flexible and adjust to student needs.

The rules of criteria, also called the evaluative rules, underpin both the regulative and instructional discourse and define what is legitimate knowledge and learning in the pedagogic and assessment context. These form part of the final field of the pedagogic device, the *field of reproduction*, where curriculum is transformed into pedagogic practice in a process that is regulated by evaluative rules (Table 4.2). The meaning of the whole of the pedagogic device is 'condensed' through the evaluative rules into a set of criteria which indicate what counts as legitimate knowledge and how this knowledge can be communicated (Bernstein 2000, p36). Hoadley and Muller (2010, p74) succinctly explain what Bernstein means by condensation:

By condensation he means that . . . it is possible to see what the work of the device has been . . . in terms of the distribution of what knowledge to which social groups. The 'what' of the distributive rules and the control over the process of transmission through the recontextualising rules result in differential specialization of consciousness through acquisition. It is at the moment of evaluation that we see the extent to which the distributive rules (both in terms of instructional knowledge and social norms) have been realized. The evaluative rules bring the 'what' (classification) and the 'how' (framing) into a final relation to each other. They condense the device.

The concept of condensation speaks back to the main question of epistemological access that drives this study. Whilst I examine what is legitimated in curriculum, pedagogy and assessment practices in ISCM in this study, it is the student response to assessment criteria, as determined by the evaluative rules, which allows me to make some judgment on whether the educational practices are in fact promoting epistemological access. I examine student response through Bernstein's (2000) concept of acquisition of recognition and realisation rules, as discussed in the following section. However, prior to that I divert briefly to re-consider the pedagogic device in light of relatively recent reconceptualisation of it.

Maton (2014a, pp49–53) develops the pedagogic device further in a number of ways but of relevance here is his work with the rules (which he calls 'logics', which is less deterministic). Whereas Bernstein claims the evaluative and the recontextualising rules (logics) regulate practices in the respective fields of reproduction and recontextualisation, the distributive rules (logics) instead 'regulate *access* to the field of production' rather than regulate its practices (ibid. p49, original italics). Maton suggests this creates a contradiction in the framework and argues that the distributive rules (logics) in fact regulate access to *all three fields* of practice, not only to the field of production. He therefore suggests the pedagogic device has four logics: overarching distributive logics which regulate access to the three specialised fields of practice as well as the three field-related logics. The recontextualising and reproduction logics are the same as Bernstein's rules with the same names. The 'newly named' epistemic logic regulates the process of generating new knowledge in the field of production. For example the epistemic logic

of science ensures that new knowledge is primarily based on empirical evidence rather than on personal opinion.

The pedagogic device, more appropriately called the epistemic–pedagogic device (Maton 2014a), was developed to conceptualise the relationship between curriculum, pedagogic practice and a wider knowledge field. The device serves to frame this study in two different ways. Firstly it enables location of the study within specific fields. Although all three fields have application in this study, the primary focus is on the recontextualising field of curriculum and the reproduction field of pedagogic practice.

Secondly, through its distributive rules, the epistemic–pedagogic device also creates space for consideration of how curriculum and pedagogic practices have the power to include or exclude certain learners – which addresses the central question in this study of epistemological access. This is based on Bernstein’s notion that the process of transforming knowledge across the three fields creates a ‘discursive gap’ or a ‘space in which ideology can play’ (2000, p32). For example, the theoretical physicist mentioned earlier will bring ideologies, epistemologies and ontologies into play when she transforms knowledge from the intellectual field to the decontextualised field, and likewise from the decontextualised field to the field of reproduction. If in this process she legitimates a very abstract and mathematical form of physics in pedagogic and assessment practices this could serve to exclude those who have little experience of working in such abstract and decontextualised ways. It is part of Bernstein’s thesis that different social groups may be differentially prepared or socialised to operate within certain contexts or codes. If a student has not been well socialised into a particular code (such as an elaborated code of theoretical physics) this could influence their levels of success.

In order to unpack student response to pedagogic and evaluative practices I now turn to Bernstein’s concept of acquisition of recognition and realisation rules or, said differently, acquisition of coding orientations.

4.4.4 Recognition and realisation: Student acquisition of codes

In order to characterise the effectiveness with which a student can operate within a particular pedagogic practice, which depends upon their capacity to understand the requirements of the field and to act appropriately, Bernstein (2000) proposes the concepts of recognition and realisation rules. This is the final aspect of Bernstein’s work that this study calls upon.

Recognition rules are the way in which ‘individuals are able to recognise the speciality of the context that they are in’ and to do this students make inferences about ‘what meanings may legitimately be put together’ (Bernstein 2000, p17). As has been mentioned, it is the classificatory principle that indicates how different one context is from another, with stronger

classification indicating clear contextual differences. If the context is made explicit, it follows that the acquirer should be able to better read what is legitimated in that context. As such, recognition rules are defined by classificatory principles. For example, if our theoretical physicist explicitly uses a mathematics-based approach to describe physics concepts, demonstrating stronger classification, it should be clear to the student that this too is required in the assessment procedures.

Even though a student may have recognition rules, in other words recognise what meanings are relevant for the context, they may not be able to produce the legitimate communication, which means that they have not acquired realisation rules. These are the rules that regulate 'how the meanings are to be put together to create the legitimate text' (Bernstein 2000, p18). Framing in pedagogy influences acquisition of realisation rules and therefore on the production of appropriate texts. For example, should our theoretical physicist provide time for and assistance to students to find solutions to mathematically-based physics problems, which represents weaker framing of pacing, it is likely students will be better able to produce the solutions or 'text' in assessment tasks (i.e. have better realisation rules) than if she simply presented the solutions herself. It is worth noting that 'text' is not only associated with assessment tasks, it can be any form of communication deemed appropriate to the context, such as asking a question in class, participating in a group project, doing unit conversions in a practical or writing an essay in an examination.

The concept of acquisition of recognition and realisation rules (i.e. acquisition of a specific coding orientation for a context) has been expanded in long-term research of teaching and learning of science subjects in schools by Morais and colleagues. Their model of student performance for a particular context (or coding orientation) relies on students not only possessing recognition rules, but also *passive* realisation rules (selection of meanings/justifications appropriate to the context), and *active* realisation rules (the production of text required by the context), as well as having the appropriate socio-affective dispositions such as 'aspirations, motivations, values and attitudes' favourable to the context (Morais, Neves and Afonso 2005, p417; Figure 4.2). The coding orientation of the context and the socio-affective dispositions mutually influence each other in order for the student to produce legitimate text (Morais and Atunes 1994). Examples will be given presently.

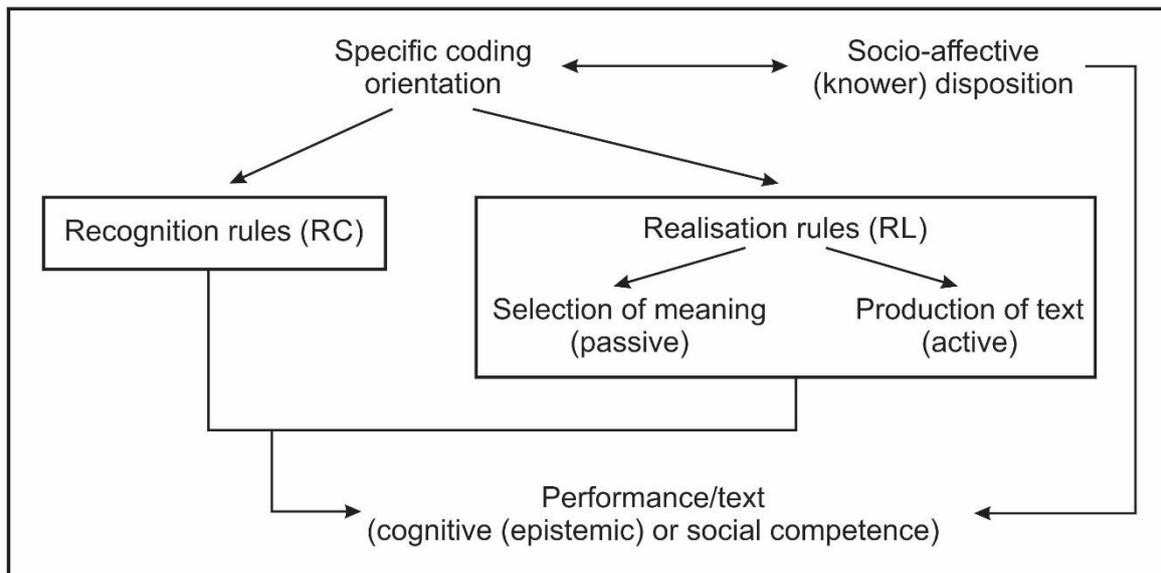


Figure 4.2: Conceptual model of relationship between recognition and realization rules, socio-affective (knower) disposition and performance or production of text in a specific learning context (adapted from Morais, Neves and Afonso 2005, p418)

At this point a small aside is needed to clarify terminology. No definition of socio-affective disposition is provided with the model but when scholars (Morais and Atunes 1994; Morais and Miranda 1996; Morais 2002; Morais, Neves and Afonso 2005) talk of socio-affective ‘aspirations’ and ‘attitudes’ this can be likened to Barnett’s (2009) dispositions, and when they talk of honesty, initiative, creativity, responsibility and critical thinking this relates to his concept of qualities (see Chapter 3). Therefore, socio-affective dispositions in this study encompass Barnett’s dispositions and qualities, which in turn relate to LCT’s knower dispositions (see section 4.5.1) – the term that will henceforth be used in this study.

It is also useful at this stage to contextualise the above conceptual model for this study. For example, in the ISCM course students may be expected to write an explanatory essay on the sun’s heat production as an assignment they produce in their own time. This would require them to (a) recognise that the assignment is a formal piece of writing drawing on physical concepts of nuclear fusion (recognition rules); (b) select the appropriate scientific information such as hydrogen fusion, proton–proton chain, energy production and transfer as well as draw on science writing norms and conventions such as introduction, conclusion, paragraphs, development of argument, drawing on data, making claims appropriately, etc. (passive realization rules); (c) produce an essay according to a set of criteria (active realization rules); and (d) possess epistemic knower dispositions of honesty, criticality and valuing accuracy in reporting. Accordingly, if they achieve all of the above, they would have demonstrated *cognitive or epistemic competence* (as opposed to social competence – see Figure 4.2). In this regard, later in the dissertation I refer to students gaining *epistemic access* to the discipline, which has

epistemic underpinnings, and to student acquirers as having *epistemic-context* recognition and realisation rules.

In contrast, in terms of achieving *social competence* (see Figure 4.2) for the same essay assignment they would have had to (a) recognise the need to work independently and responsibly (recognition rules); (b) select meanings appropriate to the context such as sourcing information and evaluating its appropriateness, developing depth understanding through appropriate means such as asking others or watching YouTube, and using opportunities for feedback on drafts (passive realisation rules); (c) produce text according to the rules of independent work such as presenting their own work rather than copied from others and the rules of responsible work such as keeping to the hand-in date (active realisation rules), and (d) possess contextual knower dispositions that enable them to work in this responsible and independent manner. In this regard, later in the dissertation I refer to students gaining *access to the learning context*, which has *axiological* underpinnings, and to student acquirers as having *learning-context* recognition and realisation rules. Axiology is about values (O'Reilly and Kiyimba 2015) and in this study it relates to personal, moral, social and affective values primarily associated with the learning context.

Whereas cognitive or epistemic competence is typically overtly legitimated through assessment practices, especially in the sciences, social competence is usually only implicitly legitimated as it is seldom directly assessed. Nonetheless, such competence is typically assumed and is often necessary for success, which has implications for epistemological access. I have not located studies that work with recognition and realisation rules at both levels in this way; they either examine the influence of the instructional discourse on acquirers attaining epistemic competence, or examine the influence of the regulative discourse on acquirers attaining social or knower competence. One of the main contributions of this study in developing better understating of epistemological access is this two-tiered approach in which both more narrow disciplinary aspects with epistemological underpinnings and broader learning-context aspects with axiological underpinnings are taken into consideration. From here on in the dissertation, this is a consistent theme.

Acquisition of recognition and realisation rules means that the learner has acquired the 'coding orientation' (or what is required) for a particular context. Since recognition and realisation rules are based on classification and framing principles, varying the relative strength of these principles in any particular pedagogic context can influence acquisition. Another important contributory factor is the coding orientation that students bring with them, which could be different from that which is required. These aspects need to be carefully considered in a curriculum if the aim is to enable epistemological access.

Which brings us back full circle to the main concept of the dissertation: epistemological access. It is likely now clear to the reader that acquiring recognition and realisation rules is about mastery of a Discourse (Gee 2012) which, as mentioned previously, requires taking on norms, values and practices and also acting and behaving in ways that are appropriate to the context, and is another way of talking about acquiring epistemological access. Whilst Gee speaks of early socialisation and literacy practices in the primary home Discourse affecting performance in and access to secondary Discourses such as at university, Bernstein similarly speaks of possible mismatches between home and university socialisation and coding orientations. The appeal of Bernstein's work, particularly his model on recognition and realisation rules and coding orientations, is that it provides a tool with which to 'operationalise' Gee's ideas on mastering Discourses and Morrow's ideas on acquiring epistemological access that were mentioned in Chapter 3. In order to be consistent with the rest of the theoretical work in this dissertation, I use Bernstein's model and terminology throughout.

4.4.5 Limitations of Bernstein's work

Maton and Muller (2007, p15) and Wheelahan (2010, chpt3) point out that Bernstein's focus in the pedagogic discourse is on social processes without much consideration of epistemic aspects of knowledge. This is because his main concern is about social processes of power and exclusion, rather than about the structure of knowledge itself². Wheelahan (ibid.) argues that, by combining critical realism with Bernstein's theories, not only can social conditions and power relations related to knowledge production, recontextualisation and reproduction be examined, but also the structures and content of knowledge itself, and the underpinning epistemic nature of knowledge can also be brought to bear.

Another limitation of Bernstein's work is that when he does focus on knowledge structures in his later work he does not take into account those fields or disciplines where the basis for legitimation lies with the knower (Maton 2010). Legitimation Code Theory (LCT), which better theorises the structures to include knower structures, takes these criticisms into account. Another useful aspect of LCT is that, through its better unpacking of the organising principles, the emphasis moves away from concepts as idealised binaries (such as presence/absence, or strong/weak grammar) and rather recognises concepts that can vary in strength along a continuum. These ideas are elaborated on in the following section.

² Bernstein only later becomes concerned with the structure of knowledge itself, but this is largely with respect to the field of production, not the fields of recontextualisation and reproduction.

4.5 Maton's Legitimation Code Theory

In a project spanning more than a decade, Maton has developed theory around knowledge, practices, and actors' dispositions. Central to his work, similar to that of Bernstein, is the concept of legitimation. In this regard, when an actor engages in a practice they are, either explicitly (through actively advocating a position) or tacitly (through routinised or institutionalised practices), making a claim for the legitimacy of the practice and, more specifically, for the organising principles that underpin that practice (Maton 2014a³). Practices can thus be understood as *languages of legitimation* and the underpinning principles of the practice are regarded as *legitimation code* (ibid. p24). The legitimation code is thus the currency used or proposed by actors to define the practice.

Maton proposes a number of dimensions (or organising principles) useful for understanding practice, and currently LCT draws on five dimensions: Specialisation (structuring relations between the social and symbolic dimensions of the field), Semantics (structuring relations to context and to condensation of meaning), Autonomy (structuring external relations to the field), Density (structuring relations within the field), and Temporality (structuring temporal aspects to these relations; Maton 2014a). Each dimension uses the concepts of classification and framing to establish different code modalities, or *legitimation codes*, by which achievement and success can be measured. The dimensions used in this study are Specialisation and Semantics and are discussed in turn below.

4.5.1 LCT(Specialisation)

Specialisation is the basis for differentiation in intellectual and educational fields or practices. In other words it is what specialises the field or practice or what is the key legitimising or organising principle (Maton 2000, 2010, 2014a chpt2). The Specialisation dimension uses two concepts for analysing the organising principles: epistemic and social relations. Epistemic relations (ER) refers to relations between knowledge claims and the object of study – in other words *what* can legitimately be claimed as knowledge (Maton 2014a, p29; original italics). Social relations (SR) refers to relations between knowledge claims and the subject (person) who is making the claim – in other words *who* can claim to be a legitimate knower (ibid. original italics). These two relations therefore indicate 'what counts' in a practice (Luckett and Hunma 2014, p183). For example, in terms of epistemic relations, in the discipline of Geology it is the content knowledge, such as the structure and mineralogy of rocks, which is highly valued and legitimised. In terms of social relations, in Fine Arts having a 'feeling' for and appreciation of different art forms is valued and legitimised.

³ Most of Maton's early ideas are presented in the book *Knowledge and knowers: Towards a realist sociology of education* (2014a). I refer mainly to this single, recent text.

Bernstein's concepts of classification (relative strength of boundaries between contexts; +C, -C) and framing (locus of control within a context; +F, -F) can be used to unpack epistemic and social relations. For each of ER and SR there can be weaker and stronger classification (-C, +C) as well as weaker and stronger framing (-F, +F). In an educational field or practice if the relations between the knowledge claim and object of study show stronger classification and framing, then the practice exhibits relatively strong epistemic relations (ER(+C, +F) or simply ER+)⁴. In contrast, if the relations between the knowledge claim and the actor or subject show stronger classification and framing, then the practice exhibits relatively strong social relations (SR(+C,+F) or simply SR+). Since each of ER and SR can be represented as a continuum, the + and - symbols each representing relatively strong (or stronger) and relatively weak (or weaker) relations respectively, the resultant two-dimensional plane results in the formation of four specialisation codes as depicted in Figure 4.3: knowledge, elite, knower and relativist codes.

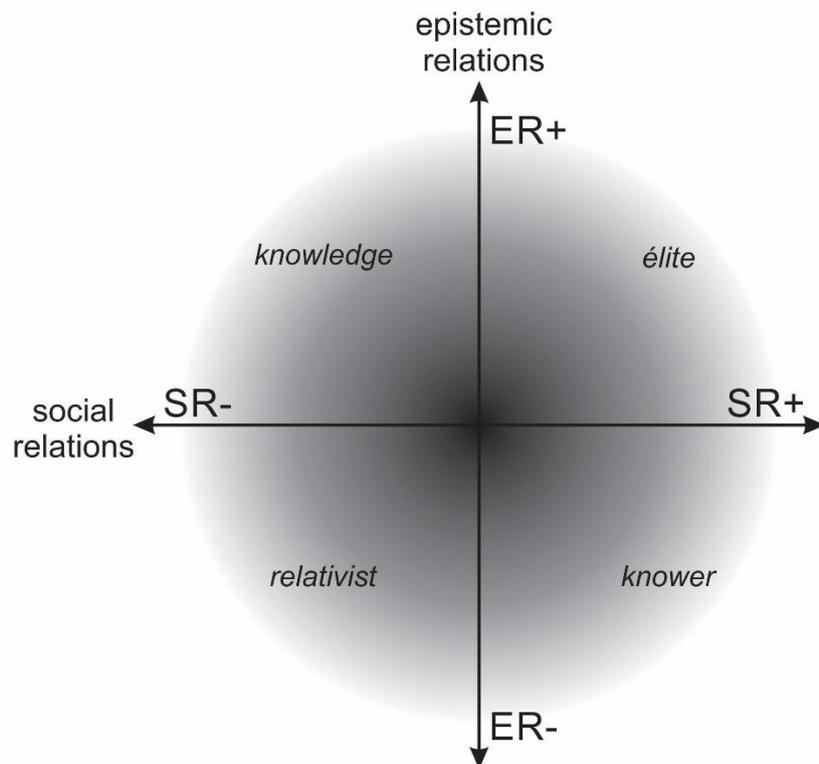


Figure 4.3: The specialisation plane: Topology of four specialisation codes based on epistemic and social relations (source Maton 2014a, p30)

When an educational field or practice has relatively strong epistemic relations and relatively weak social relations, it exhibits what is called a *knowledge code* (ER+, SR-). This means that the basis for specialisation and legitimacy in the practice depends on the possession of determinate

⁴ ER+ is the equivalent of Bernstein's (2000) collection code, and ER- is the equivalent of his integrated code.

and specialised knowledge and practices, and the attributes of knowers, such as their disposition⁵ and 'gaze'⁶, are downplayed (Maton 2014a). Science and science disciplines, with hierarchical knowledge structures, are considered to have knowledge codes.

An educational practice with a *knower code* (ER-, SR+) has relatively weak epistemic relations, but relatively strong social relations. In this case, specialised knowledge is downplayed and legitimacy is based on the disposition or 'gaze' of the knower, which can be 'innate' (born gaze), 'inculcated' (cultivated gaze), 'resulting from the knower's social position' (social gaze) or learned (trained gaze; Maton 2014a, p76). The humanities and many of their disciplines such as Sociology and Anthropology, which have horizontal knowledge structures, are considered to have a knower code.

An educational practice with an elite code (ER+, SR+) has both relatively strong epistemic and social relations. In other words, both specialist knowledge and knower dispositions are equally valued (Maton 2014a, chpt4). In an empirical study, Lamont and Maton (2008) show that a discipline such as music, which requires depth of knowledge as well as talent, could be categorised as having an elite code. Finally, a practice with a relativist code (ER-, SR-) has relatively weak epistemic and social relations. Legitimacy requires neither specialist knowledge nor knower dispositions (Maton 2014a, chpt4), which is an unlikely scenario in a specialised context such as education.

In allocating stronger or weaker ER and SR for a particular practice we are in fact identifying the *basis* for claims for legitimacy of the practice, as opposed to the *focus* of knowledge claims (Maton 2014a, p31). The *basis* is represented by the *form* of languages of legitimation (i.e. what underpins the practice) and the *focus* rather represents the *content* of the language of legitimation (ibid.). For example, borrowing from Morrow (2007, p127), in teaching addition and subtraction of whole numbers using apples in one example and cows in another, the apples and cows are the focus and are in themselves not relevant, but the rules for addition and subtraction are what need to be learned and form the basis for legitimacy for the lesson.

By disassociating epistemic and social relations, Maton demonstrates that intellectual and educational fields can be specialised both in terms of knowledge and knowers – in what he terms *knowledge-knower structures* (2014a, chpt4). The dichotomy of hierarchical and horizontal *knowledge structures*, as originally conceived by Bernstein, has been discussed already in the section on Bernstein's work. Maton builds on this by invoking a *knower structure* which, similarly, can be either hierarchical or horizontal in structure. Using the example of

⁵ Disposition here seems to encompass Barnett's (2009) dispositions *and* qualities.

⁶ Defined as a particular mode of recognising and realising what counts as an 'authentic' sociological reality (Bernstein 2000, p164)

Snow's 'two culture' debate in 1959, he suggests that humanist culture is seen to have a 'common culture' underpinned by the Classics, and the basis for specialisation is not the knowledge but rather the disposition of an ideal knower (2014a, p69). A knower in a field follows a particular 'social and educational trajectory' (ibid. p70) to become an ideal knower, developed 'through the integration of new knowers at lower levels and across an expanding range of different dispositions' (ibid. p92). The humanist culture therefore exhibits a *hierarchical knower structure*. According to this view new knowers are tacitly compared with the ideal knower and the knower's location and path are related hierarchically to the ideal knower (Maton 2014a, chpt5). A hierarchical knower structure can thus be symbolically represented as a triangle of knowers (Δ ; ibid. p70), acknowledging that there may be many ideal knowers, and therefore many triangles.

In contrast to the humanist culture, which is portrayed as class-bound, Maton maintains that Snow's scientific culture is democratic and meritocratic, where the disposition of the knower has little relevance for advancement in the field (2014a, p71) and that anyone can be a scientist provided they follow scientific rules and procedures (ibid. p96). The scientific culture therefore exhibits a *horizontal knower structure*, which is 'a series of segmented knowers, each strongly bounded from one another in terms of their (non-scientific) gaze and capable of being based on very different, even opposed, assumptions' (ibid.). A horizontal knower structure can thus be symbolically represented as segmented (I_I_I_I; ibid. p70).

For a field with a hierarchical knowledge structure and relatively strong epistemic relations, truth can be tested using empirical evidence against an agreed-upon set of criteria. However, in a field with a hierarchical knower structure with relatively strong social relations, 'truth' is a matter of acquired 'gaze'. In other words the gaze embodies the underlying principles of the field in terms of production, recontextualisation and evaluation (Maton 2014a, chpt5). Maton posits that social relations of a field can be specialised according to who the knowers are (such as social categories of race or gender) or by how they know (such as cultivation by an 'expert' knower; ibid. p184). He refers to these two respectively as '*subjective relations* (SubR) between practices in the field and the kinds of actors engaged in them; and *interactional relations* (IR) between practices in the field and the ways of acting involved' (ibid. original italics). These can be represented on a two-dimensional plane and give rise to four kinds of knowers: trained, cultivated, social and elite, each with respectively a trained gaze, a cultivated gaze, a social gaze and a born gaze (Figure 4.4).

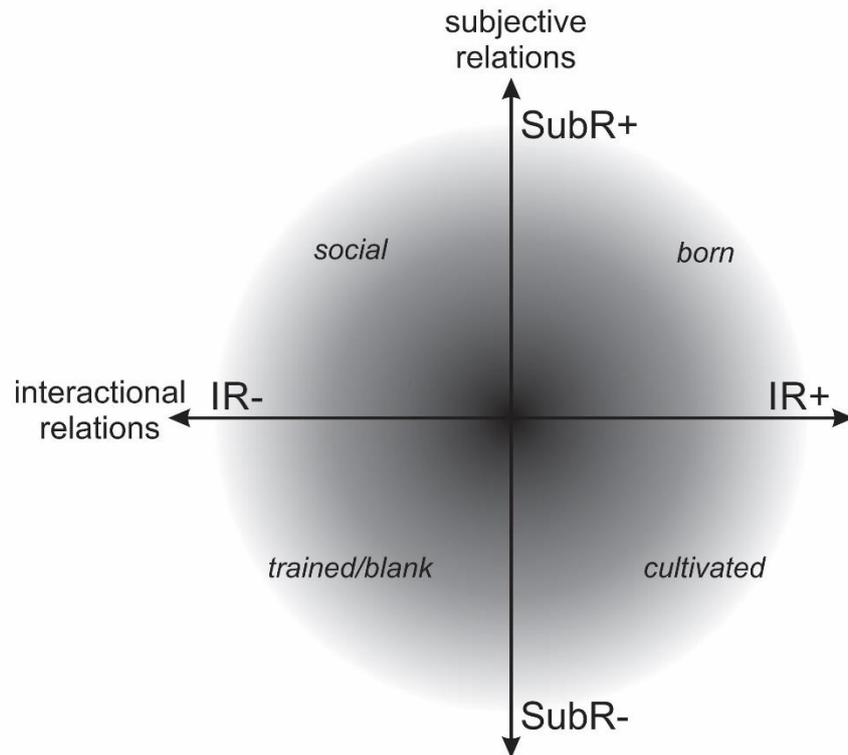


Figure 4.4: The social plane: topology of four social gazes based on subjective and interactional relations (source Maton 2014a, p186)

Maton (2014a, pp184–186) describes these gazes according to these two relations (subjective and interactional) as follows. Practices that exhibit weaker subjective and interactional relations (SubR-; IR-) legitimise a trained gaze, which comes about as a result of long-standing specific training in techniques and procedures. Practices with weaker subjective and stronger interactional relations (SubR-; IR+) legitimise a cultivated gaze. This is enabled through prolonged exposure to archetypal models and apprenticeship. A practice exhibiting stronger subjective and weaker interactional relations (SubR+; IR-) legitimises a social gaze that is based on being a member of a particular social category (such as social class, ethnic group). In the final category, practices with stronger subjective and interactional relations (SubR+; IR+) legitimise a born gaze, which is a result of the right interactional experiences with expert others as well as membership of the right social group.

Science disciplines tend to exhibit weaker social relations, which means a trained gaze is legitimated. In this view, it is a matter of ‘training’ someone to enter and become a knower in the field. As already mentioned, Maton (2014a, p96) suggests that anyone, regardless of their social background, can be successful in science provided they are able to develop the knowledge, skills and appropriate trained gaze. This begs the question as to why students in South Africa (and elsewhere) are often so unsuccessful in science. This study provides some

insight into this vexed question by arguing firstly that there are two kinds of knowers (an epistemic-context science knower (scientist) and a learning-context science knower (science learner), based on epistemological and axiological orientations respectively), and secondly that it takes more than simple 'training' to become these knowers. This argument is based on a socio-cultural view of learning in which mastering a Discourse (Gee 2012) or acquiring a coding orientation (Bernstein 2000) is an ideological, non-neutral process that can only be achieved over time through enculturation and apprenticeship. These ideas are developed throughout the dissertation.

To conclude this section, it needs to be pointed out that specialisation codes are not necessarily obvious, universal or unchallenged: in education practices different lecturers (recontextualising agents) may recognise and thus realise differently what is required, based upon their own view of the discipline or pedagogy. Examining specialisation codes in educational practices therefore allows for identification of code matches, clashes or shifts over time (Maton 2014a, p77). Empirical studies surfacing code clashes have, for example, allowed comment on low uptake rates of music as a discipline in schools (Lamont and Maton 2008) and learning difficulties for international students in an on-line post-graduate course (Chen 2010).

4.5.2 LCT(Semantics)

The second dimension of LCT used in this study is that of Semantics (Maton 2009, 2011, 2014a chpts6, 7). This dimension comprises two aspects, based firstly on issues of context-dependence and secondly on condensation of meaning in a particular field or practice:

Semantic gravity (SG) refers to the degree to which meaning relates to its context. Semantic gravity may be relatively stronger (+) or weaker (-). Where semantic gravity is stronger (SG+), meaning is more closely related to its context; where weaker (SG-), meaning is less dependent on its context. The context may be social or symbolic (Maton 2011, p65).

Semantic density (SD) refers to the degree to which meaning is condensed within symbols (terms, concepts, phrases, expressions, gestures, etc.). Semantic density may be relatively stronger (+) or weaker (-). Where semantic density is stronger (SD+), symbols have more meaning condensed within them; where semantic density is weaker (SD-), symbols condense less meaning. The meanings condensed within a symbol may be an empirical description or they may be feelings, political sensibilities, taste, values, morals, affiliations and so forth (ibid. p66).

Since there can be a strong interdependence between the two concepts, an educational practice with a weaker semantic gravity (SG-) is likely to have a stronger semantic density (SD+). For example, an educational practice such as a Chemistry course with a strong theoretical base

(SD+) is usually somewhat removed from context (SG-), could be expected to be located in quadrant 4 (rhizomatic code; Figure 4.5). The opposite is also true, and a practice with stronger semantic gravity (SG+) would likely exhibit weaker semantic density (SD-). For example, an educational practice such as a plumbing course with a practical base (SD-) is well rooted in context (SG+) and would probably be located in quadrant 2 (prosaic code). However, the concepts can also vary independently giving rise to other code combinations. Vocational curricula based on both theory (stronger semantic density, SD+) and practice (stronger semantic gravity, SG+) could be located in quadrant 3 (Shay 2013; worldly code). Shay (ibid.) also suggests a generic curriculum would be located in quadrant 1 with weaker semantic gravity (SG-) and weaker semantic density (SD-; rarefied code). This two-dimensional plane is used to identify codes used in ISCM curriculum.

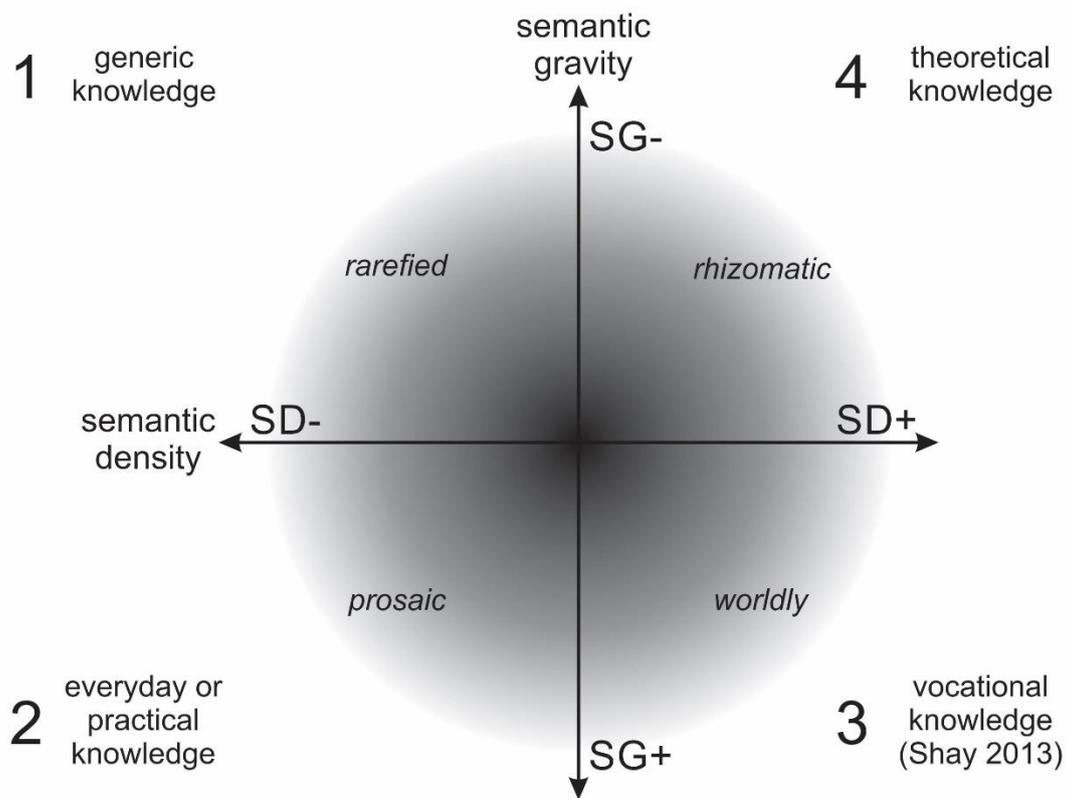


Figure 4.5: The semantic plane: Topology of four codes based on concepts of semantic density and semantic gravity (source Maton 2016, p16)

The concept of semantic gravity can be used to make statements about cumulative learning (Maton 2009, 2014a, 2014b). If understanding is developed based on integrating and subsuming previous knowledge, and the understanding is sufficiently abstract (represented by SG-) that it can be applied in a range of contexts, it is considered cumulative learning. In contrast, if understanding is developed through acquiring discrete bits of knowledge alongside

other knowledge, and understanding remains firmly rooted in the context in which it was learned (represented by SG+), it is considered segmented (Maton 2014a).

Although cumulative learning must occur in any higher education context, it is particularly important in a hierarchical field such as science, where understanding of base concepts is necessary for understanding of more overarching theories. Furthermore, in order to prepare students to meet the demands of a complex, ever-changing world, higher education needs to ensure students apply existing knowledge, and build new knowledge from existing knowledge, in a range of new and unfamiliar contexts. Maton (2014a) argues that, in order for cumulative learning to take place, students should be given access to context-independent knowledge, or knowledge that has low semantic gravity. Based on these assumptions, the concept of semantic gravity is used in this study to examine ISCM assessment practices and their possible influence on cumulative learning.

4.5.3 Epistemological and axiological charging (or concerns)

The final aspect of Maton's work that is drawn on in this study is that of 'cosmologies' and the resultant 'charging' (positive, neutral or negative) of a field or practice. Maton states that a cosmology is a set of belief systems and values that underlie a field or practice (2014a, p149). If the focus of the belief system is centred on personal, moral, social and affective values then the practice has a positive axiological charging, and if the focus is centred on the explanatory power of knowledge, then the practice has a positive epistemological charging (ibid. p153). Maton further argues that in any academic field or practice both are present, but one is usually dominant. Often, academic development courses, which have as their primary purpose change and transformation, are positively axiologically charged (Niven 2012; Shay 2012). In contrast, disciplinary courses, especially in the sciences, would likely have positive epistemological charging. This study in fact identifies both positive epistemological and positive axiological charging as dominant legitimising aspects of ISCM, and this forms the underpinning basis for the dual conceptual model of epistemological access that is developed at the end of this dissertation. Since I have found referring to 'positive charging' as somewhat cumbersome, I refer instead to epistemological and axiological 'orientations' or 'concerns' throughout the rest of the dissertation.

4.5.4 Critique of LCT

Singh (2015), in an extended review of Maton's (2014a) book, rightly suggests that, whilst LCT helps understand knowledge and knowledge practices and their organising principles, it currently does not adequately address pedagogy and the principles of recontextualisation. Furthermore, I contend that neither does LCT provide an adequate frame for understanding

student responses to practices. This study therefore draws on LCT for developing understanding on knowledge, knowledge practices and knowers in the curriculum, and on Bernstein's theories for unpacking pedagogy and student responses to curriculum and pedagogy in the assessment practices.

Chapter 5: Methodology

5.1 Introduction

The previous chapter argued that understanding how educational practices in ISCM have the power to include or exclude, and thereby enable or constrain epistemological access to the sciences, requires a theoretical focus which recognises knowledge as an object of study. The fields of recontextualisation and reproduction of the epistemic–pedagogic device help frame the study as they separate out for analysis not only educational practices (curriculum, pedagogy and assessment) but also underpinning legitimation codes in the respective practices. This chapter outlines the research design and approach used in this study in order to come to understand legitimation codes and student acquisition of these codes in the ISCM science foundation course.

This chapter is divided into five main parts. The first provides an account of the case study approach used in this study. The second is about data selection and generation, and outlines methods used such as interviews, document analysis, observation and reflective writing. Because I was researching my own institution and partly my own practice, issues relating to positionality and ethics of insider research are explicated in the third part. The fourth part relates to data analysis, which was achieved through developing external languages of description for each of the following: the curriculum (based on epistemic and social relations), pedagogy (based on framing of the regulative and instructional discourses), assessment practices (based on cognitive process levels and knowledge types) and student response to coding orientations (based on acquisition of recognition and realisation rules). Both the process of external language of description development and the supporting empirical evidence are presented in this chapter. The final part of this chapter discusses strategies used to enhance research quality.

5.2 Qualitative case study approach

The overall approach used in this study was qualitative case study research. Qualitative research uses a naturalistic¹ approach and tries to understand phenomena in a context-specific setting (Denzin and Lincoln 2008). It draws on in-depth narrative data from which themes and ideas can be generated. It is therefore usually used for description, exploration and discovery (Tashakkori and Teddlie 2003; Creswell 2013), although critical and social realist studies also

¹ Historically researchers distinguished between an experimental setting in the laboratory and a 'natural' setting in the field. In social science this natural or field setting is not necessarily a field site or natural place but is in fact is a context constituted through the researcher's questions and practices (Denzin and Lincoln 2008).

provide explanatory accounts. In this study, qualitative data were obtained through interviews, document analysis, observations and critical reflections which, in critical realism terms, generate data at the level of the empirical and actual in order to access the underpinning mechanisms at the level of the real. Some quantitative data in the form of student marks and throughput and graduation rates are also used descriptively to describe events at the level of the actual.

As mentioned, a case study approach is used. Case studies are empirical forms of enquiry which investigate in-depth contemporary phenomena that have clearly defined boundaries (Bassey 1999; Yin 2009), occur within a natural context (Bassey 1999) and are recognised as being functioning units (Stake 2005). As such, they offer the opportunity for gathering rich and detailed insights in a situation. Easton states that a case study is a 'single instance; a sample of one' which should be able to 'stand on its own' (2010, p119) in description and explanation. Furthermore, Easton argues that, because it uses causal language to describe the world, 'critical realism is particularly well suited as a companion to case research' (ibid).

Bassey argues case studies need to be conducted in such a way that *significant* features are explored, interpretations and explanations are *plausible* and *worthwhile* and they are conveyed *convincingly* to the reader (1999, p66; original italics). This usually involves gathering data from a range of different sources and exploring carefully relationships between different aspects of the case in iterative ways (Easton 2010). Two of the main strengths of a case study approach are therefore (a) that a variety of methods can be used to generate data and (b) that a rich description of the phenomenon can be achieved.

Since case studies are bounded in context, a common criticism is that they offer little basis for generalisation or application at other sites (Flyvbjerg 2006; Yin 2009). However, various possibilities for generalisation do exist. Working from a scientific and quantitative perspective, some authors suggest multiple or comparative case studies can offer a means to generalise (Newing, Eagle, Puri and Watson 2011; Kolberg no date). In contrast, Bassey (1999) develops the concept of 'fuzzy' generalisations in qualitative studies, in which she suggests generalisations can be made but their potential fallibility when applied to other contexts should be recognised. Sayer (2000), however, suggests that such fallibility is the hallmark of all qualitative research and should be expected in any social context. Increasingly it is being acknowledged in the literature that, although generalisations are difficult to make at the level of the empirical, they can more easily be made at the theoretical level (Yin 2009) and at the level of underlying causal mechanisms (Sayer 2000; Danermark et al. 2002; Hammersley 2012). Therefore, although this PhD is a single case study, through using LCT analysis both epistemic and social relations are surfaced as important underpinning mechanisms in enabling

epistemological access in ISCM. Since these relations operate at the level of the 'real', it makes it possible to imagine their influence on epistemological access in a range of similar higher education science contexts, which allows for the development of a generalised conceptual model based on these findings, whilst at the same time recognising its potential fallibility. Therefore, despite being a single, tightly bounded case study, the findings of this doctoral study should have applicability beyond the immediate context of a single science foundation course.

The rationale for using a case study approach in this study was therefore based on the need both to provide depth understanding of how knowledge, knowledge practices and knowers are legitimated in a well-contained, identifiable context (the ISCM course) and also to develop possible causal explanations for educational practices enabling or constraining epistemological access. One case was chosen in terms of the unique opportunity the PhD offered for 'burrowing' deep to gather rich and varied narrative data in a context in which I have a strong professional interest. The decision for a single case was also partly pragmatic, as accessibility of information and participants was made considerably easier since ISCM was and is the context of my daily work. The issues associated with insider research are discussed in section 5.4.

5.3 Data selection and generation

As mentioned, case study research draws on a range of different methods to meet the needs of the research questions. In this study interviews, documentation analysis, observations and critical reflection were used and are discussed in turn below.

5.3.1 Interviews

Interviews are conducted to elicit respondents' experiences and interpretations of contexts which may have remained hidden from direct observation or been taken for granted (Hatch 2002). Semi-structured interviews were used in this study not only to provide some initial structure to ensure appropriate information was elicited, but also to allow for flexibility for clarification and to follow unanticipated areas of interest.

Purposive sampling (Cohen, Manion and Morrison 2011) was used to select staff for interviews. Criteria such as early involvement in development of ISCM (three interviews) or current teaching in ISCM (four interviews) ensured the most appropriate participants. Because I was also examining students' experiences once they leave ISCM, staff members who either coordinate and lecture or provide support in each of four key first-semester mainstream courses (Cell Biology 101, Chemistry 101, Earth Sciences 101 and Physics 101²) were also interviewed (six interviews). Requests for interviews were all done by e-mail correspondence.

² ISCM is 'preparing' students for access and success in mainstream courses in the physical, chemical, life and earth sciences (Curriculum Development Report 2007). Mathematical and Computer Science courses are excluded in this analysis as ISCM does not focus on these disciplines.

For mainstream staff I first requested permission from the head of department, and thereafter wrote to each staff member directly (Appendix 5.1³).

Both purposive and convenience sampling, the latter referring to individuals most accessible and conducive to being involved (Cohen, Manion and Morrison 2011), were used to select ISCM student interviewees. I initially spoke to the class about the project and in a small questionnaire asked them to indicate their willingness to be involved and level of involvement. The forty-four percent 'willing' group were later contacted by e-mail for interview requests. All seventeen responders to the e-mail were interviewed. In terms of ex-ISCM students, I e-mailed students in each of the four respective courses and all fifteen responders were interviewed.

In a paper on prior relationships between interviewers and interviewees, Garton and Copland (2010, p535) comment on the need to negotiate the relationship in an 'acquaintance interview'. Whilst they claim a prior relationship can be advantageous for developing rapport, participants may also struggle to reconcile overlapping identities. As a relative novice interviewer with colleagues, in my first staff interview I found it awkward asking questions about aspects of their course with which I was very familiar. Also, we both kept slipping into conversational mode, discussing pedagogic issues that were of joint concern but not necessarily related to the interview topic; apparently a common occurrence in acquaintance interviews (Garton and Copland 2010). In subsequent interviews the process was 'formalised' by mutually agreeing to assume I had no prior knowledge of the course, which ensured I asked all necessary questions and avoided making assumptions about their teaching. Although conversational mode did still develop to some extent in later interviews, we tended to stay more on topic. Current staff interviews took place in their offices and the three interviews with past staff were via e-mail with a follow-up telephonic conversation with one and a follow-up meeting with another.

I also encountered some acquaintance interview difficulties with students. Professionally I knew all students relatively well as a result of close interactions with them in tutorials, and some personally from the pastoral role that inevitably seems to develop in my capacity as programme coordinator. To create some distance between us I conducted most (with the exception of four) interviews whilst I was on sabbatical and was therefore not teaching them at the time. Interestingly I am not aware of any differences between the level of engagement and openness of the interviewees between the two sets of interviews. For convenience all interviews were conducted in my office. Most students were initially slightly nervous, so to put them at ease I spent the first few minutes chatting informally, and also started with easy-to-answer questions about where they were from, what school they went to and aspects of family life. The difficulties

³ In each case I present a single sample from the study in an Appendix, the content of which would have been slightly altered for different groups or contexts.

I encountered related to my triple roles of researcher, teacher and sometimes counsellor. As researcher I was interested in students' capacity to produce legitimate texts. During the interview it was clear to me where they were battling in assessment tasks, and in the early interviews I kept switching to teacher mode to assist them; an inappropriate approach in terms of gathering quality data but, more importantly, in terms of confusion it was creating for students. In later interviews I learned to 'note' problematic learning as well as counselling issues that could be addressed after the interview if they wished. This posed an ethical dilemma which is discussed further in section 5.4.2.

In order to gauge the efficacy of my questions and interviewing techniques as well as the appropriateness of the language and questions, my first interviews with staff and students were treated as 'pilot' interviews and adjustments to questions and approach were made. Thereafter a relatively standard set of questions would be asked. However, I tended to use the questions more as a memory prompt rather than as a specific set of questions that needed to be asked in a particular way or in a particular order.

Interview questions depended upon context. For example, since I was interested in the regulative and instructional discourses in ISCM, interview questions with current and past lecturers related, amongst other things, to their understanding of the purpose of ISCM, their perceived role in the course and in student learning, what they taught and why, what process they used to select material to teach, how they interacted with students, and their approaches to assessment (Appendix 5.2). Mainstream lecturer interviews focused on understanding course content, structure, pedagogy and assessment practices, as well as their perceptions on student coping, and augmenting course⁴ (lecturer-level) practitioner interviews focused on their perception of the role of the augmenting course, how they structure and approach tutorial sessions, and their opinion on how ex-ISCM students were coping and what assistance they required.

In terms of staff with historical involvement, questions for the lecturer who wrote the original SESP proposal (which in a broad sense still informs the overall structure of the programme today) were linked directly to aspects of the proposal and focused on understanding the rationale behind it. Questions for the original ISCM course developers tried to shed light firstly on their rationale for structure and content of the course, which included similar questions to those asked of current ISCM lecturers, and secondly on the political context of course development.

⁴ Relatively recently instituted support programme in some mainstream courses, described in Chapter 10.

Since interviews with both ISCM and ex-ISCM students were focused primarily on student acquisition of recognition and realisation rules for particular assessment tasks, interview questions related, amongst other things, to their expectations on the task, their understanding of the task and criteria (asked as ‘what would get them marks’), and their knowledge of content or process required to attain marks (Appendix 5.3). In an assessment task, such as an essay with a feedback phase, questions also focused on the value of feedback and how it was used by students. These were followed up by more general questions on how they were coping and working at university in general and on their views of what was required of them to be successful. Interviews with ex-ISCM students had an additional component in which questions focused on perceived enablements and constraints in each of the four relevant mainstream courses. Table 5.1 is a summary of all interviews conducted for this study.

Table 5.1: Interviews conducted during 2014

Context and interviewee involved	Number of interviews
Historical ISCM involvement <ul style="list-style-type: none"> • <i>Original proposer for SESP design (Senior lecturer)</i> • <i>First SESP coordinator and ISCM ‘science’ course developer (Lecturer)</i> • <i>First ISCM ‘language-related’ developer (Lecturer)</i> 	3
Current ISCM lecturers <ul style="list-style-type: none"> • <i>(Two Lecturers, one Senior Lecturer, one Associate Professor)</i> 	4
Current ISCM students	17
Current mainstream lecturers <ul style="list-style-type: none"> • <i>Four disciplinary lecturers (one Lecturer, two Senior Lecturers, one Associate Professor)</i> • <i>Two augmenting course practitioners (Lecturers)</i> 	6
Current ex-ISCM mainstream students	15
Total number interviews	45

Informed consent, which included issues related to voluntary involvement, being able to refuse to answer or request erasure of comments, and the possibility of withdrawal at any time with no consequences, were discussed with all participants before forms were signed (Appendix 5.4). All interviews were audio-taped and transcribed verbatim either by myself or by a transcriber. During the checking procedure of transcripts not produced by myself I added details such as pauses, laughter and sighs to add context to statements. Transcripts were sent to interviewees for member checking. They were stored electronically using the software tool QSR NVivo 10 ®. Interviews are quoted verbatim, and can therefore be grammatically incorrect, in order to better convey the essence of what was being said. Written work of students (from document analysis as outlined in the following section), is also an exact reproduction.

5.3.2 Documentary evidence

Whilst interviews gather data about perceptions and interpretations of participants, documents are considered ‘unobtrusive’ in that their collection and use does not interfere with the social

context under investigation (Hatch 2002). This makes them useful for comparative purposes with interviews and observations as a form of triangulation. This is particularly so since in critical realism terms interviews generate data at the level of the empirical, and documents and observations mainly at the level of the actual. Documents not only provide a historical and contemporary snapshot of the context in question, but they can also provide insights into the value systems operating within the context (Hatch 2002).

In this study a range of different document types were utilised and can be categorised as historical documents, current ISCM and mainstream course documents, and student written work in response to assessment tasks:

- a) *Historical*: SESP Proposal (Williams 2003); SESP Annual Reports (2005–2009); ISCM course documents (2005–2009); Curriculum Development Report (2007); Extended Programmes at Rhodes University (Boughey 2009); Extended Programmes at Rhodes university: Review Report (2010); SESP Review Report (2011); Rhodes University Funding Application Report (2012); Policy Document on Extended Studies (RSA DoHET 2012); Ministry of Higher Education and Training: Ministerial Statement on Higher Education Funding: 2009/10 – 2011/12 (RSA MoHET 2009);
- b) *Current ISCM course*: course and semester outlines; readings; resource materials; lecture, practical, tutorial and enrichment handouts; assessment tasks and rubrics; postings on RUConnected site⁵ (all from 2013);
- c) *Current mainstream courses*: course and semester outlines; lecture handouts; assessment tasks and rubrics; postings on RUConnected site (all from 2014);
- d) *Student written work in response to assessment tasks and evaluations*: from tutorials, practicals, tests, reflective tasks, exams, major assignments and student evaluations; (data from 2010, 2012, 2014⁶).

The historical documents for SESP and ISCM, and current mainstream course documents (Cell Biology Chemistry, Earth Sciences and Physics) courses were used primarily for contextual background purposes as well as to provide supporting evidence to interview data. Current ISCM course documentation, which is extensive since virtually every pedagogic interaction has some form of documentation, was used in a detailed analysis of ISCM curriculum, pedagogy and assessment practices, not only to examine content but also to surface underpinning norms and values and generative mechanisms of the course (see sections 5.5.1–5.5.3). Student written responses provided insight into student acquisition of recognition and realisation rules (see

⁵ Rhodes University's web-based learning platform

⁶ In 2010 I conducted research on epistemological access and in 2012 on student agency in ISCM. I received consent from students to use their written responses to assessment tasks and anonymous course evaluations for research purposes.

section 5.5.4). A stratified sampling approach (Cohen, Manion and Morrison 2011), based on a range of different assessment tasks at different cognitive process levels, was used to select the student written work documents.

5.3.3 Observations and critical reflections

The main purpose of observation is to ‘understand the culture, setting, or social phenomenon being studied from the perspectives of the participants’ (Hatch 2002, p72). This provides first-hand and good understanding of the context and, in terms of triangulation, taken-for-granted issues less likely to emerge in interviews may be surfaced. As an academic development lecturer, one of my roles is to provide academic development support to students with regards to disciplinary content and, in order to do this effectively, I attend all lectures and practical sessions held by disciplinary lecturers and constantly make ‘informal’ observations about pedagogic issues. I frequently do follow-up reflective writing, both of classroom observations as well as of informal chats, which informs our yearly discussions on how to improve each component of the course. These observations and reflective comments were used to provide contextual background to ISCM pedagogic and assessment practices. Permission was obtained from lecturers to use such observations on this basis.

A critically reflective (entails deep, careful thought) and reflexive (requires awareness of one’s own effect on the process and outcomes of research) approach is an integral part of qualitative research. In arguing for reflective writing to be recognised as a method in its own right and as an acceptable data source, Jasper (2005, p246) draws on the work of others to claim that reflective writing helps develop critical thinking, analytical abilities and cognitive development; enables creativity and formulation of unique connections; and contributes to new perspectives. In addition, I find it acts as a form of ‘discipline’ to ensure regular engagement. Since 2012 I have used a ‘Reflections Journal’ of pedagogic interactions in ISCM as a means of making my experiences, thoughts, values, and feelings more visible and as a tool for guiding and improving practice. During the doctoral study I have also kept a ‘PhD Journal’ of my developing ideas. Whilst the observations operate at the level of the actual, the critical reflections can in fact operate at all three ontological levels of critical realism.

5.4 Positionality and ethics

5.4.1 Positionality in insider research

Conducting research in an institution where the researcher is employed is called insider or endogenous research (Trowler 2011). This has benefits and drawbacks. On the positive side, access to situations, documents and participants is usually logistically easier and there is often an immediate rapport and legitimacy; data collection and interpretation can be enriched

through insights gained from being familiar with the context; and positionality of the researcher can bring a nuanced perspective (Chavez 2008). In this case I had a good working relationship with staff and, because those involved in teaching in ISCM are concerned about pedagogic issues, they were, with the exception of one staff member, very willing to accommodate my requests to be interviewed, to be observed and their course notes to be used. Since I already sat in on all lectures and attended practicals, staff were used to my presence in the classroom and, although I did not use this as an opportunity to make 'formal' observations, they were agreeable that I use these sessions to gather contextual background information. I feel my long-term involvement added depth to my understanding of the overall ISCM context.

Accessing students was also relatively uncomplicated. I had sufficient volunteers and I felt those volunteering were representative of the group: academically relatively weak to relatively strong; good gender balance; from a range of school backgrounds; from a range of socio-economic backgrounds; some had visited my office often and others had never consulted with me; some were interested in numeric and mathematical careers and others in life, earth and physical sciences.

On the negative side, because the situation has become normalised in insider research it may be difficult for the researcher to 'see' what is necessary, and biases in approach and selective reporting can easily occur (Chavez 2008). In this regard I was conscious of the need to be honest and open in my practice and deeply reflexive. In all honesty, I am not sure I could always 'make the normal strange' (Trowler 2011, p2), particularly where it concerned my own practice. Critique of my practice often focused on the practical and less often at the broader, more theoretical level that is required in a study such as this. This has been a constant concern and I have tried to counter it by consulting widely with educationists, both informally and formally at workshops, PhD weeks⁷ and conferences.

Furthermore, in an effort to surface and clarify in advance my preconceptions, knowledge and interpretation of the field of ISCM and of students in ISCM, I was interviewed by an educational researcher/colleague prior to gathering any data. The interview revealed my perceptions on the importance of (a) institutional responsibility to accommodate student diversity, (b) knower and student agency work in science, (c) building students' confidence and self-esteem, (d) being explicit in teaching and intentions, and (e) research informing practice. Although these original assumptions have in essence not changed considerably, the research process has revealed that

⁷ These are held thrice yearly at Rhodes University and each time participants present on an aspect of their work. I used these as an opportunity to present my current 'concern' and found them to be extremely useful spaces for opening up conversations with and obtaining feedback from a range of scholars working in the field.

elements, such as the explicit approach to teaching, can have effects not anticipated. I also mentioned conflict I have in 'preparing' students for what I consider inappropriate higher education courses that are content-laden and as a result promote rote learning instead of developing depth understanding. I have drawn quite extensively on this interview in my analyses.

Another problem with insider research is linked to the nature of the relationship between researcher and participants. Participants may fear judgement or repercussions and be less forthcoming in their views, or because of familiarity with the researcher they may align their responses to the researcher's stance in order to maintain the relationship after the research (Mercer 2007). In all interviews conducted I believe this was not the case: staff were extremely forthcoming in their interviews, and I took particular care with students to assure them of their rights and the importance of honest answers. I think the student process was probably enhanced by self-selection; those who did not feel they could be honest most likely did not volunteer to be interviewed.

A final problem relating to insider research, particularly in a single case such as this, is the possible difficulty in maintaining anonymity of participants if required. This was avoided with students as their numbers were sufficiently large and comments could not easily be linked to individuals. However, comments by staff were much more obviously linked to particular individuals, which proved problematic for one of the lecturers, and is discussed more fully in the following section.

5.4.2 Ethical considerations

In terms of formalised processes, ethical clearance was granted by the Rhodes University Research Ethics Committee, the Science Faculty Dean and relevant Heads of Departments. Requests for participation were always in writing and included an information sheet outlining aims and purpose of the research and possible extent of involvement of participants, as well as a copy of the informed consent form. Data from interviews were treated as confidential and only written transcripts have been used in the dissertation and presentations.

The above is a methodological approach to research ethics. However, Williams (2009, p212) makes the distinction between ethics of 'custom' and ethics of 'character'. Ethics of custom relate to the measures outlined in the above paragraph: procedures and guidelines on rules of conduct and informed consent, which represent the procedural approach to ethics adopted by most ethics committees in educational contexts. In contrast, ethics of character relate to the 'character' of the researcher, who faces moral issues that can only be dealt with through careful deliberation and judgement. Williams states that character represents the 'personal identity of

the researcher as social actor' and that this can only be formed through 'attention to the reflexivity of the researcher' (2009, p213).

In this regard Pring (2001, p418) situates ethics of character in the trustworthiness of the researcher, who should have moral virtues of courage, honesty, concern, modesty and humility. In turn, Costley and Gibbs (2006) refer to character ethics as an 'ethics of care'. Whilst these authors acknowledge the importance of the procedural approach to ethical guidelines common in current educational contexts, they argue rather for a foregrounding of a reflexive researcher's character. Since in qualitative educational studies we are always working with people, they argue researchers need to be sensitive towards and care for others, and respond appropriately when unexpected moral or ethical dilemmas arise.

In the initial stages of the study my focus was on ethics of custom: following 'correct' procedures as demanded by our institutional ethics guidelines. However, as the study proceeded, I faced ethical dilemmas that, in a sense, forced me to re-evaluate my approach towards the process and in particular towards participants. The decision of a key staff informant to not be involved in the research process (neither interview nor classroom observations, although I received permission to use their course materials) stemmed from assumptions I made as an 'insider' researcher. Because of our professional and friendly working relationship I had assumed her/his involvement would be unproblematic and as a result did not consult until I made the request for interviews and classroom observations (I was already doing such observations on a regular basis as part of my teaching). This presumptuous approach was inappropriate and she/he exercised her/his right to not be involved, which resulted in a large shift in the overall direction of the study. As already mentioned, she/he was also concerned with anonymity, an issue I could not guarantee would be overcome. All my future interactions with potential interviewees were, and in the future will be, much more sensitive and consultative.

Another dilemma I faced, also associated with my insider status, was linked to the multiple roles I held in my relations with students. I have already mentioned this in the section on interviews; suffice to say here that I often had to 'park' both teaching and counselling issues during interviews and offer support at a later stage, which quite often did not materialise due to time and other constraints. This approach therefore favoured my research agenda rather than student learning or counselling agendas, which discomfited me considerably and was never satisfactorily resolved in my mind.

5.5 Data analysis: Developing external languages of description

The previous chapter elaborated on the theoretical work that frames the work in the dissertation and this section of the chapter focuses on how those theories guide the form and

nature of data analysis. Data were analysed through developing external languages of description.

Bernstein (2000) uses the phrase 'internal languages of description' to refer to languages of theories and concepts and he distinguishes them from 'external languages of description', which are languages that describe something beyond theory and are related to external, often empirical, referents. Therefore, in order to bridge the 'discursive gap' between the abstract, dense theoretical concepts used in this study, such as LCT(Specialisation) and student acquisition of recognition and realisation rules, and the empirical data held in thousands of pages of course documents and student writing and hundreds of pages of transcribed data from 45 interviews, it was necessary to develop external languages of description (Bernstein 2000, Chen and Maton 2014). Basically, the external language of description serves as a translation device and provides opportunities for dialogue between theoretical concepts and empirical descriptions and can be used, as in this study, to identify spaces of social equity/inequity (McLean, Abbas and Ashwin 2013). The external languages developed in this study emerged through iterative processes of movement between data and theory. The NVivo software tool was used to manage the data analysis process.

The sections that follow describe the development of an external language of description for curriculum which is based both on knowledge types (Table 5.2) and conceptions of knowers (Table 5.3); pedagogy which is based on framing of instructional discourse in terms of teaching (Table 5.4a) and the regulative discourse on authority relations (Table 5.5); assessment which is based on framing of relations in terms of assessment practices (Table 5.4b) as well as an analysis of criteria for assessment tasks (Table 5.6); and student response in terms of acquisition of recognition and realisation rules (Tables 5.7 and 5.8).

5.5.1 Curriculum: LCT(Specialisation)

The first research question asks how knowledge and knowers are characterised and legitimated in the ISCM curriculum. This is an LCT(Specialisation) code question and requires developing an external language of description between the theoretical concepts of epistemic and social relations and the empirical data as presented in ISCM course documentation: course and semester handouts; lecture, tutorial and practical handouts; readings; and resource materials. Assessment tasks (major assignments, tests and exams) were excluded from this analysis as they were analysed separately elsewhere.

In this case (unlike in the ones that follow) a detailed account of the external language of description is provided. The detail is a reflection of the difficulty I had finding a theoretical home for disciplinary, literacies, and academic practices knowledge types under a single

theoretical (epistemic relations) umbrella. I also battled with appropriate categorisations of social relations until I engaged with concepts of epistemological and axiological concerns, as mentioned in the previous chapter.

5.5.1.1 Epistemic relations

Epistemic relations are relations between practices and their object of focus (that part of the world toward which practices are oriented; Maton 2014a, p29). It is standard practice to use a simple dichotomous characterisation of epistemic relations: relatively stronger epistemic relations (ER+) for specialised knowledge and procedures that are strongly bounded (+C) and framed (+F), and relatively weaker epistemic relations (ER-) for less specialised knowledge that has less clear boundaries (-C) and is weakly framed (-F). In this study I refer to these as **epistemic (conceptual) knowledge** (relatively strong; ER+) and **non-epistemic (contextual) knowledge** (relatively weak; ER-) respectively (Table 5.2).

Table 5.2: Characterisation of knowledge in ISCM using LCT(Specialisation): External language of description and empirical evidence for epistemic relations

Theoretical concept	External language of description		Empirical data from course documents
Epistemic (conceptual) knowledge	Disciplinary knowledge (DK) is valued	ER++	<p>Principled knowledge - students need to know/understand: Stoichiometry Limiting reagents Chemical equilibrium</p> <p>Procedural knowledge - students need to: Perform titrations Balance equations Calculate limiting reagents</p>
	Scientific literacies knowledge (SLK) is valued	ER+	<p>Principled knowledge - students need to know/understand: Scientific concepts: standard units of measurement; significant figures; independent and dependent variables; hierarchies and connections The value of and need for: empirical data; careful observation; use of significant figures; honesty in reporting; randomisation in experiments Basis upon which knowledge claims are made (tentative claims; use of data) How scientific knowledge is constructed (inductive and deductive reasoning, experimentation, observation, measurement)</p> <p>Procedural knowledge - students need to: Design and conduct experiments; present results in scientific poster and orally Work with quantitative and qualitative data Measure accurately and precisely Write scientific laboratory reports, essays Read and think critically in the sciences Evaluate sources</p>
Non-epistemic (contextual) knowledge	Academic practices knowledge (APK) is valued	ER-	<p>Contextual (rules) knowledge - students need to know/understand: Organising principles of: library, internet, dictionary, words (prefix, suffix), paragraphs, essays, text books, learning context</p> <p>Academic practices - students need to: <i>Technical practices:</i> access information (library, internet, dictionary); organise (notes; use diaries; manage time) <i>Read/write/listen practices:</i> read (anticipate, headings, pictures); write (paragraph: topic sentence, supporting information; essay: introduction, body, conclusion); listen (cues, repetition); take notes (shorthand, leave gaps for later work) <i>Study practices:</i> prepare; review; consolidate; ask questions</p>

			<i>Assessment techniques:</i> time management, unpacking questions
	Everyday knowledge (EK) is valued	ER--	Contextual knowledge - students need to know/understand: No data
			Procedural knowledge - students need to: Draw on home-based practices related to growing of plants (to conceptualise independent research project)

However, as in the case of work by Gamble (2004, 2006, 2009) and Shay et al. (2011), this simple dichotomy proved inadequate to describe knowledge in the ISCM curriculum, as two categories of specialised epistemic knowledge and two of non-epistemic knowledge, each exhibiting relatively stronger or weaker epistemic relations along a continuum, could be distinguished. The basis for distinction of the four categories is mentioned here, but a fuller description of each follows shortly. At the one end of the continuum there is **disciplinary knowledge** (DK), such as that associated with Chemistry or Geology which, because of relatively stronger classification and framing, has an ER++ categorisation (Table 5.2). Also visible in the curriculum is more general science knowledge that has an epistemic base but, since it is less strongly classified and framed than disciplinary knowledge, it has an ER+ categorisation. As will be explained presently, this category has been referred to as **scientific literacies knowledge** (SLK). In terms of non-epistemic knowledge both **academic practices knowledge** (APK) and **everyday knowledge** (EK) are visible in the curriculum. Because classification and framing are, relatively speaking, more weakly classified and framed in the everyday context, everyday knowledge is categorised as ER-- and academic practices knowledge as ER-.

Initially it was difficult to 'see' knowledge in much of the course documentation as many tutorials were focused on literacies and academic practices work. However, by making the assumptions that (a) all practices and procedures are themselves a form of knowledge, and (b) practices and procedures are underpinned, either tacitly or overtly, by some form of principled or contextual knowledge, the next level of sub-categorisation which distinguishes between principled (or contextual) and procedural knowledge was possible. Within this sub-categorisation both disciplinary and scientific literacies knowledge have 'principled' and 'procedural' knowledge (Table 5.2). In contrast, the academic practice and everyday knowledge types instead have 'contextual' (which may be principled) and procedural knowledge. As such, these eight sub-categories make up the principled and procedural knowledge that characterise the ISCM curriculum. The eight sub-categories are described in more detail below, using empirical data from the ISCM course documentation to illustrate them.

The first of the eight sub-categories is that of **disciplinary principled knowledge**. This draws on disciplinary theory, and examples from Chemistry are the concepts of stoichiometry, limiting reagents and chemical equilibrium (Table 5.2). The second sub-category is **disciplinary procedural knowledge**, which is procedural knowledge that has a strong theoretical base such as, again using Chemistry as an example, performing titrations, balancing equations and calculating limiting reagents. Both disciplinary principled and procedural knowledge types are common in most science courses and their identification in the ISCM curriculum is not unexpected. However, the following sub-categories relating to scientific literacies and academic practices knowledge require a bit more explanation as they form the contribution of this dissertation in finding a theoretical and analytical home for such work in LCT(Specialisation). This is because literacies and academic practice work is usually 'process' oriented and has not, to my knowledge, been analysed using epistemic relations in this way.

In analysing course documentation it was clear that a large portion of procedural work done in ISCM had an epistemic base but was of a more general scientific nature rather than being associated with a specific discipline. Since academic literacies are viewed in this study as a set of social practices with an *epistemic* base (Street 2006, p2), this was named the scientific literacies knowledge category, and the **scientific literacies procedural knowledge** sub-category was based on procedural knowledge and includes what scientists *do* (e.g. design and conduct experiments; work with quantitative and qualitative data; write laboratory reports; present scientific arguments; evaluate sources), and how they *act* (e.g. work accurately and precisely; observe carefully; report honestly). However, this procedural knowledge is underpinned by **scientific literacies principled knowledge**, which relates to what scientists *know* (e.g. standard units of measurement; significant figures; independent and dependent variables; hierarchies and connections), and what and how they *value* (e.g. empirical data; randomisation in experiments; careful observation; tentative claims; basis upon which knowledge claims are made; critical thinking; Table 5.2). The work done within these two sub-categories is equivalent to Gee's concept of literacies, which relates to mastering ways of 'thinking, feeling, believing, valuing and acting, as well as using various tools, technologies, or props that can be used to identify oneself as a member of a socially meaningful group' (2012, p158).

Unlike the scientific literacies knowledge sub-categories, which are embedded in the norms and values of science and therefore have an epistemic base, the academic practices knowledge sub-categories have no epistemic underpinnings, hence an ER- categorisation (Table 5.2). The dominant one in ISCM is the **academic practices procedural knowledge** sub-category, which is referred to simply as **academic practices**. This is the equivalent to the 'study skills' term of New Literacies Studies theorists Lea and Street (1998, 2006), who suggest that skills are always

subsumed in a practice. Students in ISCM need to be able to perform a range of generic tasks in order to be successful in an academic context and these relate firstly to the various *conventions* and *techniques* that can be addressed in acontextual ways such as accessing information, working with new terminology and vocabulary, writing a paragraph, unpacking questions, and managing time in tests. Secondly, they relate to *organisational, study and learning practices* that students are expected to develop in an academic context. These relate to developing organisation procedures such as filing, using diaries and managing time; working appropriately by preparing in advance of learning (lectures, practicals) interactions, consolidating after learning interactions, asking questions, and taking good notes. The **academic contextual knowledge** that underpins the academic practices, such as the organising rules and principles of libraries, internet, text books, words, etc., tends to be fairly implicit. However, attempts are made in ISCM to make them explicit through direct teaching.

The final two sub-categories, **everyday contextual knowledge** and **everyday procedural knowledge** refer respectively to contextual and procedural knowledge that is firmly embedded in particular everyday contexts (Table 5.2). An example of the latter in ISCM is where students are required to draw on home-based practices related to growing plants to help them conceptualise their independent research project, which examines experimentally the effect of an environmental factor on the growth of pot plants.

Although the above principled and procedural knowledge types are represented as distinct categories, they in fact exist on a continuum and categorisation of data is not always as obvious as has been presented here. For example, writing a scientific laboratory report, with its conventions on report structure, basis for making claims, and conventions for referencing are categorised in this study as scientific literacies procedural knowledge (Table 5.2). However, such a report would also, of necessity, draw on disciplinary principled and procedural knowledge related to the topic of the report. In another example, the context in which something is taught influences categorisation. As such, if writing a coherent paragraph is taught in an acontextual manner based on generic 'rules', such as the use of logical connecting words, it would be categorised as an academic practice as there is no epistemic base. However, if paragraph writing is taught in the context of building an argument in science it would be categorised as scientific literacies procedural knowledge because of the epistemic underpinnings of the approach.

5.5.1.2 Social relations

Social relations are relations between *practices* and the *actor* (who is enacting the practices), and highlights *who* can be a legitimate knower (Maton 2014a, p29; my italics). In this study, when actors' dispositions, values and opinions are valued in a particular context the social

relations are relatively stronger (SR+) and the knower is being legitimated. If the dispositions, attitudes and opinions are downplayed the social relations are relatively weaker (SR-) and a knower is not being legitimated. As indicated earlier in the epistemic relations categorisations, stronger social relations here reflect stronger classification (+C) and framing (+F), and weaker social relations reflect weaker classification (-C) and framing (-F).

Maton (2014a, pp94–95) suggests that, since knowledge is privileged in science, social relations are usually relatively weak. However, in this study, stronger social relations are apparent in some contexts and in this regard I found it necessary to make the distinction between social relations based on **epistemological** concerns and those based on **axiological** concerns of the learning context. In other words, when a practice is oriented towards *science* knowledge, the social relations have ‘epistemological concerns’ and when the practice is oriented towards the *learning context*, the social relations have ‘axiological concerns’, the latter of which relate to students’ values and attitudes towards learning in the academic context. The two forms of social relations are referred to respectively as **epistemic-context social relations** (SR(ec)) and **learning-context social relations** (SR(lc)) and are explicated below drawing on empirical data.

In this study, stronger epistemic-context social relations (SR(ec)+) represents a valuing of students’ dispositions, values and opinions as legitimate scientific knowledge – and there were no data in the curriculum documentation supporting this category (Table 5.3). Weaker epistemic-context social relations (SR(ec)-) reflect a situation where students’ dispositions, values and opinions are sought but downplayed as scientific knowledge, and there were data supporting this category. For example, where opinion is sought on nuclear energy as a viable form of energy generation, students are required to frame their discussions in a scientific context of logical argument and based on empirical data. The *focus* is therefore on student opinion but the *basis* for any claims they make is the knowledge of the field or discipline.

Table 5.3: Characterisation of knowers in ISCM using LCT(Specialisation): External language of description and empirical evidence for social relations

Theoretical concept	External language of description			Empirical data from course documents*
Social relations: knower dispositions, attitudes, opinions	Epistemological orientations	Students’ science/epistemic dispositions, attitudes and opinions are emphasised and valued as legitimate scientific knowledge	SR(ec)+	No data
		Students’ science/epistemic dispositions, values, opinions downplayed as legitimate scientific knowledge	SR(ec)-	Students asked opinions on nuclear energy as a form of energy generation, but answers must have scientific base
	Axiological (learning-context) orientations	Students’ science learner dispositions, attitudes and opinions are emphasised and valued for shaping own	SR(lc)+	Students reflect on own learning strategies and consider appropriateness for university context.

		learning		Students consider own response to and engagement with feedback for learning.
		Students' science learner dispositions, attitudes and opinions are downplayed for shaping own learning	SR(lc)-	No data

*Based on curriculum documentation data. Different data surfaces later in pedagogic practices analysis

For the stronger learning-context social relations (SR(lc)+) categorisation, which reflect a valuing of students' dispositions, values and opinions related to their own learning context, there are supporting data (Table 5.3). For example, when students are required to reflect on their own learning strategies and consider appropriateness to the university context, their reflective opinions and actions are emphasised and valued. Although no data are visible in the curriculum documentation for weaker learning-context social relations (SR(lc)-), this could simply be a signal that most of the time students' attitudes, values and opinions are not being legitimated in the curriculum.

5.5.2 Pedagogy

The second research question asks how pedagogic and assessment practices are framed and legitimated in ISCM to enable access. In terms of pedagogic practices this study draws on Bernstein's (2000) concepts of regulative and instructional discourses. The regulative discourse relates to the underpinning norms and values of the teaching and learning context and the instructional discourse relates to what is taught and how it is taught. Similar to other studies on pedagogy (Morais and Neves 2001; Arnot and Reay 2004; Ensor 2004; Rose 2004; Morais, Neves and Pires 2004; Morais, Neves and Afonso 2005; Hoadley 2008), the external language of description developed in this study for the instructional discourse relates to the framing of selection, sequencing and pacing of knowledge (Table 5.4a), and aspects of working with evaluation criteria and feedback (Table 5.4b). As mentioned already, the principle of framing relates to degree of control; when framing is strong the transmitter (lecturer) has explicit control and when it is weaker the acquirer (student) has greater control.

Table 5.4a: Framing of instructional discourse associated with ISCM pedagogic practices: External language of description and empirical evidence

Concept	External language of description	Empirical data from course documents, staff interviews, observations, critical reflections, presentations, discussions
Selecting knowledge	Knowledge selected mainly by lecturer (+F)	1. Lecture content and tutorial material is determined a priori jointly by SESP and disciplinary lecturers. (Own observation) 2. ... bit of anatomy, a little bit of biomechanics, a little bit of physiology, a little bit of human information processing, ya so those are the four lectures and I try and pull them together with the last one. (Staff interview, RA8)
	Students select knowledge themselves (-F)	3. When designing their independent research project on how plants respond to variation in an environmental factor, students are strongly encouraged to call upon home practices and experiences in their choice of environmental factor. The disciplinary knowledge that underpins their projects is thus independently sourced by students. (Own observation)
Sequencing of knowledge	Sequencing determined mainly by teacher (+F)	4. We start off with foundational blocks of units, size and scale that they need for the rest of their degree ... physics is the foundational one ... starts off as not so difficult and it gets more challenging. (Staff interview, RA6) 5. Geology has a complexity that few other fields have on offer which is why it is last in ISCM course. (Staff interview, RA9)
	Sequencing influenced strongly by students (-F)	6. ... they've gone away and read the textbook and they come back [to the lecture] and I say, alright now, you tell me, what have you read. Okay, what did you find out about and they tell me and I make a list on the board of the things that they have done or found or what is this chapter about or whatever. And then I say which bits did you find difficult or not understand and ask which they want me to talk about first. (Staff interview, RA6)
Pacing of knowledge	Pace determined mainly by teacher (+F)	7. Dates for submission of assignments and tests are set at the beginning of the semester and are seldom changed. (Own observation) 8. I do way too much talking, and too much transmission ... to cover the content. (Staff interview, RA6)
	Pace influenced strongly by student needs (-F)	9. Although there is an overall teaching plan for the semester, we (literacy practitioners) meet weekly and make adjustments to accommodate current student understanding. (Own observation)

+F=stronger framing; -F=weaker framing; RA=recontextualising agent

In terms of selection of knowledge, stronger framing is exhibited when staff select course material a priori for teaching in class and weaker framing when students draw on home practices to design their research project (Table 5.4a, empirical sources 1–3). For sequencing of knowledge, stronger framing is visible when foundational concepts are addressed first in the course, weaker framing when students influence the topic and sequence of material taught within a lecture (Table 5.4a, empirical sources 4–6). In terms of pacing, when dates for assignment submission and tests are determined in advance it represents stronger framing, but when what is taught in tutorials is adjusted on a weekly basis based on student needs it represents weaker framing (Table 5.4a, empirical sources 7–9).

Table 5.4b: Framing of instructional discourse associated with ISCM assessment practices: External language of description and empirical evidence

Concept	External language of description	Empirical data from course documents, staff interviews, observations, critical reflections, presentations, discussions
Working with evaluative criteria	Evaluative criteria are explicitly stated (+F)	<p>1. <i>Stated criteria for discussion in a scientific poster:</i></p> <ul style="list-style-type: none"> • Clear and accurate <i>explanation</i> of results • Links back to literature • Conclusion accurate and linked to hypothesis • Recommendations for future study (Poster criteria handout, 2013) <p>2. <i>Section of rubric for essay draft:</i></p> <ul style="list-style-type: none"> • Sentence structure, grammar and academic register: • Excellent: Well expressed with good control of language. Appropriate academic register. Evidence of proof-reading • Good: Academic register largely maintained. Sentences well constructed. A few grammatical/spelling errors. • Needs work: Register informal. Sentences poorly constructed. Several grammatical/spelling errors. No proof-reading. • Fail: No understanding of academic register. Poorly expressed. Grammatical/spelling errors interfere with understanding. No proof-reading. (Essay rubric handout, 2013)
	Evaluative criteria are open-ended or not stated (-F)	3. No marks allocated to questions (Problem solving and critical thinking tutorial handout, 2013)
Working with feedback associated with evaluative criteria	Feedback explicit, clarifies concepts, makes suggestions for improvement, worked with actively in class (+F)	<p>4. <i>Suggested answer to question in a class test 2, semester 2:</i> <i>Question:</i> Use the graph to <i>explain</i> the effect of water on the melting of rock such as basalt. (6) <i>Suggested answer:</i> The solidus line is the temperature at which rock starts to melt. Under ‘normal’ conditions none of the rocks would melt up to 100km depth, because the temperature is always lower than the melting point. However, if water is added to the rock, the temperature at which the rock melts is lowered (i.e. the graph shifts to the left). This means at 60km depth or more, the rock will melt. (Test memorandum, 2013)</p> <p>5. Need to get back to basics here! In results you need to DESCRIBE – (1) what graph shows, (2) overall trend (3) week by week detail. In the discussion you need to EXPLAIN the results (refer back to literature) – don’t repeat all results (Feedback on student poster, 2013)</p>
	Feedback general and requires student active engagement for improvement (+/-F)	<p>6. Think carefully about logical flow of information (Feedback on student poster, 2013)</p> <p>7. These statements do not make sense. Need to express differently. (Feedback on student poster, 2013)</p>
	No feedback or feedback insufficient for student improvement (-F)	8. Mark allocated without any feedback comment (Practical 1, semester 1, 2013)

+F=stronger framing; -F=weaker framing; RA=recontextualising agent

In terms of working with evaluative criteria, stronger framing indicates explicit articulation of the criteria and weaker framing indicates implicit or open-ended criteria or no criteria (Table 5.4b, empirical sources 1–3). The data on working with feedback was sufficiently nuanced for three categories of framing: stronger framing, pointing to explicit feedback that clarifies concepts, makes suggestions for improvement and is worked with actively in class; neutral framing, referring to general feedback that requires student active engagement for improvement; and weaker framing, referring to where there is no feedback or feedback is

insufficient for student improvement – where a mark is allocated with no comment (Table 5.4b, empirical sources 4–8).

The external language of description developed in this study for the regulative discourse relates firstly to the regulation of staff–student relations, where stronger framing is represented by a strong hierarchy between lecturer and student (such as punitive measures for late assignments), and weaker framing by a weak hierarchy (such as an open-door policy for student consultation; Table 5.5, empirical sources 1–4). Secondly, the regulative discourse focuses on regulation of student science learning conduct, with stronger framing being represented by explicit articulation of expectations of autonomous learning conduct (for example explicitly modelling and talking about the need to consolidate lectures), and weaker framing when these expectations are implied (for example lecturer expectations of preparation not articulated; Table 5.5, empirical sources 5–6)⁸. Thirdly it focuses on regulation of student conduct as scientists, with stronger framing relating to explicit articulation of expected conduct and practices based on epistemic values (such as instruction and practice of careful observation in the field), and weaker framing relating to implicit expectations of the same (such as assuming involvement in practicals leads to appropriate practices; Table 5.5, empirical sources 7–8).

⁸ The reasons for valuing autonomous learning becomes clear in Chapter 7 where these concepts are dealt with in full.

Table 5.5: Framing of regulative discourse of ISCM pedagogic practices: External language of description and empirical evidence

Concept	External language of description	Empirical data from course documents, staff interviews, observations, critical reflections, presentations, discussions
Regulating staff-student relations	Strong hierarchy between lecturer and student (+F)	1. DP requirements: It is expected you attend ALL lectures, tutorials and practicals. It is compulsory you attend 80% of practicals, write all tests and hand in all assignments on time. There is a 5% mark reduction per day for late submission of assignments. (SESP handbook document, 2013) 2. <i>'Unwritten rules' of lectures/tutorials/practicals</i> Items include: Attend everything; Do not arrive late; Bring pens; paper, etc. – be ready at start; Prepare if requested; Turn off cell phone; No eating or drinking; Don't obviously fall asleep (!); Respect for lecturer and peers; Be responsible for own knowledge and learning (take notes, ask questions) ; Each contact period – spend equivalent time working on own. (Powerpoint slide, week 1, RA4)
	Weak hierarchy between teacher and student (-F)	3. We discussed entering a partnership with them in which we work together to ensure their success. (Reflective Journal, 2014) 4. I tell them my door is always open. Students may come and see me any time – if I am busy I will make a time when we can both meet. I suggest they can come on their own or in a small group if you are all having the same problem. (Staff interview, RA4)
Regulating student learning conduct in science	Expectations of autonomous learning explicitly articulated (+F)	5. This week we did not do consolidation of the lecture or the practical and I asked students why they thought this is so. The discussion that followed related to students needing to do the consolidation work themselves and how they could best go about it. (Reflective Journal, 2014)
	Expectations of autonomous learning implicit (-F)	6. Lecturer: I don't always lecture exactly the same way the whole way through ... sometimes they have to do more of the preparation themselves, ya, more prep themselves. Interviewer: So is that a conscious thing? Lecturer: I try to be ... [but] I don't think that I'm nearly conscious enough about what I'm doing and why I do it. I don't think I make it clear to students. (Staff interview, RA6)
Regulating student conduct as scientists	Explicit articulation of expected conduct and practices based on epistemic values (+F)	7. The observation exercises that [X] does on the field trip are great! It's such a good lesson on how science is based on careful and thoughtful observations, and that only after that do they need to do measurements. (Reflective Journal, 2013)
	Expected conduct and practices based on epistemic values are implicit (-F)	8. ... the interactions, the practicals are obviously invaluable ... they get involved doing what scientists do ... very often the penny drops then. (Staff interview, RA8)

+F=stronger framing; -F=weaker framing; RA=recontextualising agent

5.5.3 Assessment: Cognitive process levels

As in the previous section, this section is also aimed at answering the second research question that asks how pedagogic and assessment practices are framed and legitimated in ISCM to enable access, with the focus here being on assessment. Since I wanted to capture both the level of complexity of questions and also the range of principled and procedural knowledge types reflected in the assessment tasks, an adaptation of Krathwohl's (2002) revision of Bloom's Taxonomy of Educational Objectives (1956) proved useful in this regard.

Drawing on tests, exams, major assignments, tutorials, and practicals, six cognitive process categories were identified, listed in order of increasing cognitive complexity: recall (or follow instructions), comprehension, application, analysis, evaluation, and creation (Table 5.6). In this study recall means reproducing information, remembering one or more ideas, performing single- or multi-step practical tasks and following practical instructions (Table 5.6). Questions could relate to providing a definition or measuring the size of an object. Comprehension relates to demonstrating understanding, or performing moderately simple (or complex) tasks based on relatively simple (or complex) concepts from one or more sections of the course. Typical questions would be describing inductive thinking, or explaining a process such as decompression melting. Application refers to calling on familiar examples to illustrate a concept or applying theoretical or practical or personal knowledge in familiar (basic) or new (complex) contexts. A good example is drawing on knowledge of aspects of rocks to identify the rock-type.

Analysis requires breaking theoretical or practically-produced material into constituent parts and rearranging these to support an argument, or interpret or predict a situation. This may require reading a text and explaining how the researchers ensured reliable data, or developing an argument on energy generation in South Africa (Table 5.6). Evaluation requires students to judge, argue, or critique in well-reasoned and logical ways. A typical question could relate to assessing which of a range of scenarios of lifting objects would be most damaging to one's health. Creation necessitates putting elements together in a new, coherent whole or developing something new by applying familiar rules or procedures. Writing a research proposal and presenting a scientific oral presentation are good examples.

The tool, as developed in this study, also allowed for recognition of the main knowledge types (disciplinary, scientific literacies and academic practices; principled and procedural) identified in Table 5.2. Everyday principled and procedural knowledge are excluded as they were not visible in assessment tasks.

Aspects of evaluative criteria and feedback associated with assessment tasks has already been dealt with in section 5.5.2 on pedagogic practices (in particular Table 5.4b).

Table 5.6: Characterisation of ISCM assessment tasks: Empirical evidence for (a) cognitive process levels and (b) knowledge (principled and procedural; adapted from Krathwohl 2002)

Cognitive process levels	Knowledge (principled and procedural)		
	Disciplinary knowledge (DK)	Scientific literacies knowledge (SLK)	Academic practices knowledge (APK)
Creation Put elements together in a new, coherent whole; develop something new by applying familiar rules or procedures	Principled and procedural knowledge Develop (e.g. data sheet; procedures for choosing correct graph; principles to guide poster production) Write a research proposal (e.g. plant growth experiment) or essay (e.g. sun structure and energy) Design and conduct independent experiment (e.g. plant growth experiment) Present a scientific oral presentation (e.g. plant growth experiment)		
Evaluation Judge, argue, critique in a well reasoned and logical way	Principled and procedural knowledge Assess (e.g. which scenario of lifting objects will be most damaging to health) Evaluate (e.g. how to improve soap making procedure based on chemical knowledge)	Principled and procedural knowledge Critically evaluate (e.g. usefulness of article; data sheet; information sources) Assess (e.g. a peer's or own work using criteria)	
Analysis Break theoretical or practically produced material into constituent parts and rearrange to support argument, interpret or predict	Principled and procedural knowledge Argue (e.g. whether SA should use nuclear or renewable resources to produce electricity) Interpret (e.g. indicate on map possible location of contour path/dam)	Principled and procedural knowledge Explain (e.g. how researchers ensured reliable data; how writers organised their work) Analyse (e.g. own test answers based on criteria) Predict (e.g. graph shape and trend)	
Application Call on familiar examples to illustrate (basic); OR apply theoretical or practical or personal knowledge in familiar (basic) or new (complex) contexts	Principled knowledge Identify (e.g. rock type using a key) Illustrate (e.g. impact of nuclear fission) Procedural knowledge Investigate (e.g. effects of sex on muscle strength) Interpret (e.g. topographic maps)	Procedural knowledge Provide (e.g. a scale bar) Identify strategies (e.g. for organisation in text) Suggest change (e.g. in writing style) Use citations to develop argument Interpret unfamiliar representations (e.g. graphs)	
Comprehension Demonstrate understanding, or perform moderately simple (or complex) tasks, based on relatively simple (or complex) concepts and single (or more) sections	Principled knowledge Identify (e.g. lever class; causal links of disease) Explain (e.g. decompression melting; sliding filament theory) Procedural knowledge Draw (e.g. lever diagram; topographic profile) Work with equipment (e.g. dynamometer)	Principled knowledge Explain value of (e.g. accuracy, empirical data) Explain reasons for referencing in scientific texts Describe (e.g. inductive thinking; theory) Procedural knowledge Identify variables; draw graph; convert units	Procedural knowledge Identify themes Write paragraph with logical connectors; Cite; reference
Recall /follow instructions Reproducing information; remembering single or number of ideas; performing single- or multi-step practical tasks; following practical instructions	Principled knowledge Label (e.g. components of nuclear reactor) Define (e.g. a half-life) Procedural knowledge Weigh (e.g. triple beam & electronic balance) Draw (e.g. bone; rock strata)	Principled knowledge State (e.g. three ideas from pre-scientific period) Procedural knowledge Measure (e.g. length; mass; time) Calculate (e.g. circumference; area; volume)	

5.5.4 Student response: Acquiring recognition and realisation rules

The third research question, which asks how students interpret and respond to ISCM educational practices, informs the analysis in this section. Student responses to a wide range of assessment tasks that were set at different cognitive process levels and for different principled and procedural knowledge types were analysed according to Bernstein's (2000) concepts of student acquisition of coding orientations, or, in other words, acquisition of recognition (recognising the context) and realisation (producing legitimate text) rules. A number of authors (Morais and Atunes 1994; Bernstein 2000, Morais, Neves and Afonso 2005) distinguish between *passive* realisation, which refers to selection of meanings or justifications appropriate to a pedagogic context, and *active* realisation, which is the production of text required by the pedagogic practice. However, because the analysis of recognition of realisation rules in this study was based solely on student texts, I could not make this distinction. Nonetheless, as indicated in Chapter 4, I distinguished between *epistemic-context* recognition and realisation to produce legitimate texts in assessment tasks, and *learning-context* recognition and realisation in which legitimate 'text' is demonstrated through self-regulated, independent learning. The same distinction was made in the social relations in section 5.5.1.2. Therefore two different external languages were developed to accommodate the two levels of *epistemic-context* and *learning-context* recognition and realisation.

In terms of *epistemic-context* recognition (RC(ec)) and realisation (RL(ec)), *no recognition* indicates a student has no understanding of the context (concepts, values, conventions and procedures) necessary to produce an appropriate text (Table 5.7). For example, they may answer a calculation question with a written answer. *Recognition but incomplete realisation* indicates they have good understanding of the context but only present some correct concepts and values and apply some appropriate procedures and conventions to produce partially suitable text. A typical example is recognising the need to measure and use ratios in calculating a scale bar, but using incorrect choice of scale bar length in the final stage of calculation. *Recognition and realisation* means the student presents correct concepts and values and applies appropriate conventions and procedures to produce a suitable text, usually either in some form of written or oral answer related to course content. For example, this would include not only providing the correct scientific text, such as why large elements are radioactive, but also developing a logical argument in paragraph format.

Table 5.7: Student acquisition of epistemic-context recognition and realisation rules for assessment contexts: External language of description and empirical data

Concept	External language of description		Empirical data from student texts in June exam 2014
Recognition and realisation rules for epistemic (assessment) context	Does not possess recognition for task RC(ec)-	No understanding of context (concepts, values, conventions and procedures) necessary to produce appropriate text	Student answered a calculation question with a written word answer, and mentioned unrelated concepts (Researcher analysis of student answer to comprehension question; Paki)
	Possesses recognition but incomplete realization for task RC(ec)+/RL(ec)-	Good understanding of context (concepts, values, conventions and procedures), but only presents some correct concepts and applies some appropriate procedures and conventions to produce partially suitable text	Calculation of scale bar: Student had measured accurately, used ratios and units and calculated correctly, but their choice of length of scale bar representation as well as their final rounding off were inappropriate (Researcher analysis of student answer to application question: Paki)
	Possesses recognition and realisation for task RL(ec)+	Presents correct concepts and values and applies appropriate conventions and procedures to produce suitable text	In an answer explaining why large elements are radioactive the student correctly mentioned sub-atomic particles and the two different forces resulting in instability in large atoms. Also, correct writing conventions were followed (paragraph and sentence structure, logical flow, explanation as opposed to description, etc.)(Researcher analysis of student answer to comprehension question; Nikelwa)

Whilst student acquisition of coding orientations at an epistemic-context level was possible through analysis of student writing in assessment tasks, the coding was confirmed in follow-up student interviews. However, student acquisition of coding orientations at a learning-context level was not directly visible in assessment tasks and could only be established through student interviews, as indicated in the external language of description that follows.

In the case of *learning-context* recognition (RC(lc)) and realisation (RL(lc)) in the sciences, the external language of description relates to student learner autonomy (Table 5.8). *No recognition* means the student has no understanding that they need to be responsible for their own knowledge, work independently and develop their own understanding. A common example is students simply ignoring aspects of the work, especially if they have found it difficult. *Recognition but incomplete realisation* indicates they have good understanding of the need to be responsible for their own knowledge, work independently and develop their own understanding, but they do not achieve this consistently. A good example is students using past exams and tests to gain a sense of expected questions, but relying on this unquestioningly to guide learning. *Good realisation* means they are responsible for their own knowledge, work independently and develop their own understanding. Students who develop understanding and make links between all the different aspects of their work (from tutorials, lectures, practicals and enrichments) are demonstrating good realisation in a science learning context.

Table 5.8: Student acquisition of science learning-context recognition and realisation rules: External language of description and empirical data

Concept	External language of description		Empirical data from student interviews
Recognition and realisation rules for a science learning context	Does not possess recognition for expected science learning context RC(lc)-	No understanding of need to be responsible for own knowledge, work independently and develop own understanding	I remember the white handout [on sub-atomic particles] - I think that's where the quarks and the things were found. I didn't even look at it. (Student interview, Lulama)
	Possesses recognition but incomplete realization for science learning context RC(lc+)/RL(lc)-	Good understanding of need to be responsible for own knowledge, work independently and develop own understanding, but does not achieve this consistently	Ja I can say it was a matter of practice because as I have said I was using question papers and then I was kind of following the pattern in the question papers and then seeing that this kind of question never came out, I never minded it. So the last time I saw the question was in class and I never bothered practising, that was the problem, and I knew it. (Student interview, Sandla)
	Possesses recognition and realisation for expected science learning context RL(lc)+	Is responsible for own knowledge, works independently and develops own understanding	... right after the lesson I do consolidate with my work and make sure that I did understand it and that I did fill in the gaps and how did the prac go with the lesson that we had and why did we do the actual prac and why did you need to know this ... (Student interview, Anele)

The analysis of student acquisition of recognition and realisation rules indicates that students are least successful at acquiring learning-context realisation rules. A further level of analysis was needed to surface underpinning causal mechanisms as to why this may be so despite explicit instruction and modelling of appropriate learning and coping strategies. In order to generate such explanations at the level of the real I found it useful to code interview data as described by Maxwell (2012).

Maxwell (2012, p111-113) describes a coding process using three overlapping categories. The *organisational* categories are often established prior to data collection and do not really provide insight into causes. The *substantive* categories are descriptive categories within the organisational categories and because they are usually derived from participants comments remain close to the data (i.e. they don't imply theory). The *theoretical* categories in turn locate the coded data in a more abstract framework.

When interviewing students about their approach to learning in the broader academic context, the a priori organisational categories of recognition and realisation guided questions asked. In an inductive process of repeated reading of the interview transcripts, looking for similarities and differences in students' concepts and beliefs, clusters of concepts started to emerge which eventually resulted in a number of substantive categories. For example two categories for students not having learning-context realisation were linked to (a) a poor sense of the need to be responsible for their own knowledge, and (b) rote learning instead of developing understanding. It was then through a process of inductive reasoning that an argument is made for a code clash as well as a code conflict as being contributors to such poor learning-context

realisation. These arguments represent Maxwell's third *theoretical* category in the coding process.

5.6 Research quality

It has long been claimed that in order to legitimise our research and ensure quality we need to ensure that the methodological 'trinity' of (internal) validity, reliability and generalisation are adhered to (Tobin and Begley 2004, p389). However, concern is expressed in the literature on qualitative research on the capacity of these concepts to demonstrate rigour in naturalistic enquiry (ibid. p394). Whilst there is general agreement that rigour is important in qualitative research, just how it is demonstrated is still a matter for deliberation. In this regard many authors working in the qualitative field have suggested alternative terms for these concepts as well as a range of criteria against which such research can be compared or measured.

Generalisability, also referred to as external validity, which refers to the capacity to generalise from the study context into a wider context, has already been discussed in relation to this study in section 5.2 and is not considered further here. The concept of internal validity, which broadly relates to the degree of fit between reality and the conclusions, emerged initially in quantitative research and was often dependent on criteria related to sample size, repeatability, and statistical correlations. Establishing internal validity in qualitative research, often referred to as credibility or trustworthiness, is instead dependent upon strategies such as time in the field, triangulation, reflexivity, member checking, peer examination, interview technique, overall structural coherence, and use of 'rich' data (Lincoln and Guba 1985; Krefting 1991; Whittemore, Chase and Mandle 2001; Creswell 2007; Maxwell 2004). Reliability, referred to in the qualitative literature most often as dependability, can be demonstrated through auditing the research, triangulation, peer examination, and demonstrating a logical, traceable and clearly documented process (Krefting 1991; Schwandt 2001; Tobin and Begley 2004).

Taking into account the above-mentioned strategies, I have used the following measures to establish trustworthiness and dependability in this study:

- Wherever possible I have provided a rationale for the choices that were made in designing the study and highlighted any limitations that may be associated with these choices.
- As a result of conducting insider research I have had intensive and long-term (5 year) engagement with the context. Furthermore teaching and publishing in the academic development field for over 20 years constitutes part of that long-term engagement but in a broader context.

- Insider research allowed for gathering of ‘rich’ data as I drew not only on past studies and experiences, but also from intensive interviews in the current context.
- I used member checking by offering all participants the opportunity to check interview transcripts. Unfortunately it was not practical in terms of timing to offer participants the opportunity to comment on my interpretations of the findings in relevant chapters.
- I used triangulation in theory and concepts (LCT, student acquisition of coding orientations, literacies theory, epistemological access), in methods (interviews, observations, document analysis, critical reflection), in data (qualitative and quantitative) and in sources (ISCM and mainstream staff past and present, and students past and present).
- I have used numerous opportunities both in informal settings (‘tea-room’ chats and irregular involvement in two research ‘discussion’ groups on campus) and in more formal settings (research meetings with supervisor and colleagues as well as presentations at conferences and PhD weeks) to obtain peer input on my work.
- I tried to counter potential biases by being open about my positionality in the research, being honest about possible weaknesses in my approach – particularly in relation to my reflexivity, and documenting my educational background and the influence this had on my research.
- I have documented the process throughout by obtaining signed consent forms from participants, assembling and keeping all documentation utilised as data, storing raw and coded data in NVivo, and using a Reflective Journal and a reflective PhD Journal.

5.7 Direction in following chapters

This chapter is, in a sense, the operational link between theoretical ideas developed in Chapter 4 and the results as represented by data in the following chapters. Chapter 6 outlines knowledge legitimisation in curriculum, Chapters 7 and 8 legitimisation of pedagogic and assessment practices respectively, and Chapter 9 student response to ISCM educational practices. Chapter 10 examines ex-ISCM student response to four first-year mainstream courses.

Chapter 6: Knowledge and knowers in the ISCM curriculum

6.1 Introduction

In his early work Bernstein (1975, p85) argues that educational knowledge is realised through three main relay systems: curriculum (what counts as valid knowledge), pedagogy (what counts as valid transmission of knowledge), and assessment (what counts as valid realisation by the learner). This chapter focuses on curriculum as it aims to answer the first research question which asks 'How are knowledge and knowers characterised and legitimated in the ISCM curriculum?' The following chapters, which are answering subsequent research questions, have as their focus ISCM pedagogy and assessment (Chapters 7 and 8 respectively) as well as student response to ISCM (Chapter 9) and mainstream educational practices (Chapter 10).

The empirical data for this chapter were derived primarily from 2013 course documentation as presented to students (course outlines; lecture, practical and tutorial handouts; and resource material). The main assessment tasks (major assignments, tests and examinations) were excluded from this analysis as they are examined separately in Chapter 8. The first part of the chapter briefly describes the current purpose and overall structure of the ISCM course. This is followed by an LCT(Specialisation) analysis of recent course content, which provides insight into the principles and logics underpinning the ISCM curriculum in terms of epistemic and social relations. The epistemic relations, which prove to be visible and dominant in the analysis, allow for a detailed and nuanced differentiation of ISCM knowledge types and knowledge practices. LCT(Semantics) is used to 'map' out the different knowledge types and knowledge practices, which provides space for comment on their role in enabling epistemological access in a science foundation course such as ISCM.

6.2 Current ISCM purpose and course components

The early development of the ISCM course, and its overall structure and functioning is provided in Chapter 2. This section outlines the purpose of the course and describes the various course components. The purpose of the course, as articulated to the students in the semester 1 course outline (2013), is as follows.

The ISCM course aims to introduce students to:

- Concepts, methods and skills¹ used in the sciences
- How scientific knowledge is constructed
- Influence of science on society and *visa versa*
- Science departments, lecturers and disciplines.

¹ Called practices in this study.

The outcomes² of the course are for students to be able to:

- Know, understand and apply aspects of scientific knowledge from a range of disciplines
- Cope well in a higher education context (manage time, take notes, learn effectively, adapt to new situations, etc.)
- Locate and use different sources of information appropriately
- Communicate effectively in different modes and genres
- Collect, analyse and present numerical and other scientific information
- Solve scientific and social problems that are related to science
- Conduct an independent scientific experiment from inception until final presentation.

It is worth noting that specific disciplinary knowledge is not mentioned in this broad characterisation of the course as it is viewed and used as a contextual frame for the literacy and academic practices being developed in the course.

The Science Extended Studies Programme (SESP) tries to encompass a range of science disciplines. Since Mathematics and Computer Science are taught in separate courses the first semester of ISCM has a focus on Physics and Chemistry and the second semester tries to focus on aspects of life and earth sciences. Botany and Zoology and Environmental Science staff have been involved in the past, but currently disciplinary staff from the Human Kinetics and Ergonomics (HKE) department provide input into the life sciences component, and Geology department staff provide input into the earth sciences component.

The ISCM course has been divided into six identifiable components: 'What is science?', Size in the Universe (Physics), Matter and the Universe (Chemistry), The human body (Human Kinetics and Ergonomics or HKE), Our physical world (Geology), and Scientific and language-related literacies which includes the independent research project (IRP) (Table 6.1). For the sake of convenience each of the components that are linked to a discipline (components 2 to 5) are referred to by their disciplinary names. As mentioned, the different disciplinary components are used as a contextual frame to develop students' understanding of scientific concepts and to introduce them to methods and practices needed to construct knowledge in the sciences.

² These were developed in keeping with the OBE system adopted in South Africa, mentioned in Chapter 2.

Table 6.1: ISCM course components: Timing, duration and staff involved

Component number	Course component	Semester	Number weeks	Staff input
1	What is science?	1	2	ISCM
2	Size in the Universe (Physics)	1	5-7	ISCM and disciplinary
3	Matter and the Universe (Chemistry)	1	5-7	ISCM and disciplinary
4	Human movement (Human Kinetics and Ergonomics or HKE)	2	5-7	ISCM and disciplinary
5	Our physical world (Geology)	2	5-7	ISCM and disciplinary
6	Scientific and language-related literacies (includes independent research project)	1 and 2	26 concurrent	ISCM

Components 1 to 5 are all taught as separate sections of the ISCM course. Whereas the introductory ‘What is science?’ component is only 2 weeks long, the ‘disciplinary’ components are each between 5 and 7 weeks long (Table 6.1). The sixth scientific and language-related literacies component runs during the whole year concurrently with the other five course components. The two permanent ISCM lecturer-level practitioners, who focus on ‘language-related literacies’ and ‘scientific literacies’ respectively, teach in all six course components, and the four mainstream disciplinary staff members lecture and run practicals related to their respective disciplines. The current disciplinary staff members have made medium- to long-term commitments to the course, with the most recent member having started in 2011 and the longest-standing staff member having taught in the course since its inception in 2005.

Students attend 16 ISCM periods per week in the form of a double lecture (Monday), a four-period practical session (Monday), a double enrichment session (Tuesday morning), two double tutorials (Tuesday, Thursday) for language-related literacies work, and another two double tutorials (Wednesday, Friday) for scientific literacies work (Table 6.2). The lectures take place in a stepped venue and, although some can be interactive depending on the lecturer, are essentially transmission modes of communication similar to most lectures in the Science Faculty. The practical sessions that take place in the departmental laboratories require student preparation beforehand and active participation during the session. Students are assisted and their work is assessed by disciplinary post-graduate student demonstrators. The tutorial and enrichment sessions take place in a flat venue where active participation and individual and group work is expected. The tutorials are facilitated by one of the two full-time ISCM lecturers sometimes with additional assistance from a senior post-graduate tutor. Whilst the disciplinary lectures and practicals and major assignments are planned well in advance, the material covered by the ISCM lecturers is planned weekly depending upon student needs. By the end of the semester a record of each session has been noted in a Teaching Programme document (Table 6.2).

Table 6.2: ISCM Teaching Programme for 2013: 'What is science?', Physics and Scientific and language-related literacies components

Week	Dates	Monday	Tuesday	Wednesday	Thursday	Friday	Assignments /tests
1	11 to 15 Feb	L: ISCM intro; discuss science P: Biogr info & photos	E: Framing science T: Note making; essay topic	L: What is Science?	T: Review of L notes. Prepare for next L. Reading texts	T: Induction/deduction	
2	18 to 22 Feb	L: Reasoning in science (percept) T: Health & wellness at uni	L: Reasoning in science (percept) T: Organisation and time planning	T: Induction/deduction finish; Popper	T: Reading at university & critical thinking	T: Consolidate section; discuss student agency	
3	25 to 1 Mar	L: Physics: size of things P: Estimate & measure	T: Dictionary work, definitions T: Writing, paragraphs	T: Consolidate L; feedback on Ts	T: Essay - mind mapping, time planning	T: Accuracy and precision	
4	4 to 8 Mar	L: Physics: Solar system P: Accuracy & precision	E: Planets DVD T: Plagiarism; develop essay plan	T: Consolidate L; feedback on Ts	T: Paraphrasing and in-text refs	T: SI units and conversions	
5	11 to 15 Mar	L: Particle physics P: Measuring & unit conversions	TEST 1 T: Paraphrasing & referencing	T: Consolidate L; feedback on Ts & Ps	T: Writing introductions and conclusions	T: Working with scale bar	Small term test 12 March
6	18 to 20 Mar	L: Nuclear physics P: Scale in science	E: Discussion of SciFest T: Test feedback	T: Consolidate L; feedback on test, prep for next test	Human Rights day	Public holiday	Draft essay submission 19 March
7	8 to 12 April	L: Nuclear power P: Scale models	E: Nuclear energy in SA DVD T: Feedback essay, writing revision	TEST 2	T: Writing - paragraph, words of attribution	T: Producing scale bar	Large term test 10 April

L=lecture; P=practical; E=enrichment; T=tutorial

In order to provide an indication of interactions in a typical ISCM week, week 4 of 2013 is described (Table 6.2). On Monday morning the Physics lecture related to 'things large' and the components of the solar system were discussed, mainly in terms of size and distances and how these could be measured. The afternoon practical related to aspects of measuring and focused on estimation, accuracy and precision in science. The enrichment session on Tuesday morning, which was a DVD on the formation and structure of planets, served to both consolidate and advance material covered in the lecture, and students were also expected to provide written answers to a few questions on material covered by the DVD. In the Tuesday afternoon session the 'language-related literacies' practitioner focused on essay planning and aspects of plagiarism in preparation for their major essay assignment on the structure of the sun and its main process of heat generation. She continued with this work on Thursday by focusing on

paraphrasing and in-text referencing. The 'scientific literacies' practitioner modelled consolidation of the Monday lecture on Wednesday by getting students to 'flesh out' their lecture notes using appropriate resource material, and expanded on work from both the lecture and practical by focusing on SI units and their conversions in a practically-based tutorial session on Friday. Three small pieces of work from this week were assessed with feedback.

6.3 LCT(Specialisation) for ISCM

6.3.1 Developing an external language of description

In order to characterise the ISCM curriculum, and to identify whether legitimacy is founded on knowledge or knowers or both, an external language of description based on the epistemic and social relations was developed, as outlined in Chapter 5: herewith a brief reminder. Four categories of knowledge (disciplinary, scientific literacies, academic practices and everyday; representing a continuum of stronger to weaker epistemic relations; Table 5.2) and two categories of knower (based on epistemological and axiological concerns; Table 5.3) were identified (summarised in Table 6.3, but laminated inserts of Tables 5.2 and 5.3 with the external language of description and empirical data, are provided for ease of reference³). As mentioned in section 5.5.1.2, the social relations, with epistemological orientations are associated with the epistemic (science) context, and the social relations with axiological orientations are associated with the learning context. This gives rise to epistemic-context social relations (SR(ec)) and learning-context social relations (SR(lc); Table 6.3).

³ Laminated inserts of Tables 5.4–5.8 are also provided for later chapters.

Table 6.3: Epistemic and social relations: categories of ISCM curriculum knowledge and knower types identified in the LCT(Specialisation) analysis

Relations	Theoretical concept	External language of description		
		Categories		Sub-categories
Epistemic relations	Epistemic (conceptual) knowledge	Disciplinary knowledge (DK) is valued	ER++	Principled knowledge Procedural knowledge
		Scientific literacies knowledge (SLK) is valued	ER+	Principled knowledge Procedural knowledge
	Non-epistemic (contextual) knowledge	Academic practices knowledge (APK) is valued	ER-	Contextual (rules) knowledge Academic practices
		Everyday knowledge (EK) is valued	ER--	Contextual knowledge Procedural knowledge
Social relations	Epistemological (epistemic-context) concerns	Student science/epistemic dispositions, attitudes and opinions emphasised and valued as legitimate scientific knowledge	SR(ec)+	
		Student science/epistemic dispositions, attitudes and opinions downplayed as legitimate scientific knowledge	SR(ec)-	
	Axiological (learning-context) concerns	Student dispositions, attitudes and opinions as science learners are emphasised and valued for shaping own learning	SR(lc)+	
		Student dispositions, attitudes and opinions as science learners are downplayed for shaping own learning	SR(lc)-	

The following sections, based on an analysis of 2013 course documentation, serve not only to provide a description of ISCM course content but also to identify the underpinning logics in each of the course components in terms of epistemic and social relations. Since the sixth identifiable course component, which deals with scientific and language-related literacies, is taught concurrently with and often embedded in one of the other five components, it is mostly discussed within each section in the context of its associated course component. An exception is made for the independent research project, which forms a major part of the scientific and language-related literacies course component but is not linked directly to any of the current disciplinary components.

6.3.2 'What is science?' component

The two-week 'What is science?' component is aimed at providing students with a broad understanding of the philosophy, history, methods, and approaches in science. The analysis therefore reveals no call on disciplinary knowledge but instead a valuing of general scientific literacies principled and procedural knowledge (ER+; see Table 5.2 (laminated)). Philosophy of science; a brief history of science; scientific thinking and reasoning; distinguishing between inductive and deductive thinking; knowledge construction and the basis for claims in science; and understanding concepts such as premises, hypotheses, theories, laws, empirical data, 'uniformity of nature', tentative nature of science, and pseudo-science all form part of the 'What is science?' component. Although such concepts and knowledge are often incompletely

understood by students at this stage of the course, they form a useful point of departure for many later aspects of the course. Reading of scientific texts also forms a key part of the scientific literacies procedural knowledge in this course component.

Since 'What is science?' is the first component of the course, academic practices (ER-; see Table 5.2 (laminated)) that students will need to draw on to cope in the new academic university environment are emphasised. This includes developing organisational practices (organising notes, filing, using diaries and managing their time), preparing for and reviewing lectures, taking notes during a lecture, and discussing ideas with others in pairs or small groups. At this stage these are simply presented as generic practices useful to any student at university.

Epistemic-context social relations are downplayed in the 'What is science?' course component (SR(ec)-; see Table 5.2 (laminated)). Although students' opinions are sought with regards to various aspects of science (what is science, who are scientists, creativity and knowledge in science), this is used as a means of opening up discussion with students rather than in terms of valuing their opinions as legitimate forms of specialised knowledge. Relatively stronger learning-context social relations are visible (SR(lc)+) when students consider ways in which their attitudes towards studying may influence their learning at university.

The summary categorisation for the 'What is science?' course component is therefore ER+, ER-, SR(ec)- and SR(lc)+.

6.3.3 Physics component

Like the 'What is science?' component the Physics component, starting in the third week of the first semester, uses the lecture, tutorial, enrichment and practical sessions to develop foundational knowledge, scientific literacies and academic practices on which the rest of the course can build. This was articulated by the Physics lecturer in an interview:

We start off with foundational blocks of units, size and scale that they need for the rest of their degree . . . Physics is the foundational one.

As a result, in terms of epistemic relations, scientific literacies principled knowledge (ER+) relates mainly to size and scale and uncertainty in science and includes the following concepts: SI units, precision, accuracy, estimation, significant figures, hierarchies, and conventions for representing objects (diagrams, labels, scale). Wherever appropriate both the understanding, as well as the valuing, of the concept (for example why and under what circumstances scientists value both precision as well as estimation) are considered. The associated scientific literacies procedural knowledge (ER+) relates to estimating; measuring using tape measures, rulers and vernier callipers and weighing using a triple beam balance; working accurately and precisely; unit conversions; using scale bars and working to scale; and producing line drawings.

Since essay writing is a common writing genre in mainstream disciplines in the biological, earth, environmental and physical sciences, this course component focuses on a wide range of aspects related to scientific reading and writing in preparation for an essay assignment. In some cases the writing aspects are taught in a more technical manner (paragraph structure, overall essay structure, paraphrasing, citing and referencing, words of attribution and signposting) and these are categorised as academic practices (ER-). Other aspects of essay writing draw on epistemic norms such as the kind of information (factual, empirical), as well as the form of communication (objective reporting, use of passive voice) that are valued in science and are thus categorised as scientific literacies procedural knowledge (ER+).

Since the first four lectures relate to size and scale in general (scientific literacies principled knowledge; ER+) it is only in the last six lectures that disciplinary principled knowledge (ER++) is introduced. This relates mainly to aspects of size and scale from a physics perspective, focusing on things small (building blocks of matter and the standard model of particle physics, nuclear fission and fusion, radioactive decay, and sources of energy) and things large (our solar system). It is relevant to note that this theme of size and scale in science (spatial and temporal) is drawn on and developed throughout the rest of the ISCM course. Energy production also forms part of the content knowledge, and the structure of the sun and its energy production through a fusion process forms the topic of the essay assignment already mentioned.

Due to the foundational nature of this course component, academic practices (ER-) continue to be addressed. This includes coping with lectures (preparation, taking notes and consolidation) and also relates to generic practices such as locating sources in the library and on the internet, using dictionaries, and producing definitions.

Student opinion is sought on aspects of (a) nuclear energy and (b) a show/talk of their choice they attended at an annual Science Festival, but since they are required to frame their discussions in a scientific context, this course component exhibits relatively weaker epistemic-context social relations (SR(ec)-). Stronger learning-context social relations (SR(lc)+) are legitimated when students reflect on differences between the school and the university environment and the implications this may have on their own roles and responsibilities and approaches to learning.

The summary categorisation for the Physics course component is therefore ER++, ER+, ER-, SR(ec)- and SR(lc)+.

6.3.4 Chemistry component

When the ISCM course was originally conceptualised, mainstream staff were asked what fundamental concepts needed addressing to assist students entering mainstream. A number of

staff, particularly from the life, earth and chemical sciences, indicated that a good understanding of certain chemistry concepts were key to their disciplines. As the current Chemistry lecturer commented in an interview:

We try to focus on sections of the mainstream course where we know foundations are shaky for students. So we are very much still doing bridging, preparing them for the mainstream level of content.

The Chemistry course component is therefore used specifically to develop disciplinary principled knowledge (ER++) in terms of the following: structure of the periodic table; atom, molecule and compound structure (including aspects of charge, valency and naming of compounds); the mole concept; stoichiometry (including balancing equations and limiting reagents); chemical equilibrium (solubility constants and Le Chatelier's Principle); and water chemistry (equilibrium, acids and bases, H-bonding). In order to ensure depth understanding of these concepts, disciplinary procedural knowledge dealt with in the practicals links closely to the disciplinary principled knowledge and includes the following: identifying substances by performing anion and cation tests; determining concentration by titration; and examining the effect of substances on solubility. The practicals also build on the basic measuring and weighing processes learned in the Physics course component, and require more advanced tasks using appropriate chemical equipment such as bunsen burners, pipettes, burettes, measuring cylinders, electronic scales, and fume cupboards. Like the practicals, some tutorials also focus on disciplinary procedural knowledge through practical calculation-type tasks based on the concepts of the mole, stoichiometry and chemical equilibrium.

Other tutorials contribute to developing aspects of note-taking, reading and writing, and communication (debating and presenting a logical argument). These activities are done as generic academic practices in the Physics course component. However, in the Chemistry course component the focus shifts away from generic processes to ones more relevant to, and embedded in, Chemistry and science contexts resulting in much of this work being categorised as scientific literacies procedural knowledge (ER+). For example, the way that students prepare for, take notes in, and consolidate lectures in the sciences will be different from that in the humanities because scientists value quantitative data and factual content rather than personal opinions. By the same token, reading journal articles, writing in a scientific context, presenting a scientific argument, understanding and using assessment criteria, preparing for tests by anticipating questions, and analysing tests based on criteria for learning also all form part of the scientific literacies procedural knowledge in this course component.

The more generic academic practices (ER-) in the Chemistry course component relate to making comparisons in writing using appropriate language, understanding instructive keywords for

answering questions correctly, test and examination techniques (mainly time management) and unpacking questions by recognising and understanding task words and content phrases.

Everyday procedural knowledge (ER--) is not visible in the Chemistry curriculum documentation. Relatively stronger learning-context social relations (SR(lc)+) are visible when students actively consider past tests and tasks for learning and reflect on their own academic strengths and consider how to improve learning strategies in a university context.

The summary categorisation for the Chemistry course component is therefore ER++, ER+, ER- and SR(lc)+.

6.3.5 HKE component

Academic disciplines such as Physics, Chemistry and Geology are referred to by Bernstein (2000, p52) as 'singulars', as their own discrete discourse distinguishes them from other disciplines. In contrast, HKE is a 'region', as it draws both intellectually on a range of academic disciplines (singulars) and also practically on an external field of practice (ibid. p52). The HKE course component therefore has a particular focus of facilitating integration of ideas from a range of disciplines. This was articulated in an interview with the HKE lecturer:

HKE is quite unique because it is an interdisciplinary field so we draw a whole lot of cognate disciplines and we try and understand human movement by looking at not just the Anatomy, not just the Physiology but a whole a range of more hardcore pure sciences. So there's a little bit of Chemistry that comes in, there's Physics that comes in, there's Maths that comes in and to tie those all together in the understanding of human movement and that's also how things are structured in the course.

With the focus on human movement, which draws on disciplines such as HKE, Physiology, Anatomy, Biomechanics, Physics, Mathematics and Chemistry to better understand musculoskeletal anatomy, biomechanics, muscle physiology and human information processing theory, the analysis revealed that disciplinary principled and procedural knowledge (ER++) are highly valued in the HKE component of the course. Disciplinary principled knowledge relates to five main areas of interest: what is HKE; musculoskeletal anatomy (functions of skeleton, classes and characteristics of joints, agonists and antagonists); biomechanics (joint levers and affect on movement, vector components of muscles, muscle strength); muscle physiology (muscle tissue properties, gross and microscopic anatomy, muscle contractions); and human information processing theory (inputs, information processing, outputs, environmental and psycho-social influences). The work in the practicals (using dynamometers to measure muscle strength, working with different types of muscle contractions, using trigonometry and the concepts of levers and forces to calculate musculoskeletal forces and understand movement) is disciplinary

procedural knowledge that links directly with disciplinary theory on human movement learned in lectures.

During this course component students are required to work on two major assignments: an independent research project and a formal 10-page laboratory report based on one of the HKE practicals. The scientific literacies principled and procedural knowledge (ER+) essentially supports these two processes by focusing on the following three areas:

- Experimental design (discussed in more detail in section 6.3.7, which describes the independent research project)
- Working with data (concepts relating to forms of data, independent and dependent variables, structure of tables and graphs; procedures relating to collecting, recording, analysing, and presenting data appropriately in tables, graphs, diagrams; aspects of describing and interpreting graphs)
- Writing a scientific laboratory report (building on writing work addressed earlier in the course but specifically focusing scientific writing conventions, report structure, integrating figures into texts, good paraphrasing and referencing).

Other scientific literacies procedural work involves peer marking with feedback, using assessment criteria effectively, evaluating different sources, developing listening comprehension, and test or examination preparation.

Academic practices (ER-) are weakly valued and only visible through work on understanding roots of words and suffixes and prefixes. Everyday knowledge is not visible in the HKE course component. Relatively stronger learning-context social relations (SR(lc)+) are exhibited when students are required to reflect on their overall progress and learning processes in the first semester and in the June examination, and also to consider strategies for improved means of utilisation of feedback.

The summary categorisation for the HKE course component is therefore ER++, ER+, ER- and SR(lc)+.

6.3.6 Geology component

In the final ISCM course component we try to develop conceptual understanding and practices related to geological processes that operate across a range of different spatial and time scales. Since it is the final ISCM course component there is an attempt to reflect the content, level and pace that students would experience in mainstream. As a result both disciplinary principled and procedural knowledge (ER++) are highly valued; the former includes understanding rock types and the rock cycle, rock-forming process, plate tectonics and volcanoes and the latter relates to

working with topographic maps and drawing topographic profiles, recognising rock types, observing carefully in the field, and using Google Earth software to locate different places.

Scientific literacies procedural knowledge (ER+) is highly valued and focuses on providing support for major integrative assignments such as producing a poster and doing an oral presentation linked to the independent research project, and an abstract and a summary related to a Geology topic. This course component also focuses on high-level scientific literacies procedures such as problem solving, critical thinking, working with complex data, representing data in alternative ways and predicting outcomes of scenarios. This part of the course is also used to reiterate and further develop any scientific literacies procedures depending on students' needs. In 2013 it included paraphrasing, reducing redundancy in writing, and preparation for examinations.

Neither academic practices nor everyday procedural knowledge nor social relations are valued in the Geology course component according to the 2013 data. However, in some years relatively stronger learning-context social relations (SR(lc)+) are exhibited when students are required to produce reflective online journals in response to prompt questions relating to their learning approaches and attitudes towards being responsible for their own knowledge and understanding. Also, in most years weaker epistemic-context social relations (SR(ec)-) are visible when students debate a controversial topic such as fracking in South Africa.

The summary categorisation for the Geology course component is therefore ER++, ER+, SR(ec)- and SR(lc)+.

6.3.7 Independent research project component

Although mention has been made of the independent research project (IRP) in the two previous sections, it is worth elaborating on as it forms a major component of the ISCM curriculum. The IRP runs throughout the second semester, concurrently with the HKE and Geology components. Using ten pot plants students work in pairs and are required to examine the effect of an environmental factor of their choice on plant growth using a hypothetico-deductive experimental design. To this end they are required to identify an environmental factor, locate the necessary background information, and see the research through from conceptualisation to final presentation. Disciplinary principled knowledge (mostly botanical, but can relate to physical and chemical aspects of environmental conditions; ER++) is therefore highly valued, albeit independently sought, as this frames their entire project⁴.

⁴ The IRP was conceptualised when ISCM had a Botany component, which is currently not available. Although the plant growth topic no longer supports disciplinary learning in the main course components during which the project runs concurrently, the project has been maintained in its current form primarily

Since these are of necessity relatively simple experiments (plants are kept in student accommodation and data are collected using rulers, photographs, simple mass scales, and careful observations) scientific literacies procedural knowledge (ER+) is emphasised and focuses mainly on guiding students through each stage of the process (accessing and evaluating information sources, writing a proposal, stating a hypothesis, designing an experiment, identifying independent and dependent variables, measuring appropriate variables, drawing up data sheets, recording data, analysing and presenting data appropriately, working with complex data sets, working with simple descriptive statistics, presenting a scientific oral presentation, developing and using assessment criteria for scientific writing, producing a scientific poster, and reading scientific journal articles). This is the only course component in which everyday procedural knowledge (ER-) is sought and valued, as students are expected, where possible, to draw on their experiences of plant growth from their home environments. Stronger learning-context social relations (SR(lc)+) are visible through reflective questions relating to students' own learning processes in the research project and on becoming and being a scientist.

The summary categorisation for the IRP component is therefore ER++, ER+, ER-- and SR(lc)+.

6.3.8 Trends in knowledge differentiation: Knowledge code of ISCM

From the above analysis it is clear that, in terms of epistemic relations, disciplinary, scientific literacies and academic practices principled and procedural knowledge are valued in the ISCM curriculum, but everyday knowledge is not. The valuing of social relations is variable. The *extent* to which each of these categories is valued in each course component was calculated on a percentage time basis. This is represented on a scale of 0 (no time) to 4 (>45% of time) for each category and for each course component, as presented in Table 6.4.

for logistical reasons as the projects can be conducted independently, in any location and with minimal equipment.

Table 6.4: Trends in valuing of knowledge and knowers in ISCM: Time allocation for knowledge-type categories of epistemic relations and knower categories of social relations in each of the six ISCM course components in 2013

Semester	Course component	Epistemic relations				Social relations	
		Disciplinary knowledge (ER++)	Scientific literacies knowledge (ER+)	Academic practices knowledge (ER-)	Everyday knowledge (ER--)	Epistemic-context knower (SR(ec)-)	Learning-context knower (SR(lc)+)
1	What is science?						
1	Physics						
1	Chemistry						
2	HKE						
2	Geology						
2	IRP						



The following is a descriptive and partial explanatory account of the generalised trends that are visible in Table 6.4:

- Disciplinary knowledge (ER++) is initially absent and generally increases through the year. The low valuing of disciplinary knowledge in the ‘What is science?’ and Physics components is due to a focus instead on foundational scientific literacies procedural and academic practices knowledge in the early stages of the course. The later course components all exhibit strong valuing of the disciplinary base in order to prepare students for mainstream.
- Academic practices knowledge (ER-) is dominant initially and generally decreases through the year. This is due to the foundational generic practices forming an initial focus to establish a base upon which general university coping practices and scientific literacies knowledge can build. Therefore, by the second semester (HKE and Geology) the academic practices work is barely visible or absent altogether.
- There is a strong focus on scientific literacies knowledge (ER+) in all course components. In the early ‘What is science?’ and Physics components it is more of a principled nature and is establishing the conceptual and epistemic foundation on which the ISCM course builds throughout the year. In contrast, the scientific literacies knowledge in the later HKE and Geology components is more procedurally oriented as it

focuses primarily on procedural tasks such as conducting research and writing scientific reports.

- Everyday knowledge (ER--) is only valued for its input in the independent research project.
- Only weaker epistemic-context social relations (SR(ec)-) are visible, but this is seldom and on an irregular basis. Relatively stronger learning-context social relations (SR(lc)+) are visible throughout the year, but appear to form a minor part of the curriculum. Together these indicate a low valuing of social relations compared with epistemic relations in ISCM.

Based on identification of epistemic and social relations in ISCM the curriculum has elements that can be categorised as knowledge code, relativist code and knower code when plotted on a two-dimensional Specialisation plane (Figure 6.1a). However, based on the relative valuing of epistemic and social relations for the different course components, a different picture emerges. Stronger epistemic relations (of disciplinary (DK, ER++) and scientific literacies (SLK, ER+) knowledge) dominate throughout the year suggesting a knowledge code. Weaker epistemic relations, as reflected in the academic practices work (APK, ER-), which are fairly dominant in the first semester, indicate a relativist code in the earlier stages of the course. Even weaker epistemic relations or everyday knowledge (EK, ER--) and both stronger and weaker learning-context and epistemic-context social relations (SR(lc)+ and SR(ec)- respectively) form relatively small components in all of the course components, indicating weak legitimation. It can therefore be said that the ISCM curriculum exhibits an overall **knowledge code** (Figure 6.1b) although this shifts from a knowledge/relativist code in the first semester to a knowledge code in the second semester.

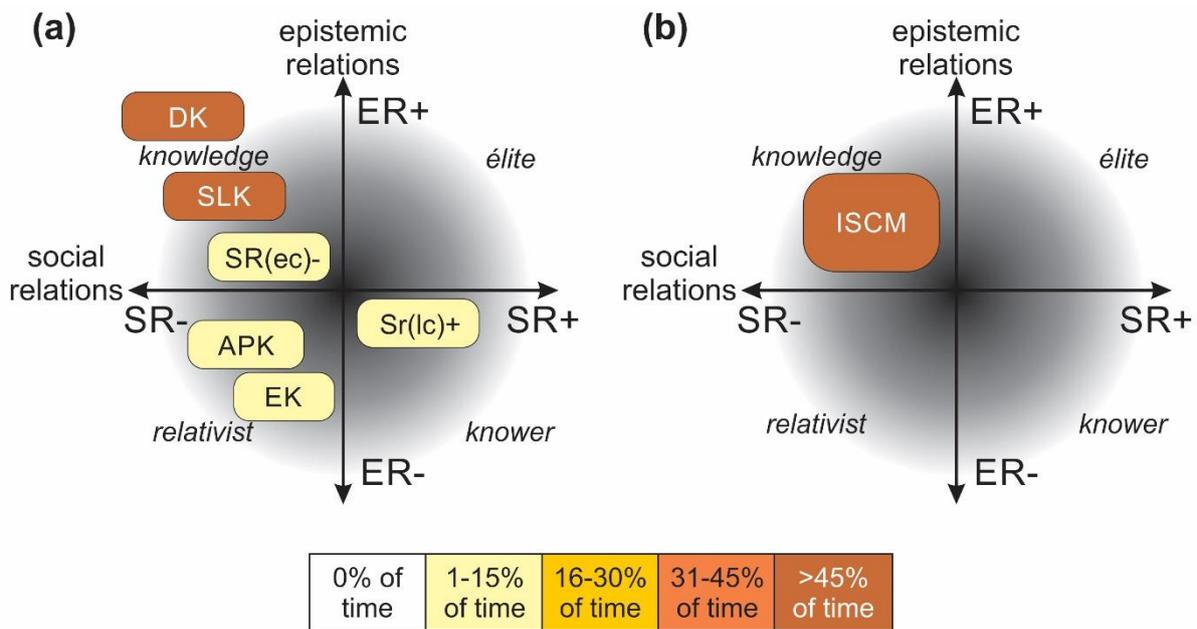


Figure 6.1: Specialisation codes for ISCM based on curriculum documentation (adapted from Maton 2014a, p30): (a) knowledge and knower types legitimated in curriculum; (b) overall **knowledge code** based on relative importance of knowledge and knower types (DK=disciplinary knowledge; SLK=scientific literacies knowledge; APK=academic practices knowledge; EK=everyday knowledge; SR(lc)+=stronger learning-context social relations; SR(ec)-=weaker epistemic-context social relations)

LCT(Specialisation) provides broad insights into epistemic and social relations in the ISCM curriculum, the implications of which are explored in the discussion of this chapter. However, despite having identified a range of knowledge types along a continuum of weaker to stronger epistemic relations, I am still left with the dichotomous choice of epistemic (conceptual) and non-epistemic (contextual) knowledge in the final Specialisation analysis, which does not allow for analytical ‘teasing’ out of scientific literacies and disciplinary knowledge types and their associated practices. Although they have relatively different strengths of epistemic relations, they are still categorised in a single quadrant forming part of a knowledge code (Figure 6.1a). Maton suggests that when we obscure differences in this way we are creating ‘blind spots’ that may lead to false choices in curricula (2014b, p186). I argue below and in the discussion that scientific literacies knowledge is key for enabling epistemological access in an academic development (foundation) course and, in order to make this argument, it helps if this knowledge type is analytically more visible. For this I turn to LCT(Semantics).

6.4 LCT(Semantics): A differentiated ISCM curriculum

Although the concepts of semantic gravity and semantic density have been explicated in Chapter 4, it is useful to briefly outline the main points to contextualise the analytical work that follows.

Semantic gravity, which describes the external relations of knowledge practices, is defined as the degree to which meaning relates to *context*, and the closer the relation the stronger the semantic gravity (SG+). Semantic density, which describes the internal relations of knowledge practices, is defined as the degree to which meaning relates to *concepts*, and the closer the relation the stronger the semantic density (SD+). These two relations may be plotted on a two-dimensional plane to provide a 'topological semantic space' (Maton 2011, p66; see Figure 6.2 below).

The 'mapping' of ISCM knowledge types onto separate quadrants on the semantic plane (Figure 6.2) allows us to better unpack what is distinct about the ISCM curriculum. In particular it provides for analytical separation of scientific literacies knowledge from disciplinary knowledge. The rationale for the 'mapping' is explained below.

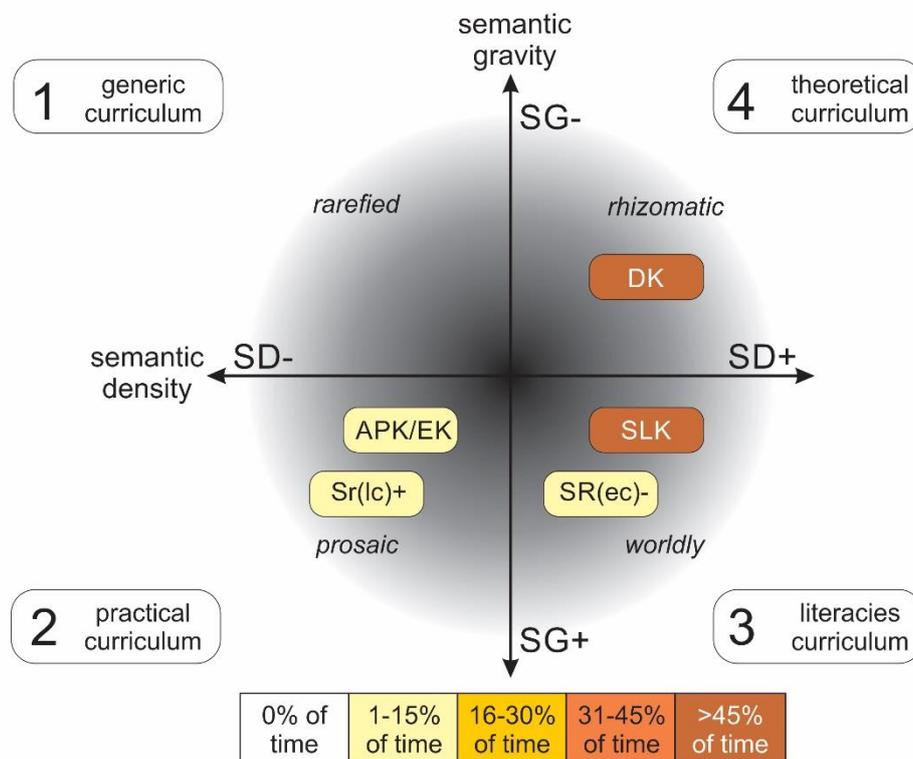


Figure 6.2: Semantic codes for ISCM based on curriculum documentation (adapted from Maton 2016, p16). DK=disciplinary knowledge; SLK=scientific literacies knowledge; APK=academic practices knowledge; SR(ec)-=weaker epistemic-context social relations; SR(lc)+=stronger learning-context social relations

Quadrant 4

Since quadrant 4 represents theoretical knowledge (see section 4.5.2) it follows that the disciplinary principled and procedural knowledge (DK) of the ISCM curriculum would be placed in this quadrant. As such, for the disciplinary knowledge in ISCM, meaning and principles are

derived from explicit theories, concepts and empirical referents linked to the specific discipline, resulting in a relatively strong semantic density (SD+). However, because meaning and principles are not linked to particular specific contexts, semantic gravity is relatively weak (SG-). For example, Geology knowledge and practices in ISCM draw on principled knowledge such as mineralogy to understand rock types and rock origins (SD-) but this is generalised knowledge that can be applied to any rocks in any setting (SG-). This aspect of the ISCM curriculum, where legitimacy is based on context-independent and conceptually dense meanings, would therefore be classified as a *theoretical curriculum* with a *rhizomatic code* (see Maton 2014b, 2016).

Quadrant 2

As mentioned previously, in an educational context quadrant 2 can represent practical knowledge that, in Shay's (2013) work, is derived from workplace contexts. Through recontextualisation, the workplace practical knowledge becomes codified in the curriculum into a set of rules, principles or guidelines for the practice. An example used by Shay (ibid.) is of a journalistic workplace in which the practice of interviewing is taught through a set of procedurally-based guidelines. Since the practice of interviewing is related to the journalistic workplace context, semantic gravity is stronger (SG+) and since the guidelines are derived from practice and not theory, semantic density is weaker (SD-).

Drawing on the above reasoning, I have located academic practices knowledge (APK) in quadrant 2. In this case the practical knowledge relates to the academic learning context (rather than a workplace context). The practices associated with the academic learning context could be note-taking in class, note-making from resources, consolidation of lectures, preparation for practicals, developing own understanding, locating sources of information, or using feedback. These practices become organised into a set of principles or guidelines in the curriculum recontextualisation process. For example, when modelling consolidation of a lecture in an ISCM class I may suggest principles of identifying the overall theme of the lecture, drawing out the main points of the lecture, summarising all information, and seeing links with other aspects of the course. Since the practice of consolidating a lecture is located firmly in an academic learning context, semantic gravity is stronger (SG+). However, since the principles are derived from practice and not from theory, semantic density is weaker (SD-).

Since everyday knowledge (EK) is such a small part of the curriculum, I have not considered it in depth here but the principles and coding as outlined for APK would also apply to EK, which would therefore also locate it in quadrant 2. Similarly, I suggest that the stronger learning-context social relations (SR(lc)+) would also be located in this quadrant. For example, students may be required to reflect on their dispositions and attitudes in relation to their own learning in an academic context. Since the practice of self-reflection is itself an academic learning practice,

and since it is directed towards the academic learning context, semantic gravity is stronger (SG+). However, since the principles of reflection are based in practice, semantic density is weaker (SD-).

These aspects of APK and SR(lc) in the ISCM curriculum, where legitimacy is based on context-dependent practices with simpler meanings, would therefore be classified as a *practical curriculum* with a *prosaic code* (see Maton 2014b, 2016).

It is worth noting at this stage that principles related to academic learning practices are seldom explicitly stated in higher education. Knowledge on how to take notes in a lecture or how to locate a source of information is assumed by many lecturers. Similarly, the scientific literacies work that is discussed in the following section on quadrant 3 is underpinned by knowledge that has been internalised by the teacher (lecturer) and can often operate at an unconscious level and therefore remain tacit (Jacobs 2007, p75). This, of course, has implications for student access, and many academic development-type courses such as ISCM attempt to be explicit to better promote access.

Quadrant 3

In Shay's (2013) work she places professional or vocational knowledge, and hence professional or vocational curricula, in quadrant 3. This quadrant is different from quadrant 4, as the 'logic of the curriculum is the demands of the practice', and is different from quadrant 2, as the 'principles informing the practice are derived from theory' (ibid. p575). Shay uses a Mechatronics design project as an example in which the workplace practice of design guides the direction of the project (hence is grounded in context; SG+), but students are expected to draw on theoretical knowledge from a range of electrical, mechanical and information technology disciplines which exhibit stronger condensation of concepts (SD+). In her analysis the curriculum in quadrant 3 therefore draws on the practice elements of quadrant 2 and the theory elements of quadrant 4.

Based on the above reasoning, I have placed scientific literacies principled and procedural knowledge (SLK) in quadrant 3. The values and meanings in scientific literacies are based on theoretical (scientific and epistemic) principles and concepts, resulting in a relatively strong semantic density (SD+). Examples of relevant scientific values drawn on in ISCM are the basis upon which knowledge claims are made, and the valuing of empirical data, objective approaches, and inductive and deductive reasoning – which were classified as scientific literacies *principled* knowledge in the original analysis. However, since scientific literacies work is based on practices such as writing appropriate texts, reading texts critically, listening constructively in lectures, and arguing critically – classified as scientific literacies *procedural*

knowledge – the principles and guidelines are derived from these academically-based practices, representing relatively strong semantic gravity (SG+). Thus, the distinction made earlier between propositional and procedural knowledge strengthens the argument for placement of scientific literacies work in this quadrant.

Previously, I indicated that the task of consolidating a lecture could be located in quadrant 2. However, as I have shown throughout this chapter, it does not take much to shift what appears to be a generic academic context task to become a scientific literacies task that draws on scientific knowledge and values. In ISCM, the first two or three times I model consolidating a lecture it is simply done as a generic task based on the principles derived from practice that were mentioned earlier (such as overall theme, summary, main points, and links). However, very soon I interrogate how lecture consolidation in sciences may differ from other fields. For example, the fact that in science we value precise definitions, factual information (as opposed to opinions), empirical data (preferable to say 10 kg instead of ‘quite heavy’) and mathematical condensation (as opposed to longer descriptions) would considerably influence the lecture consolidation process. In this context, students would still draw on practical principles derived from practice, but they would also draw on the scientific value-base for effective consolidation. Similar logics would be used for other scientific literacies practices such as writing texts or reading resources.

By the same token the weaker epistemic-context social relations (SR(ec)-) work in ISCM would be located in quadrant 3. For example, by asking students to express their opinion of fracking in a debate, the basis on which they are judged is their scientific argument (SD+), but debating or developing a logical argument draws on a set of principles from academic learning-context practice (SG+).

These aspects of SLK and SR(ec) of the ISCM curriculum, where legitimacy is based on context-dependent practices with complex meanings, would therefore be classified as a *scientific literacies⁵ curriculum* with a *worldly code* (see Maton 2014b, 2016).

⁵ I have substituted ‘scientific literacies’ for ‘professional/vocational’ curriculum as used in Shay 2013 and Maton 2014b.

Quadrant 1

As in Shay's work (2013, 2014), ISCM appears to have no data related to quadrant 1, which represents a *generic curriculum* with a *rarefied code* (see Maton 2014b, 2016). Shay (2013, p575) suggests this could represent a curriculum that focuses on developing general graduate attributes such as problem-solving, critical thinking, and professional communication, which are neither rooted in context nor have conceptually dense meanings.

The LCT(Semantics) analysis therefore indicates a differentiated ISCM curriculum that operates across a range of contexts and legitimates theoretical, scientific literacies and academic practices knowledge types and knowledge practices. However, based on the trends analysis done earlier in the chapter, and depicted in Table 6.4, that shows the dominance of disciplinary and scientific literacies knowledge throughout the year, it can be stated that ISCM exhibits a **rhizomatic/worldly code**, indicating a curriculum that has predominantly stronger conceptual relations (SD+) but operates across the range of contexts, from context specific (SG+) to quite abstract (SG-) situations. In the final discussion that follows, the appropriateness of this differentiation for a science foundation course is deliberated.

6.5 Discussion

The research question being addressed by this chapter is how knowledge and knowers are characterised and legitimated in the ISCM curriculum. In the first part of this discussion I find it useful to provide a descriptive account of the overall structure of the ISCM curriculum in its recontextualised form in order to relate this to the overall structure of science knowledge in the intellectual field. The second part of the discussion then answers the research question directly by using LCT(Specialisation) to examine epistemic and social relations and thus legitimation of knowledge and knowers in the curriculum, and to identify underpinning codes. The third part provides additional insights into the question, by drawing on LCT(Semantics) to reveal what is distinct about the ISCM curriculum, and provides an explanatory account based on the dual role that ISCM plays in being both a science and an academic development (foundation) course.

6.5.1 Overall ISCM course structure: Multidisciplinary, integrated and hierarchical

In terms of overall structure, ISCM is a **multidisciplinary, integrated and hierarchically-structured** science course. It is *multidisciplinary* in that it draws primarily on four science disciplines in which some conceptual depth is developed: Physics, Chemistry, HKE and Geology. With the exception of HKE, which by its nature draws on other disciplines, the analysis shows little *integration* and few opportunities for knowledge transfer between the disciplines. These strong boundaries (+C) between disciplines are partly an attempt to convey the 'essential'

nature of each discipline⁶, but are also partly due to each course component being taught by an academic from a different department and discipline, making weaker boundaries practically quite difficult.

In contrast, the scientific literacies course component provides numerous opportunities for integration and transfer and thus serves to weaken boundaries (-C) between the disciplines and different course components. Since scientific literacies work runs concurrently with the disciplinary components and is embedded in the disciplinary work, the general science concepts, principles and practices are applied, wherever possible, across the disciplines. A specific example of integration across disciplines is the foundational concept of 'estimation in science', which is introduced in the Physics component by getting students to practise estimating and consider why estimation is important in an exact field such as science. Later in the Chemistry and HKE components students use estimates as a means of providing a 'check' for calculated answers, and in Geology they estimate distances where large spatial scales preclude the necessity or practicality of absolute accuracy and precision.

It was mentioned in Chapter 4 that, at the level of intellectual fields, both the scientific field and most scientific disciplines have a *hierarchical* knowledge structure. Ideally, in the recontextualising process from intellectual field to educational field, this essential structure should be maintained to relay the appropriate messages and principles about knowledge for that particular field or discipline (Muller 2009). In this regard Shay (2014, ep8⁷) states: '[c]urricula provide epistemic entry to disciplinary communities that legitimate certain methods of inquiry, which hold entrants and members of the community accountable to a certain set of epistemic values'. The analysis revealed visible hierarchical structures in the ISCM curriculum both at a conceptual and at a procedural level. The conceptual hierarchy is most obvious within each of the disciplinary components. For example, in Chemistry, foundational concepts such as the structure and meaning of the periodic table are addressed before the more complex concepts of molecular compounds, molecular weights and moles, which build on the foundational concepts. Likewise, the final chemical equilibrium concept draws on most of the preceding concepts developed during the six-week course component.

Muller (2014) cautions against assuming the hierarchical structure in a vertical discourse is linked only to principled conceptual knowledge, but notes that it should also include procedural knowledge. In this study the hierarchical principle also guides the procedurally-based academic practices and scientific literacies work. Activities such as 'showing direction' in paragraph

⁶ One of the aims of the course is give students a 'feel' for different disciplines, as this helps them in curriculum planning when they move into mainstream studies.

⁷ I have only been able to locate an electronic version. In the final publication the page number is different.

writing through the use of logical connector words or phrases, or drawing on standard referencing conventions, are taught initially as generic academic practices. These form the foundation upon which the later scientific literacies procedural work is based, where writing is instead viewed as a discursive practice embedded in the norms and values of science. Essays, laboratory reports, literature reviews and summaries are thus all integrative products of a range of different literacies and academic practices. Likewise, producing a data collection table, or conducting an independent experiment, integrates a number of epistemic and procedural concepts. These reflect an increase in cognitive complexity as the course proceeds.

6.5.2 LCT(Specialisation): Knowledge and knower characterisation and legitimation

Traditionally the primary concern of academic development (foundation) courses is learning and pedagogy, focusing on student 'ways of knowing' in the context of language and literacies and academic practices (or skills) development. This is usually based on an underpinning premise that the 'problem lies with the practices of teaching and learning rather than with the logic of the knowledge or its curricular recontextualisation' (Muller 2014, p5). This 'practice' emphasis has meant that disciplinary knowledge is often not particularly visible, or, even if it is, it is seldom interrogated.

The difficulty in the curriculum analysis in this study was capturing and making visible both the varied 'practices' (which included developing academic practices, modelling learning practices, ensuring students work actively with feedback, self- and peer-assessment and critical self reflection, embedding scientific literacies, making overt reference to epistemology of science) and the wide 'knowledge base' (principled and procedural disciplinary and scientific literacies knowledge) under a single conceptual umbrella. In this regard the social realist assumptions that all practices are themselves forms of knowledge and are underpinned by principled or contextual knowledge provided the necessary conceptual 'move' to accommodate 'practice' work (such as academic and literacies practices) in a knowledge framework, drawing on the work of Gamble (2006, 2009) and Shay et al. (2011) – as outlined in the theoretical and methodological chapters. In a sense I am working in the opposite direction of the academic language and literacy theorists such as Freebody, Maton and Martin (2008) and Jacobs (2013), who argue for placing knowledge at the centre of language and literacies work, and am instead saying that academic literacies and practices are in fact forms of knowledge practices and therefore can be an object of study like any other form of knowledge.

In this regard, a **typology of knowledge types** was distinguished based on relative strength of epistemic relations. With progressive strengthening of epistemic relations, four categories of knowledge are legitimated in ISCM: everyday and academic context (with a non-epistemic base), and scientific literacies and disciplinary (with an epistemic base). Each of these

knowledge categories was subdivided into sub-categories of principled and procedural knowledge, providing a fine-grained account of eight knowledge types. In terms of social relations, only two categories with data supporting them were identified in the analysis. The first was the relatively weaker epistemic-context social relations (where knower attitudes, values and opinions are downplayed as legitimate scientific knowledge) and the second was the relatively stronger learning-context social relations of axiological concern (where knower attitudes, values, opinions and reflections are valued for shaping students' own learning). Despite the valuing of knower opinions and reflections, social relations only forms a very small part of the curriculum, according to documentation analysis.

The relative valuing of epistemic and social relations in the ISCM course, based on percentage time allocated to each, provides an indication of the underpinning curriculum code. In an overall sense, for social relations, knowers are poorly legitimated in ISCM. In contrast, for epistemic relations, there is good legitimation of knowledge across the epistemic/non-epistemic range in the first semester resulting in a knowledge/relativist code. This shifts to a knowledge code in the second semester as a result of a gradual decrease in valuing and use of academic practices (weaker epistemic relations), which is accompanied by a gradual increase in valuing of disciplinary knowledge (stronger epistemic relations). Scientific literacies knowledge is highly valued throughout the year. These trends are reflective of a foundation course that highly values academic and literacies practices initially but also recognises the need to increase disciplinary content and workload, and maintain the literacies work throughout, in preparation for the rigours of mainstream. Despite the shift from a knowledge/relativist code to a knowledge code, the *overall* code for ISCM would be classified as a **knowledge code**. As mentioned in the previous section, it is preferable to have the same essential structures or codes in the recontextualised field as in the intellectual field from which it has been derived (Muller 2009; Maton 2014a). Science, and most disciplines in science, have a knowledge code.

6.5.3 LCT(Semantics): Differentiated curriculum codes

The fine-grained account of knowledge types identified in the LCT(Specialisation) analysis opened the space for a detailed and nuanced account of the ISCM curriculum using LCT(Semantics), drawing primarily on the curriculum differentiation work of Shay (2013, 2014). Mapping of ISCM knowledge types on a two-dimensional plane that represents typologies of semantic gravity and semantic density indicates a **differentiated curriculum** based primarily on **rhizomatic/worldly** codes, which draw mainly on theoretical (disciplinary) and scientific literacies knowledge respectively. This indicates that knowledge types and practices with stronger semantic density are favoured in ISCM. However, I argue below that a

broad-based, differentiated curriculum that draws on theoretical, scientific literacies *and* academic practices knowledge helps enable student access and success.

The overall purpose of any course, and its resultant curriculum structure, has implications for student access and success (Gamble 2006; Muller 2009; Wheelahan 2010). ISCM has the dual function of (a) developing the concepts and skills [practices] required by first-year students in a science degree and (b) preparing students for success in mainstream (Curriculum Development Report 2007). In ISCM, staff seem to have interpreted this as facing inwards towards *disciplines* (and the field of science) and outwards towards an *academic learning context*, drawing on a range of differentiated knowledge types to achieve this. This is similar to Bernstein's (2000) notion of a 'region' that faces both inwards towards disciplines and outwards towards professional or workplace practice. Whilst this use of 'academic learning context' is a somewhat unconventional interpretation of the 'practice' component of a region, I believe it serves the same function: it regulates the practice part of the curriculum that shapes academic learning and literacies work – which in the case of ISCM is scientific literacies work.

I argue that any higher education course, but particularly academic development (or foundation) courses, should have a two-way focus, both towards the field or discipline and also towards learning in a higher education context in order to enable epistemological access. What I suggest below is that this dual focus necessitates a broad-based, differentiated curriculum that operates in three of the four quadrants on the semantics plane. The extent to which a course or curriculum draws on each of the quadrants would depend on the purpose of the course and possibly on the background socialisation contexts of the students.

A curriculum that operates primarily in quadrant 4, as do many traditional content-dominated science courses, would expose students to powerful theoretical knowledge. However, as has been shown in other studies (see Brown and Glasner 1999; Ramsden 2003), this does not necessarily give students the tools or means to access the tacit framework of norms and values and practices necessary for understanding the abstract context (Maton 2014b). Conceivably, however, a curriculum located mainly in quadrants 3 (SLK) and 4 (DK), with the scientific literacies work serving to make the underpinning epistemic logics overt, could achieve this. This is supported by the notion that working across the range of semantic gravity (as do quadrants 3 and 4) has the potential to promote effective student conceptual and cumulative development (Humphrey and Robinson 2012; Macnaught et al. 2013; Clarence 2014). The examination of likely 'semantic waves' (recurrent shifts in context-dependence and condensation of meaning; Maton 2014b, p181) would be a useful close-up addition to the work done in this study in terms of understanding knowledge building and achievement in the ISCM context.

Nonetheless, I suggest that, taking into consideration both the process nature of learning and the home and school backgrounds of many ISCM learners, a developmental approach that also draws on knowledge types, practices and knower work located in quadrant 2 may be appropriate. In this regard I propose that the learning-context social relations, where students' dispositions and attitudes for shaping their own learning are legitimated, is important in an academic development course, particularly when students come from backgrounds that do not encourage a level of self-regulation in this regard. I also propose that the academic practices work of quadrant 2 (which is equivalent to Lea and Street's (2006) 'study skills' perspective) form the foundation and entry point to some of the scientific literacies work in quadrant 3 (which would be equivalent to Lea and Street's (ibid.) 'academic socialisation' perspective⁸). Hence, drawing on generic academic practices provides a base and some initial structure to the scientific literacies work. It is important, however, that a course such as ISCM does at some stage make the shift to stronger semantic density in order to contextualise the work in a disciplinary context and to increase the cognitive complexity as is required in higher education.

6.6 Moving forward

This chapter has revealed ISCM to be a multidisciplinary, integrated and hierarchically structured science course which, using LCT(Specialisation), is identified as having a knowledge code. Using LCT(Semantics), differentiated knowledge types and practices give rise to a differentiated curriculum, which can be described as exhibiting a rhizomatic/worldly code.

Since most teaching-learning interactions in ISCM have documentation (handouts and resource materials) associated with them, the document analysis in this chapter provided good insights into the *intended* curriculum. However, the *enacted* curriculum, and underpinning regulative discourses of current recontextualising agents, are better revealed through interviews, observations, my own critical reflections, discussions, and student evaluations. The following chapter provides insights at this level.

⁸ Despite commitment of current recontextualising agents to developing academic literacies, the relatively broad-scale analysis indicates that probably only a small portion of the ISCM curriculum work could be categorised according to Lea and Street's (2006) third 'academic literacies' perspective.

Chapter 7: Legitimation and framing of ISCM pedagogy

7.1 Introduction

The previous chapter provides insight into how knowledge and knowers are legitimated in the ISCM curriculum. The focus in this chapter shifts to pedagogy and aims at answering part of the second research question, which asks how pedagogic and assessment practices are framed and legitimated in ISCM to enable access.

Both the classification and framing principles can be used to understand pedagogic practice. Classification denotes strength of boundaries between knowledge types and knowledge practices and work in the previous chapter points to clearly-defined boundaries between disciplines (with the exception of HKE), indicating stronger classification (+C), and weakly-defined boundaries in the scientific literacies and academic practices work, indicating weaker classification (-C). In contrast, the principle of framing regulates how the discourse is transmitted and acquired in the pedagogic context. This relates to degree of control, and when framing is strong the transmitter has explicit control over the social base as well as over selection, sequencing and pacing of knowledge and over criteria of assessment (Bernstein, 2000, p13). Framing forms the main focus of analysis in this chapter, drawing on the external languages of description developed in Chapter 5. Data for this chapter is from staff interviews, documents, observations, my own critical reflections, discussions, presentations and student evaluations.

The chapter is divided into two main sections. The first examines the underpinning regulative discourse of ISCM pedagogic practices, and the second the instructional discourse. The discussion focuses on modalities of framing within both discourses and the influence this may have on promoting epistemological access. Because social relations, which were virtually invisible in the curriculum analysis, become highly visible in the pedagogic practices analysis, legitimation of knowers and associated gazes are also considered.

7.2 Regulative discourse

The regulative discourse is the discourse of moral and social order (Bernstein 2000, p13), which can operate at different levels. This has been variously interpreted by different authors as the social order of (a) the classroom (Ivinson 2002; Singh 2002; Morais, Neves and Afonso 2005; Liu and Hong 2009), institution or society (Singh 2002; Vorster and Quinn 2012), or (b) the discipline and curriculum (Ylijoki 2000; Geirsdóttir 2008; Martin, Maton and Matruglio 2010). These distinctions are important; whilst the social order of the classroom or institutional context would have *axiological* underpinnings the social order of a discipline and curriculum

would instead have *epistemological* underpinnings. The same distinction was made in the previous chapter when two forms of social relations were recognised – the axiologically oriented learning-context social relations (SR(lc)) and epistemologically oriented epistemic-context social relations (SR(ec)). These two forms of underpinnings or concerns frame the rest of this section on the regulative discourse of ISCM pedagogic practice which should, by its nature, reflect the perceived and articulated role and purpose of a course.

7.2.1 Regulation of axiological concerns

There are two components to the axiological concerns of the ISCM regulative discourse. The first relates to regulation of staff–student relations in the classroom¹, and the second to regulation of students becoming and being autonomous science learners in a broader institutional context. These are discussed in turn below.

7.2.1.1 Staff-student relations: General ISCM ‘classroom’ conduct

Personal preference of ISCM lecturers gives rise to both stronger and weaker framing in terms of regulation of staff–student relations in the classroom (see Table 5.5 (laminated), empirical sources 1–4), which Bernstein (2000) refers to as the rules of hierarchy. However, staff who choose to teach in this course generally have a concern for student success and well-being, which often translates to weaker framing. For example, all lecturers invite e-mail contact and have open door policies:

My door is always open. You may come and see me any time – if I am busy I will make a time when we can both meet. You can come on your own or in a small group if you are all having the same problem. (Paraphrase in week 2 tutorial, RA5²)

Students appreciate the more personal approach and frequently comment on this in their evaluations:

Not only can you approach [X] in terms of academic she also acts as a mother figure helping us with every aspect of university life. (Student evaluation, June 2012)

Similarly,

She is very good at helping you understand and she always makes sure that she checks if everyone is following and if not how can she be of help. (Student evaluation, June 2012)

Weaker framing was also exhibited in staff expectations for students to interact, engage, and to question science and authority:

¹ ‘Classroom’ in ISCM refers to tutorial, practical or lecture sessions as well as ISCM interactions beyond the formal contact sessions.

² In line with the work of Bernstein (2000), I refer to past and current staff members of ISCM as recontextualising agents (RAs). They have been allocated a number in an attempt to retain anonymity, although I am aware this has not necessarily been maintained for all staff members.

You mustn't accept everything we say at face value. You are welcome to question things.

In fact, you should always question things! (Paraphrase in week 5 tutorial, RA5)

However, students can still find it difficult to approach and engage with staff, indicating stronger framing:

[X] is a great lecturer but very strict, that is why I would find it difficult for me to approach her about my work. (Student evaluation, June 2012)

A relatively stronger framing is also signified by articulation of clear rules on expected format of submitted work (such as information on cover page and formatting conventions), strict working with submission deadlines, and adherence to due performance (DP) requirements which include compulsory attendance at practicals, writing all tests and submission of all assignments. Individual lecturers also have their own preferences in relation to student conduct in the classroom, this particular lecturer indicating stronger framing in this regard:

After a couple of weeks when students arrive late for class I do not let them come in because I find it so disruptive – I lose concentration and so do the students. They quickly learn to come on time for my classes. (Discussion paraphrase, RA5)

For another, expected classroom practice is articulated in their first lecture and expressed as a set of 'unwritten rules' (Figure 7.1).

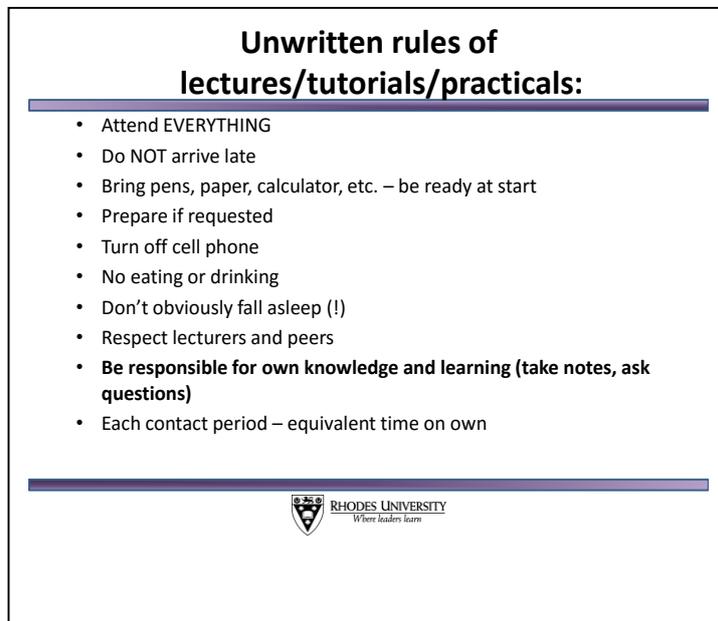


Figure 7.1: Expected classroom practice (Powerpoint slide, RA4)

In general, in terms of regulation of the relationship between staff and students, ISCM exhibits relatively stronger framing with respect to rules of classroom conduct, DP requirements, and assignment submissions (+F), but weaker framing in terms of availability and approachability of

staff and being open to questioning (-F). There is, however, variability in this regard between the different lecturers, and students appear to quickly understand what is required from each.

7.2.1.2 Becoming and being autonomous science learners

When asked about the purpose of ISCM it was clear from interviews that staff perceived the *primary* goal of ISCM was enabling students to become effective science learners in an academic context. As such, staff articulated the norms, values and practices they perceived as necessary for becoming a science learner in a number of ways. Firstly they mentioned the need for students to **learn how to study** and their comments quite often related to metacognitive aspects of thinking about learning:

... they need to know what to do if they don't understand ... thinking about how they learn and what they're going to learn and what they're going to do about it ... and I suppose also realising that they don't know what's going on ... a lot of it is, you know, helping them know how to study and thinking about study ... to learn that there are places that they can go to find answers. (Staff interview, RA6)

Staff also spoke about appropriate study techniques:

... they need to become capable as students to study effectively ... unlearning of poor learning techniques ... (Staff interview, RA9)

One of the most frequent comments related to learning to work independently:

... students need to work independently, not always rely on someone to teach them everything nor rely on someone to always check whether they have understood ... requires reflexivity ... (Staff interview, RA4)

Staff also spoke about students needing to develop **good conceptual understanding** rather than rote learning and **engage at a higher level**:

... develop an ability to understand and to ask the right questions of what's in front of them ... to bring them up to the right kind of academic level in terms of the scientific reasoning approach and that fact that they can't rote learn ... (Staff interview, RA7)

... have the skills to select the right kind of material, to extract the meaning, to put it together into coherent text and this way to generate a new piece of knowledge ... be able to engage with course handouts and material on a higher level ... acquisition of higher-level learning techniques ... (Staff interview, RA9)

Two staff members recognised the important role **affect** plays in student learning:

I've always felt that the work that [we] do is very much around the person, and a lot less around the science. It's about motivation and self-esteem but always within the context of becoming a scientist, and thinking and being curious ... it's all those more socio-affective things than necessarily the science. (Staff Interview, RA4)

. . . [the course] starts off as not so difficult and it gets more challenging where they are definitely going to find things that they don't know . . . you are building their confidence in the transition.
(Staff interview, RA6)

When questioned about successful learners in their own disciplines, the disciplinary staff seldom mentioned particular disciplinary content knowledge and practices but instead spoke of knower dispositions such as willingness to engage, participate, be challenged, and seek help as well as being confident, motivated, curious and reflective. In their interviews they were mostly unsure how their own teaching engendered these dispositions.

The norms and values implicit in the statements thus far in this section point to a recognition of the need to develop practices and learner dispositions that are appropriate for learning in a higher education science context. This includes dispositions such as being independent, engaged, critical, reflective, confident and responsible for one's own learning, which I encapsulate here as being **autonomous science learners**. Bhattacharya and Chauhan state that autonomy is defined by a 'capacity for detachment, critical reflection, decision making, and independent action' (2010, p376). As such, an autonomous learner should take responsibility for their own learning, be able to set goals and find ways of meeting those goals by choosing appropriate strategies, and monitor and evaluate progress and respond appropriately (Dickinson 1993; Bhattacharya and Chauhan 2010; Po-Ying 2007).

The data presented thus far relates to *perceived* pedagogy as expressed in staff interviews. The framing of regulation of student learning conduct, as indicated in additional sources of data such as classroom observations and critical reflections, relates to the *enacted* pedagogy and provides an indication of how pedagogy enables development of autonomous science learners. The development of an external language of description in Chapter 5 showed that stronger framing of regulating student learning conduct in science was through explicit articulation of expectations, and weaker framing was through a more implicit approach (see Table 5.5 (laminated), empirical sources 5–6). The data below shows that modelling of expected practices and scaffolding of these practices also contribute to stronger framing in this regard.

The two literacies practitioners are deliberately **overt** about expectations with respect to students being active, engaged and independent self-regulated science learners. Therefore, in tutorial sessions that relate to students developing independent learning practices, they are explicitly informed that these activities are **modelling** practices expected of them in the future without lecturer input. Such tutorials cover developing good note-taking and note-making practices, consolidating lectures, 'joining the dots', developing a 'big picture', linking theory with practice, testing understanding, asking questions, practising technical aspects (such as calculations, measuring, estimating), responding to feedback, locating and using resources (past

papers, readings, resource notes, handouts, dictionaries, internet, YouTube, model answers). To give an example, preparation and consolidation of lectures is a key tutorial activity during the first term, but this decreases during the second term and desists by the third term. However, students are constantly reminded that this support is being deliberately withdrawn in order that they continue the work independently. My Reflective Journal indicates that in a tutorial in the third term I asked students why I was not doing a consolidation of the practical or the lectures that week. The discussion that followed related to students needing to do the consolidation work themselves and how they could best go about it.

Similar **scaffolded** reduction of support occurs where individualised feedback from staff on drafts of large assignments is gradually withdrawn, being replaced by supported peer-assessment of assignments in the third term and supported self-assessment in the fourth term. The reasons for these shifts in terms of developing learner autonomy are discussed with students. Another example of encouraging autonomous learning practices is through the inclusion of additional tasks in tutorial handouts. Students are required to provide answers for selected tasks *during* class for feedback and assessment purposes, but are explicitly encouraged to complete the remainder *in their own time*, consulting posted model/suggested answers later if necessary. Further guidance on self-regulated learning is provided through discussion of the concept of notional hours and the amount of time students are expected to work outside of formal contact sessions. The self-reflective exercises in the literacies tutorials relating to students' own progress, attitudes and approaches to their studies (mentioned in Chapter 6) also contribute in this regard. In addition, independent work is an underpinning aspect of the research project in the second semester, where students drive the entire process themselves. One student stated:

During my research project I have encountered numerous challenges which I think were caused by the fact that I had to adapt myself to the fact that I was independent and had only my partner to rely on . . . included the fact that I had to take care of the environment my research treatments were under . . . being responsible for the recording of data which was very important and the core underlying factor of our experiment (Student interview, Rolihlahla)

In contrast to the explicit approach in tutorials, one of the disciplinary lecturers commented on the fact that, although she does expect learner preparation outside of class, she is not always explicit about it:

Lecturer: I don't always lecture exactly the same way the whole way through . . . sometimes they have to do more of the preparation themselves, ya, more prep themselves.

Interviewer: So is that a conscious thing?

Lecturer: I try to be . . . [but] I don't think that I'm nearly conscious enough about what I'm doing and why I do it. I don't think I make it clear to students. (Staff interview, RA6)

It is worth mentioning here that the disciplinary staff interviews revealed a perception that, by exposing students to a range of science disciplines and approaches in ISCM, students can make better and more informed choices about their own studies when they proceed into mainstream. As one staff member suggested:

We are giving them a little bit of a taste of lots of different kinds of people, kinds of lecturers they're going to meet along the way, and how to handle it . . . [so they can] make better subject choices when moving into mainstream. (Staff interview, RA6)

Students too perceive this as one of the purposes of ISCM and many comment on the value of such exposure:

It helped me with choosing courses on mainstream. If there was not science extended studies then maybe I might have chosen courses that I would have problem and fail and that would result to exclusion. (Student evaluation, 2012)

I view this disciplinary 'exposure' as part of the axiological concern of enabling science learners in a university context, as students are developing an understanding of who they are, what their interests are and where their strengths lie.

As mentioned, since course inception the aim of ISCM has been to both provide concepts and skills [practices] as required by first-year students in a science degree and to ensure student success in mainstream. The analysis in this section indicates that current recontextualising agents have interpreted the second aim in a relatively broad sense through focusing on social relations that enable development of autonomous learners in the sciences. This is embedded in the notion that ISCM is an academic development (foundation) course that provides much support to students in their first year at university, but that students will need to work in autonomous and independent ways once in mainstream, where opportunities for support are greatly diminished:

When they leave us [to go into mainstream] students need to be able to get on with the job. They need to be able to work on their own, find help when they need it . . . know *when* they are battling and know *what* to do about it. (Staff interview, RA4; original emphasis)

In summary, the overall approach adopted in ISCM pedagogy, through explicit articulation of expected learner dispositions, values and practices in science and underpinning norms and values of such practices, as well as through modelling and scaffolding of such practices, indicates relatively **stronger framing of the regulation of science student learning conduct (+F)**. In LCT terms this would be expressed as stronger learning-context social relations (SR(lc)+). In

this regard they are expected to become autonomous learners who are responsible for developing their own understanding in independent, proactive and reflective ways. Although there is little evidence of weaker framing in this regard (except in the comment in this section by RA6), it is acknowledged that implicit expectations are more difficult to surface.

7.2.2 Regulation of epistemological concerns: Becoming and being scientists

The SESP Review Report states that learners need to not only '*know* the content and concept knowledge of science (or relevant disciplines), they also need to learn to *act* and *be* like scientists when they work in the laboratories, write reports, conduct experiments, engage in field work, develop a logical argument, etc.' (2011, p8; original italics). Interestingly, although the norms, values, conduct and practices associated with becoming autonomous science learners are highly visible from staff interviews as stated in the previous section, those associated with **becoming and being a scientist**, which have an *epistemic* base, were hardly mentioned at all in the interviews. Only one lecturer mentioned students developing a 'scientific reasoning approach'. However, evidence of the ontological concern of becoming and being scientists is visible in ISCM pedagogic practices. The external language of description developed in Chapter 5 shows that regulating student conduct as scientists can be both through explicit instruction, exhibiting stronger framing, and through tacit processes, exhibiting weaker framing (see Table 5.5 (laminated), empirical sources 7–8).

Science is about developing reliable knowledge of the physical and natural world. The values that promote this goal relate mainly to how knowledge is generated (e.g. inductively through seeking 'patterns', or deductively through hypothesis generation and controlled experiments, careful observation and measurement, making and confirming predictions) and to the basis on which claims are made (e.g. based on empirical evidence, recognising the tentative nature of science). Therefore, in order for students to become and be scientists they would be expected to develop practices and knower dispositions based on scientific epistemic values linked to knowledge generation and claim-making, such as being rigorous, curious, reliable, critical, and objective; working accurately and precisely; estimating appropriately; observing carefully; seeking simple solutions; and thinking analytically, amongst others. This type of epistemic values work forms a backdrop to much of the scientific literacies work done in ISCM. As stated in section 6.3.3: 'wherever appropriate both the understanding, as well as the valuing of the concept (for example why and under what circumstances scientists value both precision as well as estimation), are considered'. To continue with this example, in the practical session in which accuracy, precision and estimation are addressed, 10% of questions relate to epistemic values. However, as is often the case, these values questions usually become sidelined by students, who instead focus on the practical tasks related to measuring accurately and precisely (e.g. using

vernier callipers that allow readings to the nearest 0.02mm in length measurements) and estimating appropriately that have more readily identifiable right or wrong answers.

Other instances in ISCM pedagogic practice where epistemic values are highlighted are discussions on:

- Why scientists can prove something to be false but they cannot prove something to be true, they can only add evidence to support an idea or hypothesis
- Being tentative in writing conclusions of an experiment by using language such as 'the evidence supports the hypothesis' or the 'data suggests' a particular trend
- Referencing sources as a means of developing and supporting a scientific argument
- Why empirical evidence is valued over personal opinion
- The value of repetition (replicates) to validate results through statistical analyses
- The importance of evaluative, critical and honest approaches to develop good scientific knowledge (see Ellery 2011 for student reflective comments indicating their understanding of these epistemic values).

These discussions suggest relatively stronger framing (+F) of underpinning epistemic norms and values that will influence students' practices as scientists. As mentioned already, since underpinning epistemic values are best understood within an appropriate scientific context these are usually addressed alongside scientific content and process in ISCM pedagogic practice. Therefore, when talking about tentative writing, this is within a context of students producing a scientific laboratory report. Also, the opportunity to discuss the importance of replicates always arises in the independent research project when some plants die unexpectedly. This too allows us to discuss the most appropriate strategy of dealing with such events in statistical analyses and interpretation of results. The stronger framing of selection and sequencing of much of the science work which supports the regulation of students becoming and being scientists is discussed more fully in the following section on instructional discourse.

Although ISCM focuses on epistemic values that guide knowledge generation and writing in science, it also attempts to surface the role that the values of individuals play in science. In this regard, for example, the contrasting explanations for the location of forest patches on south slopes in the hills surrounding Grahamstown are discussed. Soil scientists relate this to soil moisture and organic matter, ecologists relate this to the influence of fire. These examples provide opportunities for discussions on bias, objectivity and careful observations, as well as critical and open thinking.

A third aspect of values addressed in ISCM is the social values associated with and emerging from science. Where possible we move beyond the science and economics of an issue to include the impact that science may have on society. Students therefore not only learn how an atom bomb works, but after watching a DVD showing the scientific and historical context of the release of atom bombs on Hiroshima and Nagasaki, we pose the following question: 'Do you think it is the role of scientists to be concerned about the impact of science on society? If not, whose concern is it?' (Tutorial handout; 2013). Debates on social, economic and safety aspects of nuclear waste storage at Vaalputs in the Northern Cape and fracking in the Karoo, and the effect of Genetically Modified Organisms (GMOs) on human health and environment form part of this thrust of social values in science. Questions guiding their thoughts include who the stakeholders are, what their interests are, who is involved in decision-making, who benefits and what their motives are, what the social, economic and environmental costs are, what possible consequences are, and what the alternatives are.

In summary, the approach in ISCM pedagogic practices, through explicit questions and discussions particularly related to underpinning norms and values of science, indicates relatively **stronger framing of regulation of student conduct as scientists (+F)**, which in LCT terms would be expressed as stronger epistemic-context social relations (SR(ec)+). The fact that this contrasts with the weaker epistemic-context social relations (SR(ec)-) identified in the previous chapter is expanded on at the end of the chapter. This stronger framing of regulation of student conduct as scientists is supported by various modalities of framing in the instructional discourse, as outlined in the following section.

7.3 Instructional discourse

Whilst the regulative discourse of a course relates to the social order of the classroom, institution or discipline (or field) underpinned by axiological or epistemic concerns, the instructional discourse relates to what is transmitted and the manner in which it is transmitted. In order to characterise the instructional discourse of ISCM pedagogic practices an external language of description was developed for the framing of rules of the discursive order of selection, sequencing, and pacing of knowledge, as described in Chapter 5 (see Table 5.4a (laminated), empirical sources 1–9). These are discussed in turn below. The framing of discursive rules relating to evaluation criteria and feedback are examined in the following chapter on assessment practices.

7.3.1 Framing of selection of knowledge

Since lecture content and tutorial material are determined a priori jointly by literacies and disciplinary lecturers it is clear that staff, rather than the students, play a key role in knowledge

selection in the ISCM curriculum. Interviews with disciplinary staff indicated an overall bridging and 'plug the gap' approach in ISCM, based primarily on the fact that the hierarchical structure of science, as well as the cumulative nature of learning in general, requires building blocks in place before proceeding to others:

. . . still very much bridging a knowledge gap, we try to focus on sections of the main course where we know foundations are shaky . . . not just content related but cognitive skills so the manipulation of information to fit a certain problem . . . to bring them up to the right kind of academic level in terms of the scientific reasoning approach. (Staff interview, RA7)

In this regard, one staff member indicated they were cognisant of ISCM students' school backgrounds:

. . . bridging year where pupils from previously disadvantaged schools are brought up to speed with certain skills that we assume, starting from writing skills to literacies skills to ya, basic research skills, you know, statistical analysis, stuff like that that we can easily impose on first year students that come through a more privileged system (Staff interview, RA8)

Decisions in terms of which disciplines should be taught have a historical precedent linked to the original setting up of the course, and continue in part today. This too was based on the 'building blocks' concept where the 'What is science?', Physics and Chemistry components have existed since the inception of the course and are considered foundational and therefore essential. The 'What is science?' component is considered useful for more general scientific concepts and literacies:

The 'What is science' section starts with philosophy and history of science and then looks at scientific method and reasoning. This is used as a basis upon which the rest of the course builds. (Oral conference presentation, RA4)

In contrast the Physics and Chemistry components are considered useful in building foundational knowledge:

. . . the Physics and Chemistry we think are fundamental and I think they will always be there [in ISCM] in some form or another, and that is very much linked with the way science is structured. (Staff interview, RA4)

With the 'foundational' Physics and Chemistry components in place, the coordinator consults and negotiates with Heads of Departments and lecturers concerned with regards to the rest of the disciplinary content. The current HKE/Geology combination is an attempt to broaden the range of science disciplines:

. . . what we do in the second half of the semester . . . is really a matter of [our] choice. I like the earth/life science combination because it encompasses quite a lot of the choices

that students can do [in mainstream courses] in the Science Faculty. (Staff interview, RA4)

However, there are a number of non-pedagogical factors that influence this choice, as indicated by the following comment:

. . . political and practical things that play into what gets taught . . . haven't had easy or good support from some Departments . . . there is reluctance by some departments to include ISCM teaching in their teaching allocation accounting . . . [however] there is one department [currently involved in ISCM] that is very supportive as they want to draw some black youngsters into their programme . . . (Staff interview, RA4)

In terms of the 'Scientific and language-related literacies' course component, which runs concurrently with the other components, the choice of knowledge and tasks is influenced both by the current disciplinary work in the ISCM course and by what will be expected of students when they move into mainstream disciplines. As one lecturer commented:

. . . for our major assignments we do an essay, a laboratory report, a research project, a research poster, an oral presentation and an abstract/summary as these are commonly used in most disciplines in mainstream teaching. (Staff interview, RA4)

The decisions regarding what is taught within each course component are similarly a matter of consultation between literacies and disciplinary staff based on perceived needs of students:

We do a bit of the periodic table and electronic structure, atoms, conservation of mass, stoichiometry and the chemical reactions and equilibrium . . . it is disciplinary knowledge that has implications for other disciplines. (Staff interview, RA7)

I pick introductory sections across the Geology syllabus selecting topics that are easy to grasp and/or very important in Geology. (Staff interview, RA9)

In summary, the analysis indicates relatively **stronger framing** in terms of **selection of knowledge (+F)** in the ISCM course. The only apparent exception to this trend is when students are expected to decide on and independently locate disciplinary knowledge for their independent research projects, although this is still within the context of strong framing in terms of the project (an experiment in which they examine how plants respond to variation in an environmental factor) that has been decided a priori by staff (see Table 5.4a (laminated), empirical source 3).

7.3.2 Framing of sequencing of knowledge

The sequencing of knowledge in the ISCM course has been touched on already, but is determined mainly by the lecturing team. At one end of the scale one lecturer commented on the need to present foundational blocks first:

We start off with foundational blocks of units, size and scale that they need for the rest of their degree (Staff interview, RA6)

At the other end of the scale a lecturer commented on the complexity of one of the components, which is better suited to being later in the course:

Geology has a complexity that few other fields have on offer which is why it is last in the ISCM course. (Staff interview, RA9)

From the above statements we see that sequencing, like knowledge selection, is based upon the hierarchical view of knowledge in the sciences, where foundational concepts are integrated and subsumed to form more complex and abstract or generalised knowledge. This hierarchical pattern plays out firstly in the entire course, as evidenced by this statement on the necessity for Physics to be the first disciplinary component:

. . . there is some content in there that builds foundations for the rest of the courses, you know, all from science faculty, significant figures and units and so on. We don't do a huge amount of actual Physics content, a lot of it is foundational work. (Staff interview, RA6)

The hierarchical pattern also plays out within course components, as evidenced in the statement on the Geology component:

. . . first you need to teach the very basics: what is a rock, what is a mineral, what different rock types exist . . . there are some basics that you need to do in order to explain higher level concepts. (Staff interview, RA9)

This hierarchical trend is also visible in the 'Scientific and language-related literacies' course component where, for example, writing an essay is the culmination of a series of tutorials in which foundational tasks such as unpacking the question, accessing sources, writing paragraphs, introductions and conclusions, linking words and sentences, planning a draft, working with criteria, and citing and referencing may be addressed. Likewise, working with data concepts such as types of data and simple representations and descriptions is addressed before working with complex data representations, interpretations and critical thinking.

The ISCM course therefore exhibits relatively **stronger framing** in terms of **sequencing of knowledge** (+F), and the only real evidence of relatively weaker framing of sequencing of knowledge is in individual teaching interactions, where, for example, a disciplinary lecturer initially interacts with students with regards to their understanding on a topic, and then selects and sequences the knowledge based on their immediate needs (see Table 5.4a (laminated), empirical source 6). This approach is more common with the literacies practitioners.

7.3.3 Framing of pacing of knowledge

Unlike for selection and sequencing of knowledge, there is evidence that both lecturers and students influence pacing of knowledge in the ISCM course, thus indicating both stronger and

weaker framing (see Table 5.4a (laminated), empirical sources 7–9). Stronger framing tends to be at the macro level with a programme for lectures, practicals, major assignments and tests that is set at the beginning of the semester (see assignment and test dates in semester plan, Table 6.2). This stronger framing is expressed by first semester disciplinary staff, who speak of the need to both cover content and address foundational concepts:

I feel constrained to get those foundational concepts in and if I don't they might be stuck.
(Staff interview, RA6)

We teach content – the list of topics . . . because if there is strength missing in these areas, they can't do anything else. (Staff interview, RA7)

In contrast, one of the second semester disciplinary lecturers seems to have a more flexible approach:

. . . every year I am getting slower and slower, because students seem to need it. But it doesn't matter because if you communicate the content in a slower way with more repetitions, the more sinks in . . . (Staff interview, RA9)

There is much weaker framing in the tutorial sessions. Although there is an overall teaching plan for the semester, the literacies practitioners meet weekly and make adjustments to accommodate current student understanding. An example of this is from my own critical reflections:

I saw a lot of blank faces at the end of the session when we discussed falsifiability in science. I thought we should work with the concept some more, so I developed a few statements and questions that would help guide their thinking and discussions in a follow-up [unscheduled] tutorial session. I think this helped them a lot as they were able to argue around the question 'Do you think Karl Popper's idea that 'all science should be falsifiable' is a good one?' - which is a high level philosophical question for week 2 of the year! (Reflections Journal)

However, by the second semester both literacies practitioners become less flexible with pacing, expecting students to complete all tasks in class. As one mentioned:

. . . [students] really do need to learn to work faster or they will never cope in mainstream. (Discussion paraphrase, RA5)

The ISCM course therefore exhibits both **stronger and weaker framing** in terms of **pacing** of knowledge (+/-F). Weaker framing is usually in response to students' immediate needs in tutorial sessions.

7.4 Discussion on ISCM pedagogic practices

Like education systems the world over (Arum, Gamoran and Shavit 2012), it is the contention in this study that the South African higher education system is underpinned by the norms and

values of middle-class educated families and does not favour working-class students. In his work on pedagogic discourse Bernstein (1990, 2000) maintained that pedagogic practice has the potential to either reproduce or transform social class differences. Pedagogic practice characterised by strong classification and framing and a logic of transmission is referred to as 'visible' pedagogy, and that which is characterised by weaker classification and framing and a logic of acquisition as 'invisible' pedagogy (Bernstein 2000, pp109–110). 'Mixed' pedagogies can also be generated through differential strengthening and weakening of classification and framing for different aspects of the regulative and instructional discourses (Morais, Neves and Pires 2004, p75; Hoadley and Muller 2010). A series of close-up empirical studies examining performance of scholars and student teachers has shown how particular modalities of mixed pedagogies can be used to provide better epistemological access to particular groups of students – especially those that could potentially be disadvantaged by the system (see Morais and Neves 2001; Arnot and Reay 2004; Ensor 2004; Rose 2004; Morais, Neves and Pires 2004; Morais, Neves and Afonso 2005; Hoadley 2008). The principles of framing and mixed modalities are used to examine the regulative and instructional discourses of ISCM pedagogic practices. Although they have been considered separately for analytical purposes, the two discourses are closely linked in the ISCM pedagogic practices themselves.

7.4.1 Framing of the instructional discourse

In studies of pedagogies with mixed modalities designed for learners from 'educationally-disadvantaged'³ or working-class backgrounds, access is mostly attributed to stronger framing of selection and sequencing of knowledge (and evaluation criteria discussed in the following chapter on assessment) and weaker framing of pacing and staff–student social relations. The rest of this section discusses these in turn.

Empirical research in teacher education (Ensor 2004) and school science (Morais, Neves and Afonso 2005) indicates how stronger framing at the level of *selection* and *sequencing* can assist with acquisition of recognition and realisation rules, and therefore epistemological access. It is clear from the analysis that framing of selection and sequencing of knowledge in ISCM is relatively strong and that the concept of a hierarchical knowledge structure is a key driver of this trend in a number of ways. Firstly, at a general science level, introductory science concepts such as SI units, measurement and significant figures are addressed in the earlier part of the year and drawn on throughout. Secondly, in disciplinary terms, Physics and Chemistry concepts are taught first as they underpin aspects of HKE and Geology which are taught later. Thirdly, within each discipline foundational concepts are dealt with before more complex, integrative

³ In this context 'educationally-disadvantaged' means the educational system has not prepared students well for higher education.

ones. Fourthly, basic generic academic practices often form the building blocks for later, more complex, epistemically-based scientific literacies practices. For this reason the independent research project, which draws on a wide range of previously addressed generic academic practices, scientific literacies practices and disciplinary knowledge and practices, takes place in the latter half of the year and is considered particularly useful as serving an integrative function.

Bernstein (2000), Morais, Neves and Pires (2004), Neves, Morais and Afonso (2004) and Rose (2004) all argue, and some show empirically, that weaker framing of *pacing*, especially in terms of flexible time on task, is particularly beneficial for 'educationally-disadvantaged' working-class, students. ISCM provides for such flexibility through its accommodating tutorial programme, although the lectures, practicals, and assignment and test regime are more fixed. Nonetheless, the latter more rigid aspects of ISCM are evaluated yearly and adjusted to respond to students' perceived needs. Morais, Neves and Pires (2004) also suggest that weaker framing of pacing is best supported by weaker framing of *staff-student relations*. ISCM offers this through its classroom context of open communication, where students can question, discuss, share and critique ideas. Although research by Hoadley (2005) in a school context shows support for stronger framing of staff-student relations, I suggest that weaker framing in a higher education context is necessary to better enable independence, autonomy and critical thinking.

7.4.2 Framing of the regulative discourse

The regulative discourse is essentially about social relations and although these were only marginally visible in the curriculum analysis they become much more visible in the pedagogic practices analysis – indicating the value of doing both analyses for a more holistic view. In Chapter 6 a distinction was made between epistemic-context social relations (for the field of science) and learning-context social relations (for science learning), and these come sharply into focus in the analysis of ISCM regulative discourse.

The learning-context social relations in ISCM show an axiological valuing of attributes, norms and values associated with the process of becoming and being successful, independent, autonomous learners in the sciences in higher education. In this regard it is mainly the tutorial sessions that contribute to development of science learners in a higher education context. ISCM staff have identified that science learning in an academic context requires knower dispositions and attributes such as being engaged, critical, reflective, confident, independent, responsible, and autonomous. The relatively stronger framing of regulation of student learning conduct through explicit articulation of expectations of particular academic contextual practices, and the relatively weaker framing of the staff-student relations through open-door policies and encouragement of a questioning and critical attitude, are two key approaches utilised in the instructional discourse to support this axiological concern. A third contributor is the relatively

stronger framing of selection and sequencing of knowledge (in this case academic practices knowledge; APK) that ensures appropriate practices such as lecture preparation and consolidation are both explicitly modelled and appropriately scaffolded to increase student independence during the year. The fourth major contributor is the research project that enables students to work in independent and autonomous ways that will be expected of them once in mainstream.

The epistemic-context social relations show a valuing of epistemic attributes, norms and values that underpin the process of becoming and being a scientist. This requires knower dispositions and attributes such as being rigorous, accurate, precise, objective, critical, honest; thinking analytically; and observing carefully. The relatively strong framing of selection and sequencing of knowledge and of aspects of staff–student relations and student conduct as scientists in the instructional discourse supports this concern by providing opportunities to be explicit about epistemic values and to model and scaffold practices underpinned by these values. Unlike for learning-context social relations (where tutorials are the main pedagogic interaction for enabling science learners), lectures, practicals and tutorials that have as their focus scientific knowledge, concepts and practices *all* offer opportunities for enabling epistemic-context social relations, as does the independent research project.

7.4.3 Overview of framing of pedagogic practices

Different modalities of pedagogic practices have the potential to enable or constrain student access. According to the literature in this regard, the instructional discourse of ISCM pedagogic practices appears to be well formulated to enable such access. The pedagogic analysis also indicates a concerted effort to surface what can often be ‘hidden’ aspects of the regulative discourse by explicitly articulating norms and values as well as providing explicit instruction and modelling of practices.

Whilst hardly visible in the curriculum analysis (based on course documentation only), social relations, particularly learning-context social relations, were very visible and highly legitimated in the pedagogic practice analysis (based on documentation, interviews, observations and reflections). This opens up the opportunity to revisit social relations and to comment more fully on the kind of knowers, and their associated gazes, that are being legitimated in ISCM. This chapter therefore ends with a diversion into this territory, which includes re-examination of LCT(Specialisation) codes that are legitimated by ISCM.

7.5 Revisiting ISCM code legitimization

7.5.1 Social relations: Knowers and associated gazes

Since two kinds of social relations are legitimated in ISCM pedagogy, so too are two kinds of knowers. The stronger framing of axiological concerns in the regulative discourse indicates stronger learning-context social relations (SR(lc)+), which means a science learner, or learning-context knower (Kn(lc)), is being legitimated. Likewise, the stronger framing of the epistemological concerns in the regulative discourse indicates stronger epistemic-context social relations (SR(ec)+), which means a scientist, or epistemic knower (Kn(ec)), is also being legitimated.

ISCM therefore legitimates two kinds of knowers, although each is intimately shaped by the other. In other words, the learning-context knower that ISCM is engendering is located within an epistemic (science) context, and the epistemic knower that is engendered needs to be a certain kind of learner in order to access the sciences. This suggests that the learning-context knower of ISCM is not necessarily a generic knower that would be successful in any higher education context. In this regard, I would argue that, when we try to engender ISCM learners to be organised, purposeful and systematic in their practices by working independently and autonomously, and developing a deep questioning approach related to their own conceptual understanding, this is better suited to disciplines in the sciences than, for example, the dramatic arts, where perhaps a more creative, expressive and visually-communicative learner may be appropriate.

Every knower has a gaze. By indicating that both learning-context and epistemic-context social relations are relatively strongly legitimated in ISCM pedagogic practices (i.e. SR+), I am making a claim for something more than a trained gaze, which has weaker social relations (SR-)⁴. In both cases I suggest a gaze in which the knower's way of knowing is valued (i.e. a cultivated gaze) rather than a gaze in which the kind of knower is valued (i.e. a social gaze). A cultivated gaze usually involves developing a 'feel' for practices through prolonged participation and apprenticeship (Maton 2014a, p186).

This claim for two cultivated gazes is strengthened by the ideological contention that all practices have socio-cultural origins and that accessing them, and therefore developing the appropriate gaze, is neither a neutral nor an uncontested process. This suggestion is based on

⁴ I have grappled with social relations constantly in this study for two reasons. Firstly, the two kinds of knowers (learning-context and epistemic-context) identified here were only very recently conceptualised as such – so for a long time they were conflated in my mind. Secondly, because both these knowers appeared to be SR+, they did not conform to the conventional categorisation of a trained gaze, which is SR-. Although I have *some* confidence in my argument of cultivated knowers, I invite and look forward to dialogue with others in order to either strengthen my argument or be convinced otherwise.

four interlinked premises as outlined in Chapter 3 in the sections on access and identity development: (a) any social practice is underpinned by norms, values, attitudes, motivations and perspectives (see Street 2006; Morrow 2007, 2009; Gee 2012); (b) taking on new norms, values and attitudes is a social act that results in developing new dispositions and practices (i.e. a new identity; see Barnett 2000, 2004, 2007; McKenna 2004; Dall’Alba and Barnacle 2007; Gee 2012); (c) identity development is hard work, takes time and cannot be achieved through direct instruction alone (see Gee 2012; McKenna 2012; Pym and Kapp 2011); and (d) the greater the gap between prior and new identities, the more time it will take, and the more guidance, immersion and socialisation in the new context is required (see Boughey 2002, 2008; Niven 2011; Gee 2012). Of course, change can also be resisted (Gee 2012). Based on these above four premises it is, in fact, difficult to envisage *any* form of trained gaze.

The concepts of immersion and socialisation within the new context are key in developing a cultivated gaze, as ‘legitimacy arises from dispositions of the knower that can be inculcated’ (Maton 2104a, p95). This is best illustrated by looking at the two knower types identified in this study in turn, and in so doing I draw on the distinction made by Gee (2012) and Morrow (2007, chpt7) of acquisition (through apprenticeship) and learning (through direct instruction), as described in Chapter 3.

In terms of enabling a **learning-context knower** (Kn(lc), also called a **science learner**), I make the argument that, since learning science in an academic context requires acquisition of set dispositions, attitudes and practices based on norms and values of the context, they cannot simply be taught in neutral and acontextual ways but have to be embedded in context. For example, science academia requires learners to be responsible for their own knowledge and therefore to work in self-regulated ways to develop real, rather than rote, understanding. If a learner comes from a context where communal and negotiated interactions are more valued than individualised and independent ways of working, as was shown in Chapter 3 for African foundation students at Rhodes University (Dison 1997; Niven 2005), or, for example, they have an underdeveloped capacity for independent reading (Mgqwashu 2012, p240), autonomous learner dispositions and practices will be ‘foreign’ to them and will therefore be more difficult to take on. Although explicit instruction would assist, apprenticing through modelling, scaffolding and supported interaction by experienced others would facilitate the becoming and being of such an autonomous learner. In another example, learning to know whether one understands a difficult concept (i.e. cultivating a metacognitive understanding of the ‘nature of understanding’ in academia) cannot simply be taught through direct instruction; it is about honing appropriate reflective and questioning practices and developing metacognitive awareness within the context

of a particular discipline. As Bhattacharya and Chauhan state, autonomy does not happen on its own: it requires '[i]nteraction, negotiation, [and] collaboration' (2010, p377).

In terms of enabling an **epistemic-context knower** (Kn(ec), otherwise called a scientist), I make the same argument. Since the values and associated norms and practices of science have developed in particular social contexts, they cannot simply be taught in neutral and acontextual ways but require immersion in such contexts. For example, being objective is highly valued in science. However, this is not a natural way of working or thinking for most as we tend to automatically draw on our experiences and feelings to make judgments about, and develop understanding of, the world around us. I contend that suppressing our subjective 'lens' is not simply a matter of training but instead requires socialisation into practices that not only require learning of technical practices to gather 'objective' empirical data, but also require the development of attitudes and dispositions that allow us to *value* such data and give us the *confidence* to believe in what the data are telling us⁵.

This argument runs somewhat counter to Maton's (2014a) claim that in the sciences legitimacy arises from the knowledge one possesses rather than from any sort of privileged gaze. Whilst I agree that legitimation in science arises predominantly from the knowledge one possesses, I suggest here that the gaze in science, although not dominant, may in fact be a privileged gaze. Maton states that the sciences engender a trained gaze that is gained through 'training in specialised principles or procedures' (ibid. p95). He also goes on to claim that 'in principle anyone can be trained into the legitimate gaze' (ibid. p96). I think this may well be true for many middle-class learners who, due to early socialisation, have developed elaborated coding orientations appropriate for science contexts, but this is less likely for those whose early socialisation has engendered a restricted coding orientation. For students entering higher education with an elaborated code, it is possible that 'training' in the sciences would be sufficient for them to become and be good scientists, as they are already the 'right kind of knower' with the 'right kind of gaze'; in other words, their backgrounds have provided the necessary socialisation and privileged gaze. However, it is unlikely that mere training of a student entering higher education with a restricted code would result in their developing the requisite elaborated code. It would instead require a process of active engagement, socialisation and enculturation into the norms, values and practices of the sciences. Recent work by Wolff and Hoffman (2014) in engineering also suggests that knower attributes and a privileged knower gaze may be more important in the sciences than previously imagined.

⁵ In fact, the example in Table 5.3 where the *focus* is on student opinion on nuclear energy as a form of fuel but the *basis* is on their scientific argument, the social relations are classified as SR(ec)-. However, this could arguably be classified as SR(ec)+ since it requires a particular privileged knower to 'know' that personal opinion is not being sought.

I posit that the concept of a trained gaze in the sciences may have developed because science practices have become so normalised in western, middle-class society that, for the majority of science academics, the socio-cultural nature of science and its underpinning values are tacit and even unarticulated (see Jacobs 2005, 2007). As such, science is treated as a disinterested and acontextual set of practices that can be overtly taught. However, just how difficult this becoming and being a scientist can be for students who are not steeped in this normalised and socialised view of science becomes clearer in the narratives of students when I examine acquisition of recognition and realisation rules in ISCM and mainstream in Chapters 9 and 10 respectively.

This 'difficulty of process' is the same for becoming and being a science learner. Transition to university learning is easier for those with early socialisation into independent and critical ways of working, but, for those without such socialisation advantages, profound and fundamental changes in who they are, what they value and the work practices they need to develop are required in order to be successful. I again suggest that, to achieve this, immersion, cultivation and apprenticeship are required to 'take on' these new learning social practices.

In summary, although we can overtly teach someone content knowledge and technical practices, we cannot overtly teach them to 'be a scientist', as this instead requires social apprenticeship and enculturation over time in order to develop the appropriate cultivated gaze. The same applies for 'being a science learner' in a higher education context.

7.5.2 ISCM: Two kinds of codes

This focus on social relations in pedagogy necessitates re-examination of what is being legitimated in ISCM. In Chapter 6, the LCT(Specialisation) analysis indicated that specialised science knowledge is valued and social relations are downplayed, indicating an overall knowledge code is legitimated. However, the pedagogic analysis, which brings to the fore two separate types of social relations that are valued, indicates a more complex picture. Using the same approach as in Chapter 6, the *extent* to which each of the sub-categories of epistemic and social relations is valued in ISCM pedagogy has been calculated on a percentage time basis. This is represented on a scale of 0 (no time) to 4 (>45% of time) for each category as presented in Figure 7.2. When there was overlap between knowledge and knower legitimation, the time was allocated to both categories.

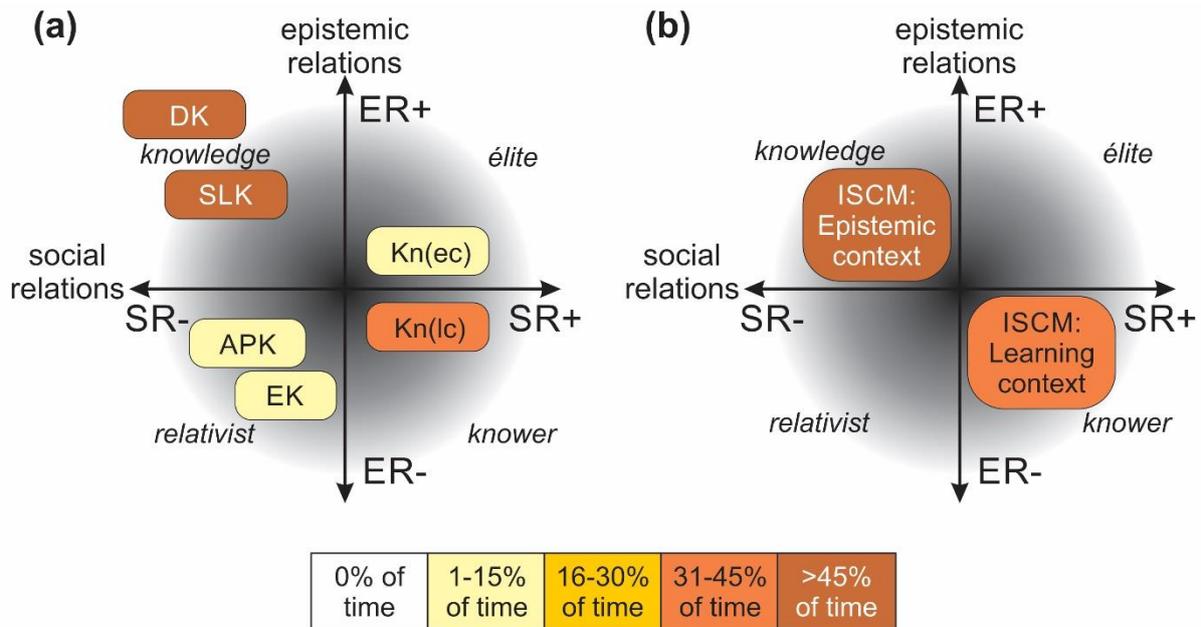


Figure 7.2: Specialisation codes for ISCM based on pedagogy and curriculum (adapted from Maton 2014a, p30): (a) knowledge and knower types legitimated in pedagogy; (b) overall **epistemic-context knowledge code** and **learning-context knower code** based on relative importance of knowledge and knower types (DK=disciplinary knowledge; SLK=scientific literacies knowledge; APK=academic practices knowledge; EK=everyday knowledge; Kn(lc)=learning-context knower; Kn(ec)=epistemic-context knower)

When ISCM teaching and learning practices are axiologically oriented, the personal, social and affective dispositions, attitudes and practices related to students' own learning contexts are valued (SR(lc)+). If students are asked knower-focused reflective questions or are required to work/learn in a particular way (such as engaging productively with feedback or consolidating a lecture), a knower code is being legitimated. In other words, if students are required to consolidate a lecture in class, the *focus* is on the content of the lecture, but the purpose of doing lecture consolidation, and therefore the *basis* on which they are expected to perform, is their development as independent, self-regulated learners. In this regard, a learning-context science knower (Kn(lc); Figure 7.2a) is being legitimated. I have located this in the knower quadrant as the focus is on social rather than on epistemic relations. Pedagogic activities associated with the learning-context knower are fairly dominant in ISCM (31–45% of the time; Figure 7.2a).

When ISCM teaching and learning practices are epistemologically oriented, there is obviously a focus on epistemic knowledge, but the dispositions and attitudes of students related to the epistemic context are also often being valued (SR(ec)+). For example when students are involved in an experiment, an understanding of the experiment is based on the underpinning disciplinary knowledge, but the dispositions and attitudes required for accurate recording, being honest about the data and 'believing' what that data is showing indicate that social relations are being valued. Both direct assessment and also explicit discussions on the values

underpinning science, and therefore expected dispositions and attitudes of scientists, are the means for such social relation legitimation in ISCM. I have located the epistemic-context knower (Kn(ec); Figure 7.2a) in the elite quadrant, as the stronger epistemic-context social relations are always associated with stronger epistemic relations (i.e. scientific values, knowledge and practices are always interrelated). However, pedagogic activities directly associated with the epistemic-context knower are not that common in ISCM (1–15% of the time; Figure 7.2a).

In summary, curriculum and pedagogic practices in ISCM legitimate specialised science knowledge (disciplinary and scientific literacies knowledge, DK and SLK respectively), non-specialised knowledge (academic practices and everyday knowledge, APK and EK respectively), a cultivated scientist knower (Kn(ec)) *and* a cultivated learning-context knower (Kn(lc); Figure 7.2a). However, practices can have a range of activities in all four quadrants on the two-dimensional plane, although it is the *dominant* ones that determine the code (Maton 2014a). As such, specialised science knowledge remains dominant in ISCM and the LCT(Specialisation) code associated with epistemological concerns would still be categorised as a **knowledge code** (Figure 7.2b). Nonetheless, this section has highlighted that axiological concerns associated with the learning context are almost as dominant, in which a **knower code** (for the learning context) is also legitimated (Figure 7.2b). The extent to which students engage with the knowledge and the knower codes, and recognise when different codes are being asked for, becomes clearer in Chapter 9, when students' responses to ISCM practices are examined.

Chapter 8: Legitimation and framing of ISCM assessment practices

8.1 Introduction

The second research question asks how pedagogic and assessment practices are framed and legitimated in ISCM to enable access. The previous chapter focused on pedagogic practices and this chapter concentrates on assessment practices.

As mentioned in Chapter 4, the evaluative rules define what is legitimate knowledge and learning in the pedagogic and assessment context. These rules can manifest in a number of ways, and in this study this is through (a) the different levels of cognitive complexity and different knowledge types and knowledge practices in assessment task questions, (b) framing of the evaluative criteria, and (c) framing of feedback associated with the evaluative criteria. This chapter examines each of these aspects in turn. The discussion focuses on the extent to which assessment practices are reflecting and communicating knowledge and knowledge practices as well as underpinning values of ISCM, and thereby enabling epistemological access.

8.2 Assessment practices in ISCM

Assessment forms an integral part of the ISCM course and is mostly geared towards guiding learning. Each year there are five or six major class tests, two examinations, and four major assignments, which in 2013 included an essay, a major laboratory report, an independent research project (including a proposal, poster and oral presentation), and an abstract/summary assignment (Box 8.1). These tests, examinations and assignments make up 85% of the final class mark. The other 15% comes from numerous minor tasks completed throughout the year in tutorial sessions. Feedback is provided in all tasks except the final November examination.

Box 8.1: Major assignment tasks in ISCM in 2013

Essay assignment:

Write an essay on “The Sun”. You should describe the structure of the sun, explain how the sun generates energy and discuss the significance of sunspots. (800-900 words)

Laboratory report:

Write a laboratory report on the effect of sex on range of motion (flexibility) in shoulder, elbow, knee and hip joints. (8-10 pages)

Independent research project:

Design and conduct an experiment that examines the effect of any environmental factor on the growth of potted petunia plants. The assessment tasks associated with this are a proposal (30%), a scientific poster (50%) and an oral presentation (20%).

Abstract/summary assignment:

Watch the DVD entitled “The Earth has a history” and summarise the information in 2 texts:

- A **short abstract**, which outlines the essential facts and processes presented on the DVD. (300 words)
- A **longer summary** which explains and discusses the content of the DVD in greater detail. (1000-1500 words)

This study uses a tool, based on Krathwohl’s (2002) revision of Bloom’s Taxonomy of Educational Objectives (1956), to analyse assessment tasks in ISCM according to level of complexity and knowledge type (see section 5.5.3 and Table 5.6 (laminated)). The tool uses a range of six cognitive process categories, listed in order of increasing cognitive complexity: recall (or follow instructions), comprehension, application, analysis, evaluation, and creation (summarised in Table 8.1). As indicated by Maton (2009) and Kilpert and Shay (2013), categorisation in this way also represents a continuum of relative strength of semantic gravity. At the one end of the continuum, assessment tasks requiring recall of facts or procedures would be firmly rooted in the context in which they were learned and are therefore operating with relatively strong semantic gravity. At the other end of the continuum, assessment tasks requiring creation by definition require putting elements together in a new, coherent whole to develop something original and are therefore operating with relatively weak semantic gravity. The other categories are relatively placed along the continuum between these two extreme categories.

Table 8.1: Cognitive process categories and knowledge categories used to characterise ISCM 2013 assessment tasks

Cognitive process categories		Knowledge categories		
		Stronger semantic density	↔	Weaker semantic density
		Disciplinary knowledge	Scientific literacies knowledge	Academic practices knowledge
Weaker semantic gravity ↔ Stronger semantic gravity	Creation	✓	✓	
	Evaluation	✓	✓	
	Analysis	✓	✓	
	Application	✓	✓	
	Comprehension	✓	✓	✓
	Recall/follow instruction	✓	✓	

✓ indicates the cell is populated by empirical data in Table 5.6.

The tool also allows for recognition of the main knowledge types that are identified in the epistemic relations of the curriculum analysis in Chapter 6: disciplinary, scientific literacies and academic practices knowledge (Table 8.1). The everyday knowledge category is excluded as it was virtually non-existent in the curriculum analysis. The assessment of social relations for marks is also marked by its absence, although reflective tasks aimed at improving student learning are present in the course. The knowledge categories represent a continuum of relative strengths of semantic density, with disciplinary knowledge exhibiting stronger semantic density, and the academic practices knowledge weaker semantic density. Although ISCM assesses across the range (see following paragraph), the propensity of questions to be based on disciplinary and scientific literacies knowledge indicates a legitimization of stronger semantic density in assessment tasks, which matches findings in the curriculum analysis in Chapter 6 where a rhizomatic/worldly code is legitimated.

Using this tool and drawing on data from tests, examinations, assignments, tutorials, and practicals from 2013, a qualitative analysis indicates that ISCM assesses across the range of knowledge types (i.e. across the semantic density range). For example, at the level of *comprehension* a student could be asked to draw on knowledge types as follows (see Table 5.6 (laminated)):

- *Disciplinary principled knowledge* such as explaining sliding filament theory in HKE
- *Disciplinary procedural knowledge* such as drawing a topographic profile in Geology
- *Scientific literacies principled knowledge* such as explaining the value of accuracy and precision in science or explaining reasons for referencing in scientific texts

- *Scientific literacies procedural knowledge* such as identifying variables and drawing the most appropriate graph type or writing a scientific paragraph that draws on empirical data rather than opinion, or
- *Academic practices knowledge* such as providing a complete and correct reference list for an assignment.

The analysis also indicates that ISCM assesses across the range of cognitive process categories (i.e. across the semantic gravity range). For example, tasks requiring *recall* or following of instructions are the simplest and can relate to principled knowledge such as defining a half-life, or procedural knowledge such as weighing an object (see Table 5.6 (laminated)). *Comprehension* tasks can be based on single concepts such as identifying a lever class for a joint in HKE, or they can require demonstration of understanding at a more complex level that draws on more than one concept such as explaining decompression melting beneath the earth's surface. *Application* tasks can also be fairly basic such as applying a simple set of 'rules' to produce a scale bar on a diagram, or more complex such as applying a range of principles to interpret a topographic map.

Typical *analysis* tasks, which require breaking material into constituent parts and rearranging them to support an argument, interpret or predict could include developing an argument on the most appropriate resources to meet South Africa's electricity needs, or predicting trends in a graph based on a particular scenario (see Table 5.6 (laminated)). The *evaluation* tasks usually require the student having to judge, critique or justify in a well-reasoned manner, such as critically evaluating the usefulness of an article for a particular context, or assessing a peer's work based on a set of criteria. The *creation* level tasks require integration of many elements in a new and coherent whole, or development of something new. Examples in ISCM are writing an essay, designing and conducting an experiment and presenting a scientific oral presentation.

Whilst this section has provided a qualitative account of assessment tasks in ISCM, the following quantitative analysis provides an indication of assessment trends during the year.

8.3 Trends in assessment practices

The overall trends in high-stakes assessment tasks (tests, examinations, major assignments; Box 8.1) in ISCM in 2013 were quantified using a percentage mark allocation for all questions according to (a) knowledge type and (b) cognitive level process.

The first quantitative analysis, which examines knowledge types, indicates that all three knowledge types (disciplinary, scientific literacies and academic practices knowledge) were assessed in all of the main tests and examinations (Figure 8.1). As expected, scientific literacies questions dominated (75%) in the first test as it assessed mainly the 'What is science?' course component with few questions from the Physics component. Thereafter, scientific literacies

knowledge formed a much smaller but consistent component throughout. From the second test onwards disciplinary-related questions formed more than 50% of test or examination marks. Consistent assessment of scientific literacies knowledge and an increase in disciplinary knowledge assessment match the generalised curriculum trends as depicted in Table 6.4. However, the persistent presence of academic practices-related questions throughout the year in tests and examinations and the quite high proportion (21%) in the final examination do not match the overall curriculum trends in Table 6.4, which show a steady decline in academic practices work throughout the year. This suggests an overemphasis on assessing generic academic practices towards the end of the year, which tend to be fairly easy to assess, that does not align well with classroom practices.

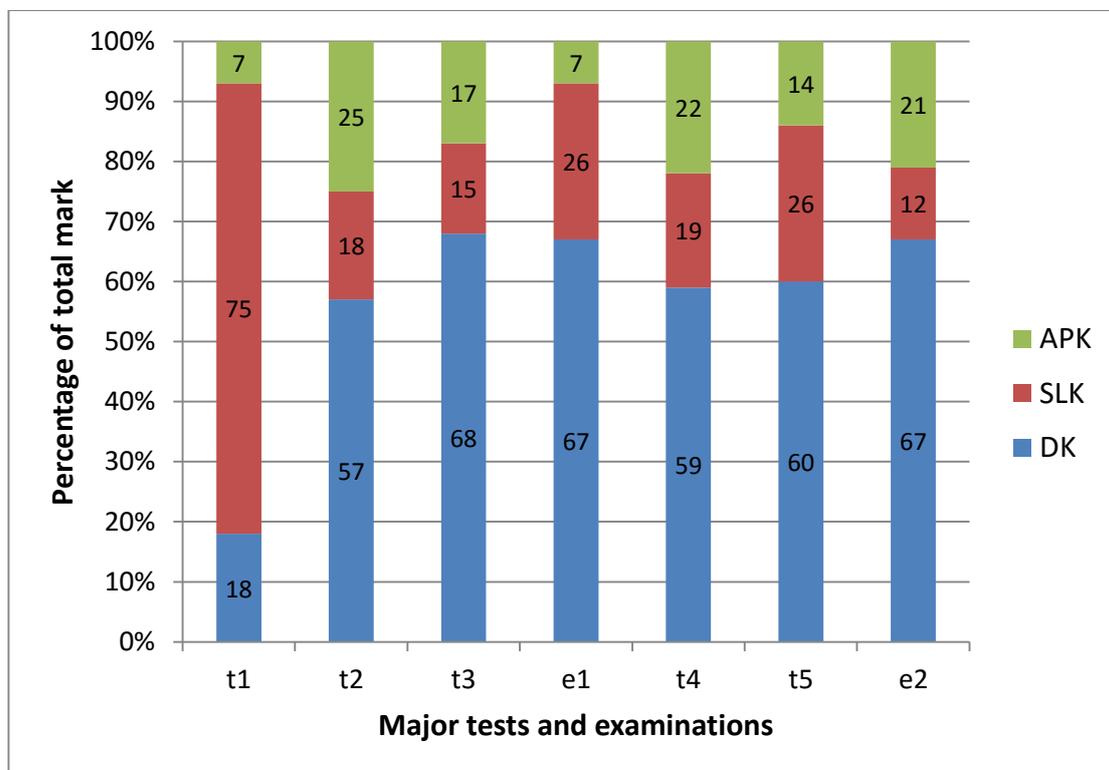


Figure 8.1: Percentage marks related to knowledge type in ISCM tests and examinations in 2013 (t1 to 3=semester 1 tests; e1=semester 1 examination; t4 and 5=semester 2 tests; e2=semester 2 examination; DK=disciplinary knowledge; SLK=scientific literacies knowledge; APK=academic practices knowledge)

The second quantitative analysis, which examines cognitive process levels, indicates that recall questions were present but seldom formed more than 10% of test or examination questions through the year, which were instead dominated by comprehension and application-type questions (Figure 8.2), with the highest proportion of application questions (40%) being in the HKE test (t4), a discipline that lends itself well to such questions. Whereas tests (t1 to 3) and the examination (e1) in the first semester mostly asked relatively lower cognitive recall,

comprehension and application questions, second-semester tests (t4 and t5) and the examination (e2) included questions at the higher cognitive levels of analysis, evaluation and/or creation, although the percentage mark allocation at the higher levels was generally low, being 20% for test 4, 8% for test 5 and 35% for the final examination (Figure 8.2). Tight time allocations in tests and examinations do not easily allow for the higher cognitive demand questions and it was only in the final examination in 2013 that 24% of marks were allocated to a creation task of an integrative essay.

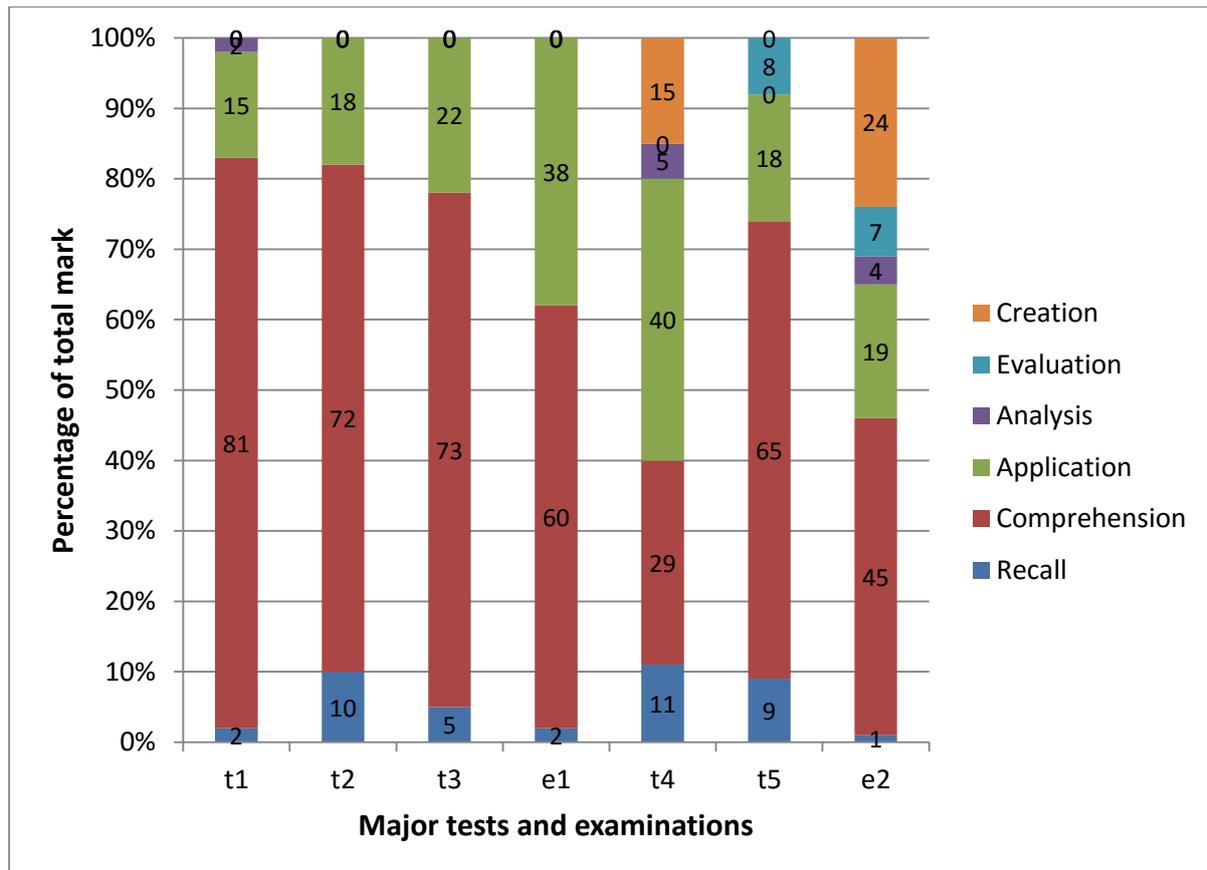


Figure 8.2: Percentage marks related to each cognitive process category in ISCM tests and examinations in 2013 (t1 to 3=semester 1 tests; e1=semester 1 examination; t4 and 5=semester 2 tests; e2=semester 2 examination)

In contrast to tests and examinations, the major assignments provided better opportunity for students to work across the cognitive levels, including that of creation, although the laboratory report and the independent research project completed in the second semester offered a wider range of the more conceptually-challenging cognitive tasks than the essay and the abstract/summary assignment (Table 8.2).

Table 8.2: Cognitive process categories required for each of the four major assignments in 2013

Evaluation criteria category	Essay	Laboratory report	Independent research project	Abstract/summary report
	DK, SLK, APK	DK, SLK, APK	DK, SLK, APK	DK, SLK, APK
Creation	✓	✓	✓	✓
Evaluation/reflection		✓	✓	
Analysis		✓	✓	
Application	✓	✓	✓	✓
Comprehension	✓	✓	✓	✓
Recall/follow instructions	✓	✓	✓	✓
Percentage final mark	5	3.75	3.75	3.75

✓ indicates categories drawn on, but marks could not be allocated as these are integrative tasks;
DK=disciplinary knowledge; SLK=scientific literacies knowledge; APK=academic practices knowledge

Overall the quantitative analysis of 2013 assessment data indicates that, despite the general and progressive increase in cognitive demand through the year, comprehension remained the dominant cognitive process category, and application was second, with the other categories forming relatively minor components.

The macro-scale trend of progressive increase in cognitive demand is visible at a micro-level as well, with evidence of attempts to scaffold the progression. For example, in a Chemistry component tutorial on limiting reagents, the first question is broken into six sub-components, indicating the six steps required to answer the question (Box 8.2). A similar question requiring the same six steps is asked in question two, but less guidance is provided, likewise in the third question, where there is no guidance. The intention is for students to see the pattern themselves, although in many cases this needs to be pointed out.

Box 8.2: Initial use of structured questions to guide answering of a complex task in a tutorial

Tutorial 4: Limiting reagents/reactants

1. For the reaction $\text{H}_2 (\text{g}) + \text{N}_2 (\text{g}) \rightarrow \text{NH}_3 (\text{g})$, 1.60 mol H_2 is reacted with 6.00 mol N_2 .
 - a. Balance the equation
 - b. How many moles of NH_3 are produced from 1.60 mol H_2 ?
 - c. How many moles of NH_3 are produced from 6.00 mol N_2 ?
 - d. Which is the limiting reactant?
 - e. How many moles of H_2 remain after the reaction has gone to completion?
 - f. How many moles of N_2 remain after the reaction has gone to completion?
2. For the reaction $\text{Fe}_2\text{O}_3 (\text{s}) + 3 \text{CO} (\text{g}) \rightarrow 2 \text{Fe} (\text{g}) + 3 \text{CO}_2$, 224 g of CO is available to react with 400 g Fe_2O_3 .
 - a. Check if the equation is properly balanced
 - b. Which is the limiting reagent?
 - c. How much (g) of iron is produced?
 - d. How much (g) CO_2 is produced?
3. A 2.00 g sample of ammonia is mixed with 4.00 g of oxygen (see unbalanced equation below). Which is the limiting reactant and how much excess reactant remains after the reaction has stopped?

$$\text{NH}_3(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{NO}(\text{g}) + \text{H}_2\text{O}(\text{g})$$

A similar trend is noted in the two examinations. Many questions in the June examination are structured in ways that guide students in their answers, starting with recall-type sub-questions and proceeding to comprehension and/or application sub-questions that build on the earlier concepts (Box 8.3). In contrast, a higher proportion of questions in the December examination offer less guidance.

Box 8.3: Typical structured and unstructured questions in the 2013 June and November examinations respectively

June examination

1. Consider the concept of radioactive decay.
 - a. Define radioactive decay. (2)
 - b. Describe the difference between alpha and beta decay. (6)
 - c. The decay of Uranium (atomic number 92, mass number 238) to Thorium is an example of alpha decay. Write this decay equation in full. (5)

November examination

1. Describe and explain the difference between immature and mature sedimentary rocks. (10)

In order to comment on the appropriateness of these assessment trends in terms of preparing students for success in mainstream, they are compared with first-year mainstream assessment practices in Chapter 10.

8.4 Framing of evaluative criteria and feedback

Whilst the preceding two sections have mapped out the assessment tasks of ISCM as presented in curriculum documentation, this section unpacks how assessment tasks are framed in the classroom through evaluative criteria and feedback. The external language of description developed for these two components is associated with the instructional discourse. In this study two categories of framing of evaluative criteria are identified (see Table 5.4b (laminated), empirical sources 1–3): weaker framing, where criteria are open-ended or not stated (-F), and stronger framing, where criteria are explicitly stated (+F). Three categories of framing of feedback are distinguished (see Table 5.4b (laminated), empirical sources 4–8): weaker framing, where there is no feedback or insufficient to guide student improvement (-F), neutral framing, where general feedback is provided and requires student active engagement for improvement (+/-F), and stronger framing, where criteria are explicit, they clarify concepts, suggestions are made for improvement, or they are actively worked with in class. Framing of evaluative criteria and feedback is dealt with in the respective sections that follow.

8.4.1 Evaluative criteria

The ISCM literacies and disciplinary lecturers try to make evaluative criteria as explicit and as visible as possible. Handouts are provided for all tutorials and practicals, each with a set of

background information, associated assessment tasks, and often an indication of the criteria by which they will be assessed. For example, in a first-semester tutorial on *critical reading* of 'science in the media' students are cautioned against accepting everything they read in the media as 'scientific fact'. The handout provides information on how the media select and construct news; have limited time, expertise and resources; have embedded values; and can use conflict and controversy. Students are urged to monitor their own response to what they read and given a series of questions to help guide this process (Box 8.4 provides two out of the six sets of questions). These questions not only signal critical questions they should be asking, but also the evaluative criteria that will be used when they are asked to make such judgements.

Box 8.4: Tutorial questions guiding critical reading of science in the media

Question 3: Is there information about **who** did the study, **where** the study was done **and how** the results were **made public**?

- Who did the research?
- Where did they do it?
- Who funded the study?
- Is it likely that the scientist or funder has an 'interest' in the outcome? What makes you say this?
- Where did the scientists report the results of their research? How do you think this influenced their reporting?

Question 4: Is there any information about **what other scientists think**?

- Is there any reference to other studies? Give some details.
- Is there support from other scientists? How is this conveyed?
- What do other sources say about the research or topic?

Another example is a second-semester tutorial on *interpreting and describing graphs*, where students first complete a simple exercise on terminology that can be used in describing graphs (e.g. linear, inversely proportional, rapid rate) that has already been discussed in an earlier tutorial. They are then expected to describe trends in two complex graphs, with some guidance on what is expected in their answers in the first task, but not in the second (Box 8.5). This initial good articulation of expectations in terms of legitimate text with later withdrawal of guidance, such as is seen in Boxes 8.2, 8.3 and 8.5, is a common strategy used in ISCM.

Box 8.5: Tutorial questions related to describing trends in graphs

Exercise 2:

Describe the trends in atmospheric CO₂ concentrations at Mauna Loa over the last 50 years (i.e. describe Figure 4b). In order to answer this adequately you will need to describe the overall trend (type of trend, including period and extent of change in trend), and also talk about the variation (by how much, how often, etc.). Figure 4a may help you interpret Figure 4b. (8)

Exercise 3:

Describe the trends in the hydrograph in Figure 5. (8)

The disciplinary lecturers also indicate expectations from their own disciplines. As the HKE lecturer stated:

I explain to students every question [in HKE] has two purposes, the one purpose is to see whether you understand the factual knowledge and the other half of the question usually entails the application of it . . . once students have understood that, then they work well with it.

Explicit criteria are provided for all major assignments. The criteria used to provide feedback on the first draft of the essay signal to students what is valued (Box 8.6): correct and relevant scientific information; logical flow within and between paragraphs using appropriate academic register; appropriate use of sources through paraphrasing, quoting, citing and referencing; and appropriate inclusion of illustrations, as well as various writing conventions such as correct grammar and punctuation and also conventions related to essay production such as a good title, and provision of a word count and a cover page. Since students receive the criteria at the start of the process, this helps contextualise the unpacking of criteria in tutorial sessions, but also allows for independent, active student engagement:

Ja, I look carefully at the [criteria] grid when I am writing the essay. I keep going back to it so when I write some more I see if I am doing it [aligning with criteria]. (Student interview on essay writing, Nickelwa)

Box 8.6: Criteria used to provide student guidance on production of an essay, and to assess the final product

The Sun: Draft Essay criteria guidelines				
CRITERIA	EXCELLENT	GOOD	NEEDS WORK	FAIL
Content				
Topic	Topic correctly interpreted. Virtually all information relevant	Understands topic. Much of information relevant	Topic poorly interpreted. Some sections partially relevant	No understanding of topic. Information not relevant
Factual correctness	Facts correct & consistent. Shows real understanding and engagement with source information.	Many facts present/correct. Has tried to engage with source information but some areas need more work	Several facts missing/incorrect. Has not fully engaged with source information	Most essential facts missing/incorrect. Has not understood source information at all.
Illustrations	Relevant. Labelled well. Linked well to text. Source acknowledged.	Somewhat relevant. Labels fair. Link to text fair. Fair	Hardly relevant. Labels poor. Link to text poor. Poor source acknowledgement	Irrelevant. No labels. No link to text. No source acknowledgement
Structure				
Introduction	Relevant background information. Good signposting of essay structure.	Some background information. Fair signposting of essay structure.	Insufficient background information and signposting	No introduction or introduction irrelevant. No signposting
Paragraphing	Well structured: good topic sentences with supporting information	Paragraphs with clear themes, but occasional irrelevance.	Unity of theme lacking in many paragraphs.	Text not organised into paragraphs
Overall ordering of information/flow	Clear, logical flow within and between paragraphs.	Logical flow largely maintained. More links between ideas needed.	Information disconnected.	No clear, logical flow or order to information.
Conclusion	Draws main points together. Refers back to essay topic. Points to the future.	Summarises aspects of the essay content. Attempts to relate back to essay topic.	Conclusion abrupt/introduces new information. Poor link back to essay topic.	No conclusion or conclusion irrelevant. No link back to essay topic.
Sentence structure, grammar and academic register	Well expressed with good control of language. Appropriate academic register. Evidence of proof-reading	Academic register largely maintained. Sentences well constructed. A few grammatical/spelling errors. Some proof-reading	Register informal. Sentences poorly constructed. Several grammatical or spelling errors. Little proof-reading.	No academic register. Poorly expressed. Grammatical or spelling errors interfere with understanding. No proof-reading.
Referencing				
Referencing	Good paraphrasing and in-text referencing. Correct reference list.	More paraphrasing needed. Check in-text referencing. Reference list generally correct	Large sections plagiarised. Poor in-text referencing. Inadequate or no reference list	
General				
Title	Good, informative, relevant title.		Title not informative or too informal	Title same as the topic.
Length and word count	Appropriate		Too long, or too short, or no word count	
Cover page	Correct – all details given		Details missing	
Additional comments:				

However, despite provision of criteria and discussion of them in class, students may not always make good sense of them:

Interviewer: And then this concept of relevance, we used it here [in the essay] . . . it says some sections [in your essay are] not relevant. Do you understand what that means?

Student: No Ma'am, I don't . . . maybe what I wrote was not right.

Interviewer: In what way?

Student: Uh [long pause], maybe the facts were wrong. I'm not sure. (Student interview on essay writing, Inam)

The explicit articulation of **evaluative criteria**, especially in major assignments, indicates **stronger framing** (+F) in ISCM. However, framing can be somewhat weakened by poor articulation or poor student understanding of criteria.

8.4.2 Feedback

Feedback is a key part of the assessment process in ISCM and is considered 'crucial for developing student understanding' (SESP Review Report 2011, p11). There is relatively stronger framing with regards to provision of feedback associated with assessment tasks. 'Model' or 'suggested' answers for most tutorials and all tests and examinations, particularly for content-related as opposed to language-related questions, are posted regularly on the notice board. Box 8.7 is an example of answers to questions from a lecture handout on experimental design. The answers were in fact discussed during class, but students were supported in this instance by provision of appropriate answers in print. Note that the answers are preceded by suggestions (italics in Box 8.7) related to working independently and in terms of providing appropriate information on explanatory answers.

Box 8.7: Suggested answers to questions from a lecture handout, posted on the notice board in semester 2

Notes on experimental design: Suggested answers to questions on page 2

Ideally you should try to provide written answers yourselves before you look at the answers – as this will help you learn to answer questions at the level required at university. Note – as a general principle it is useful to give a brief definition/description of something first before answering a ‘why’ question – see all the answers below.

- **Why do we need a control treatment?**

In an experiment the experimental treatment is exactly the same as the control treatment – with the exception of one single factor. We therefore need a control treatment so that we have something to compare the experimental treatment with, to see whether the one single factor is influencing the results. This allows us to draw conclusions as to whether the experimental treatment is effective or not.

- **Why do we need replicates?**

Replicates are repeats of the same treatment. We need them to provide more evidence. The greater the number of replicates means the more confidence we have in that the results we get are due to the experiment – and not due simply to natural variation. If we have sufficient replicates we can do statistical analyses.

- **Why is the process of randomisation important?**

Randomisation is the process where ‘subjects’ in an experiment are chosen at random (or by chance). This process is important to avoid bias and allows us to have relatively homogenous treatment groups.

Individual written and group verbal feedback is part of the weekly tutorial routine with the literacies lecturers. As one student commented:

Her support and feedback on my work has been a great success and I can see the improvement on my work. (Student evaluation, 2012)

Some tutorial sessions work directly with feedback and students resubmit work based on their new understanding. This not only serves to model good study techniques, but also assists in developing better conceptual understanding.

As a deliberate strategy, feedback in ISCM is almost without exception very prompt. Students receive feedback weekly on tutorials and practicals, test feedback is always within seven days of writing and before examinations, and individual and written feedback on assignment drafts is provided timeously for final phase completion. Box 8.8a is a sample of feedback provided to a student on a section of the first essay, where students were expected to write on the sun and its structure (the criteria guidelines are presented in Box 8.6). The type of feedback provided indicates what is valued in essay writing in ISCM, and works across the semantic density range (the letters in parenthesis are transposed onto the document in Box 8.8a):

- Disciplinary knowledge: precision of meaning (a); correct factual information (b); relevance (c).
- Scientific literacies knowledge: labelling of diagrams (d); signposting (e); overall logical flow (f); better sentence structure for clarification (g).
- Academic practices knowledge: writing conventions (h); grammar and punctuation (i).

In some cases the assessor explicitly provides what is required (line 4 paragraph 1; Box 8.8a), at other times some direction on what is required is provided (comment at end of paragraph 1), and in other cases there is simply a signal of a problem with no indication of how the student should proceed (such as the 'check this' statement). This represents a range from stronger to weaker framing of feedback.

In her final essay draft it was clear the student had engaged well with both individual written feedback as well as global oral feedback provided in class (Box 8.8b). The main areas of improvement were in terms of punctuation and other writing conventions, better signposting, using words of attribution (according to Suplee . . .), correct factual information, and correct order of the sun's layers with appropriate wording to signify order (. . . is the innermost layer . . .; Following the radiation zone . . .). When asked about the value of written feedback in a later interview she stated:

Definitely I found the feedback [on the essay] very, very useful. I looked at the comments that were written on the side. Like where when information was wrong, I'd go back to the article and find out what was wrong with the information (Student interview on essay writing, Ntombizodidi)

Some feedback in ISCM is personal and dialogic. This occurs when students reflect on axiological aspects of their work that relates to their own personal development and work at university. Box 8.9 has a series of feedback comments provided by one of the literacies practitioners when students were asked to comment on (a) learning strategies they were putting in place to succeed at university, (b) how they were responding to feedback, and (c) advice they would give to incoming SESP students (this question was asked at the end of the year)¹. The feedback generally served firstly to affirm the student's reflections, and secondly to provide further suggestions or ideas for student consideration. The approach to this feedback is dialogic and conversational – which supports the earlier contention in the pedagogic analysis that there is a weaker framing of hierarchy of staff–student relations at a personal level.

¹ I have been somewhat indulgent in including a number of feedback comments here as I think they provide some indication of the slightly formal but caring, supportive and honest relationship we develop with students, which has not been conveyed thus far in the analysis of ISCM pedagogic and assessment practices.

Box 8.8a: First page of first draft of Ntombizodidi's essay with lecturer feedback

The Centre of our Universe

The Sun is the centre of our universe. ⁽⁴⁾ It is a round ball of flame filled with gases and known to many as a star. According to Suplee (2004) the ^(b) Sun has been burning for more than 6 billion years. The Sun's structure is made up of different layer. ⁽ⁱ⁾ These layers assist in the generation of energy that we receive. ^(j) The sun also consists of spots called ^(k) sunspots. ^(l) These spots have a great significance for the Earth. This essay ^(m) will discuss the sun's structure, and ⁽ⁿ⁾ ^(o) ^(p) ^(q) ^(r) ^(s) ^(t) ^(u) ^(v) ^(w) ^(x) ^(y) ^(z) ^(aa) ^(ab) ^(ac) ^(ad) ^(ae) ^(af) ^(ag) ^(ah) ^(ai) ^(aj) ^(ak) ^(al) ^(am) ^(an) ^(ao) ^(ap) ^(aq) ^(ar) ^(as) ^(at) ^(au) ^(av) ^(aw) ^(ax) ^(ay) ^(az) ^(ba) ^(bb) ^(bc) ^(bd) ^(be) ^(bf) ^(bg) ^(bh) ^(bi) ^(bj) ^(bk) ^(bl) ^(bm) ^(bn) ^(bo) ^(bp) ^(bq) ^(br) ^(bs) ^(bt) ^(bu) ^(bv) ^(bw) ^(bx) ^(by) ^(bz) ^(ca) ^(cb) ^(cc) ^(cd) ^(ce) ^(cf) ^(cg) ^(ch) ^(ci) ^(cj) ^(ck) ^(cl) ^(cm) ^(cn) ^(co) ^(cp) ^(cq) ^(cr) ^(cs) ^(ct) ^(cu) ^(cv) ^(cw) ^(cx) ^(cy) ^(cz) ^(da) ^(db) ^(dc) ^(dd) ^(de) ^(df) ^(dg) ^(dh) ^(di) ^(dj) ^(dk) ^(dl) ^(dm) ^(dn) ^(do) ^(dp) ^(dq) ^(dr) ^(ds) ^(dt) ^(du) ^(dv) ^(dw) ^(dx) ^(dy) ^(dz) ^(ea) ^(eb) ^(ec) ^(ed) ^(ee) ^(ef) ^(eg) ^(eh) ^(ei) ^(ej) ^(ek) ^(el) ^(em) ^(en) ^(eo) ^(ep) ^(eq) ^(er) ^(es) ^(et) ^(eu) ^(ev) ^(ew) ^(ex) ^(ey) ^(ez) ^(fa) ^(fb) ^(fc) ^(fd) ^(fe) ^(ff) ^(fg) ^(fh) ^(fi) ^(fj) ^(fk) ^(fl) ^(fm) ^(fn) ^(fo) ^(fp) ^(fq) ^(fr) ^(fs) ^(ft) ^(fu) ^(fv) ^(fw) ^(fx) ^(fy) ^(fz) ^(ga) ^(gb) ^(gc) ^(gd) ^(ge) ^(gf) ^(gg) ^(gh) ^(gi) ^(gj) ^(gk) ^(gl) ^(gm) ^(gn) ^(go) ^(gp) ^(gq) ^(gr) ^(gs) ^(gt) ^(gu) ^(gv) ^(gw) ^(gx) ^(gy) ^(gz) ^(ha) ^(hb) ^(hc) ^(hd) ^(he) ^(hf) ^(hg) ^(hh) ^(hi) ^(hj) ^(hk) ^(hl) ^(hm) ^(hn) ^(ho) ^(hp) ^(hq) ^(hr) ^(hs) ^(ht) ^(hu) ^(hv) ^(hw) ^(hx) ^(hy) ^(hz) ^(ia) ^(ib) ^(ic) ^(id) ^(ie) ^(if) ^(ig) ^(ih) ⁽ⁱⁱ⁾ ^(ij) ^(ik) ^(il) ^(im) ⁽ⁱⁿ⁾ ^(io) ^(ip) ^(iq) ^(ir) ^(is) ^(it) ^(iu) ^(iv) ^(iw) ^(ix) ^(iy) ^(iz) ^(ja) ^(jb) ^(jc) ^(jd) ^(je) ^(jf) ^(jg) ^(jh) ^(ji) ^(jj) ^(jk) ^(jl) ^(jm) ^(jn) ^(jo) ^(jp) ^(jq) ^(jr) ^(js) ^(jt) ^(ju) ^(jv) ^(jw) ^(jx) ^(jy) ^(jz) ^(ka) ^(kb) ^(kc) ^(kd) ^(ke) ^(kf) ^(kg) ^(kh) ^(ki) ^(kj) ^(kk) ^(kl) ^(km) ^(kn) ^(ko) ^(kp) ^(kq) ^(kr) ^(ks) ^(kt) ^(ku) ^(kv) ^(kw) ^(kx) ^(ky) ^(kz) ^(la) ^(lb) ^(lc) ^(ld) ^(le) ^(lf) ^(lg) ^(lh) ^(li) ^(lj) ^(lk) ^(ll) ^(lm) ^(ln) ^(lo) ^(lp) ^(lq) ^(lr) ^(ls) ^(lt) ^(lu) ^(lv) ^(lw) ^(lx) ^(ly) ^(lz) ^(ma) ^(mb) ^(mc) ^(md) ^(me) ^(mf) ^(mg) ^(mh) ^(mi) ^(mj) ^(mk) ^(ml) ^(mm) ^(mn) ^(mo) ^(mp) ^(mq) ^(mr) ^(ms) ^(mt) ^(mu) ^(mv) ^(mw) ^(mx) ^(my) ^(mz) ^(na) ^(nb) ^(nc) ^(nd) ^(ne) ^(nf) ^(ng) ^(nh) ⁽ⁿⁱ⁾ ^(nj) ^(nk) ^(nl) ^(nm) ⁽ⁿⁿ⁾ ^(no) ^(np) ^(nq) ^(nr) ^(ns) ^(nt) ^(nu) ^(nv) ^(nw) ^(nx) ^(ny) ^(nz) ^(oa) ^(ob) ^(oc) ^(od) ^(oe) ^(of) ^(og) ^(oh) ^(oi) ^(oj) ^(ok) ^(ol) ^(om) ^(on) ^(oo) ^(op) ^(oq) ^(or) ^(os) ^(ot) ^(ou) ^(ov) ^(ow) ^(ox) ^(oy) ^(oz) ^(pa) ^(pb) ^(pc) ^(pd) ^(pe) ^(pf) ^(pg) ^(ph) ^(pi) ^(pj) ^(pk) ^(pl) ^(pm) ^(pn) ^(po) ^(pp) ^(pq) ^(pr) ^(ps) ^(pt) ^(pu) ^(pv) ^(pw) ^(px) ^(py) ^(pz) ^(qa) ^(qb) ^(qc) ^(qd) ^(qe) ^(qf) ^(qg) ^(qh) ^(qi) ^(qj) ^(qk) ^(ql) ^(qm) ^(qn) ^(qo) ^(qp) ^(qq) ^(qr) ^(qs) ^(qt) ^(qu) ^(qv) ^(qw) ^(qx) ^(qy) ^(qz) ^(ra) ^(rb) ^(rc) ^(rd) ^(re) ^(rf) ^(rg) ^(rh) ^(ri) ^(rj) ^(rk) ^(rl) ^(rm) ^(rn) ^(ro) ^(rp) ^(rq) ^(rr) ^(rs) ^(rt) ^(ru) ^(rv) ^(rw) ^(rx) ^(ry) ^(rz) ^(sa) ^(sb) ^(sc) ^(sd) ^(se) ^(sf) ^(sg) ^(sh) ^(si) ^(sj) ^(sk) ^(sl) ^(sm) ^(sn) ^(so) ^(sp) ^(sq) ^(sr) ^(ss) ^(st) ^(su) ^(sv) ^(sw) ^(sx) ^(sy) ^(sz) ^(ta) ^(tb) ^(tc) ^(td) ^(te) ^(tf) ^(tg) ^(th) ^(ti) ^(tj) ^(tk) ^(tl) ^(tm) ^(tn) ^(to) ^(tp) ^(tq) ^(tr) ^(ts) ^(tt) ^(tu) ^(tv) ^(tw) ^(tx) ^(ty) ^(tz) ^(ua) ^(ub) ^(uc) ^(ud) ^(ue) ^(uf) ^(ug) ^(uh) ^(ui) ^(uj) ^(uk) ^(ul) ^(um) ^(un) ^(uo) ^(up) ^(uq) ^(ur) ^(us) ^(ut) ^(uu) ^(uv) ^(uw) ^(ux) ^(uy) ^(uz) ^(va) ^(vb) ^(vc) ^(vd) ^(ve) ^(vf) ^(vg) ^(vh) ^(vi) ^(vj) ^(vk) ^(vl) ^(vm) ^(vn) ^(vo) ^(vp) ^(vq) ^(vr) ^(vs) ^(vt) ^(vu) ^(vv) ^(vw) ^(vx) ^(vy) ^(vz) ^(wa) ^(wb) ^(wc) ^(wd) ^(we) ^(wf) ^(wg) ^(wh) ^(wi) ^(wj) ^(wk) ^(wl) ^(wm) ^(wn) ^(wo) ^(wp) ^(wq) ^(wr) ^(ws) ^(wt) ^(wu) ^(wv) ^(ww) ^(wx) ^(wy) ^(wz) ^(xa) ^(xb) ^(xc) ^(xd) ^(xe) ^(xf) ^(xg) ^(xh) ^(xi) ^(xj) ^(xk) ^(xl) ^(xm) ^(xn) ^(xo) ^(xp) ^(xq) ^(xr) ^(xs) ^(xt) ^(xu) ^(xv) ^(xw) ^(xx) ^(xy) ^(xz) ^(ya) ^(yb) ^(yc) ^(yd) ^(ye) ^(yf) ^(yg) ^(yh) ^(yi) ^(yj) ^(yk) ^(yl) ^(ym) ^(yn) ^(yo) ^(yp) ^(yq) ^(yr) ^(ys) ^(yt) ^(yu) ^(yv) ^(yw) ^(yx) ^(yy) ^(yz) ^(za) ^(zb) ^(zc) ^(zd) ^(ze) ^(zf) ^(zg) ^(zh) ^(zi) ^(zj) ^(zk) ^(zl) ^(zm) ^(zn) ^(zo) ^(zp) ^(zq) ^(zr) ^(zs) ^(zt) ^(zu) ^(zv) ^(zw) ^(zx) ^(zy) ^(zz) ^(aa) ^(ab) ^(ac) ^(ad) ^(ae) ^(af) ^(ag) ^(ah) ^(ai) ^(aj) ^(ak) ^(al) ^(am) ^(an) ^(ao) ^(ap) ^(aq) ^(ar) ^(as) ^(at) ^(au) ^(av) ^(aw) ^(ax) ^(ay) ^(az) ^(ba) ^(bb) ^(bc) ^(bd) ^(be) ^(bf) ^(bg) ^(bh) ^(bi) ^(bj) ^(bk) ^(bl) ^(bm) ^(bn) ^(bo) ^(bp) ^(bq) ^(br) ^(bs) ^(bt) ^(bu) ^(bv) ^(bw) ^(bx) ^(by) ^(bz) ^(ca) ^(cb) ^(cc) ^(cd) ^(ce) ^(cf) ^(cg) ^(ch) ^(ci) ^(cj) ^(ck) ^(cl) ^(cm) ^(cn) ^(co) ^(cp) ^(cq) ^(cr) ^(cs) ^(ct) ^(cu) ^(cv) ^(cw) ^(cx) ^(cy) ^(cz) ^(da) ^(db) ^(dc) ^(dd) ^(de) ^(df) ^(dg) ^(dh) ^(di) ^(dj) ^(dk) ^(dl) ^(dm) ^(dn) ^(do) ^(dp) ^(dq) ^(dr) ^(ds) ^(dt) ^(du) ^(dv) ^(dw) ^(dx) ^(dy) ^(dz) ^(ea) ^(eb) ^(ec) ^(ed) ^(ee) ^(ef) ^(eg) ^(eh) ^(ei) ^(ej) ^(ek) ^(el) ^(em) ^(en) ^(eo) ^(ep) ^(eq) ^(er) ^(es) ^(et) ^(eu) ^(ev) ^(ew) ^(ex) ^(ey) ^(ez) ^(fa) ^(fb) ^(fc) ^(fd) ^(fe) ^(ff) ^(fg) ^(fh) ^(fi) ^(fj) ^(fk) ^(fl) ^(fm) ^(fn) ^(fo) ^(fp) ^(fq) ^(fr) ^(fs) ^(ft) ^(fu) ^(fv) ^(fw) ^(fx) ^(fy) ^(fz) ^(ga) ^(gb) ^(gc) ^(gd) ^(ge) ^(gf) ^(gg) ^(gh) ^(gi) ^(gj) ^(gk) ^(gl) ^(gm) ^(gn) ^(go) ^(gp) ^(gq) ^(gr) ^(gs) ^(gt) ^(gu) ^(gv) ^(gw) ^(gx) ^(gy) ^(gz) ^(ha) ^(hb) ^(hc) ^(hd) ^(he) ^(hf) ^(hg) ^(hh) ^(hi) ^(hj) ^(hk) ^(hl) ^(hm) ^(hn) ^(ho) ^(hp) ^(hq) ^(hr) ^(hs) ^(ht) ^(hu) ^(hv) ^(hw) ^(hx) ^(hy) ^(hz) ^(ia) ^(ib) ^(ic) ^(id) ^(ie) ^(if) ^(ig) ^(ih) ⁽ⁱⁱ⁾ ^(ij) ^(ik) ^(il) ^(im) ⁽ⁱⁿ⁾ ^(io) ^(ip) ^(iq) ^(ir) ^(is) ^(it) ^(iu) ^(iv) ^(iw) ^(ix) ^(iy) ^(iz) ^(ja) ^(jb) ^(jc) ^(jd) ^(je) ^(jf) ^(jg) ^(jh) ^(ji) ^(jj) ^(jk) ^(jl) ^(jm) ^(jn) ^(jo) ^(jp) ^(jq) ^(jr) ^(js) ^(jt) ^(ju) ^(jv) ^(jw) ^(jx) ^(jy) ^(jz) ^(ka) ^(kb) ^(kc) ^(kd) ^(ke) ^(kf) ^(kg) ^(kh) ^(ki) ^(kj) ^(kk) ^(kl) ^(km) ^(kn) ^(ko) ^(kp) ^(kq) ^(kr) ^(ks) ^(kt) ^(ku) ^(kv) ^(kw) ^(kx) ^(ky) ^(kz) ^(la) ^(lb) ^(lc) ^(ld) ^(le) ^(lf) ^(lg) ^(lh) ^(li) ^(lj) ^(lk) ^(ll) ^(lm) ^(ln) ^(lo) ^(lp) ^(lq) ^(lr) ^(ls) ^(lt) ^(lu) ^(lv) ^(lw) ^(lx) ^(ly) ^(lz) ^(ma) ^(mb) ^(mc) ^(md) ^(me) ^(mf) ^(mg) ^(mh) ^(mi) ^(mj) ^(mk) ^(ml) ^(mm) ^(mn) ^(mo) ^(mp) ^(mq) ^(mr) ^(ms) ^(mt) ^(mu) ^(mv) ^(mw) ^(mx) ^(my) ^(mz) ^(na) ^(nb) ^(nc) ^(nd) ^(ne) ^(nf) ^(ng) ^(nh) ⁽ⁿⁱ⁾ ^(nj) ^(nk) ^(nl) ^(nm) ⁽ⁿⁿ⁾ ^(no) ^(np) ^(nq) ^(nr) ^(ns) ^(nt) ^(nu) ^(nv) ^(nw) ^(nx) ^(ny) ^(nz) ^(oa) ^(ob) ^(oc) ^(od) ^(oe) ^(of) ^(og) ^(oh) ^(oi) ^(oj) ^(ok) ^(ol) ^(om) ^(on) ^(oo) ^(op) ^(oq) ^(or) ^(os) ^(ot) ^(ou) ^(ov) ^(ow) ^(ox) ^(oy) ^(oz) ^(pa) ^(pb) ^(pc) ^(pd) ^(pe) ^(pf) ^(pg) ^(ph) ^(pi) ^(pj) ^(pk) ^(pl) ^(pm) ^(pn) ^(po) ^(pp) ^(pq) ^(pr) ^(ps) ^(pt) ^(pu) ^(pv) ^(pw) ^(px) ^(py) ^(pz) ^(qa) ^(qb) ^(qc) ^(qd) ^(qe) ^(qf) ^(qg) ^(qh) ^(qi) ^(qj) ^(qk) ^(ql) ^(qm) ^(qn) ^(qo) ^(qp) ^(qq) ^(qr) ^(qs) ^(qt) ^(qu) ^(qv) ^(qw) ^(qx) ^(qy) ^(qz) ^(ra) ^(rb) ^(rc) ^(rd) ^(re) ^(rf) ^(rg) ^(rh) ^(ri) ^(rj) ^(rk) ^(rl) ^(rm) ^(rn) ^(ro) ^(rp) ^(rq) ^(rr) ^(rs) ^(rt) ^(ru) ^(rv) ^(rw) ^(rx) ^(ry) ^(rz) ^(sa) ^(sb) ^(sc) ^(sd) ^(se) ^(sf) ^(sg) ^(sh) ^(si) ^(sj) ^(sk) ^(sl) ^(sm) ^(sn) ^(so) ^(sp) ^(sq) ^(sr) ^(ss) ^(st) ^(su) ^(sv) ^(sw) ^(sx) ^(sy) ^(sz) ^(ta) ^(tb) ^(tc) ^(td) ^(te) ^(tf) ^(tg) ^(th) ^(ti) ^(tj) ^(tk) ^(tl) ^(tm) ^(tn) ^(to) ^(tp) ^(tq) ^(tr) ^(ts) ^(tt) ^(tu) ^(tv) ^(tw) ^(tx) ^(ty) ^(tz) ^(ua) ^(ub) ^(uc) ^(ud) ^(ue) ^(uf) ^(ug) ^(uh) ^(ui) ^(uj) ^(uk) ^(ul) ^(um) ^(un) ^(uo) ^(up) ^(uq) ^(ur) ^(us) ^(ut) ^(uu) ^(uv) ^(uw) ^(ux) ^(uy) ^(uz) ^(va) ^(vb) ^(vc) ^(vd) ^(ve) ^(vf) ^(vg) ^(vh) ^(vi) ^(vj) ^(vk) ^(vl) ^(vm) ^(vn) ^(vo) ^(vp) ^(vq) ^(vr) ^(vs) ^(vt) ^(vu) ^(vv) ^(vw) ^(vx) ^(vy) ^(vz) ^(wa) ^(wb) ^(wc) ^(wd) ^(we) ^(wf) ^(wg) ^(wh) ^(wi) ^(wj) ^(wk) ^(wl) ^(wm) ^(wn) ^(wo) ^(wp) ^(wq) ^(wr) ^(ws) ^(wt) ^(wu) ^(wv) ^(ww) ^(wx) ^(wy) ^(wz) ^(xa) ^(xb) ^(xc) ^(xd) ^(xe) ^(xf) ^(xg) ^(xh) ^(xi) ^(xj) ^(xk) ^(xl) ^(xm) ^(xn) ^(xo) ^(xp) ^(xq) ^(xr) ^(xs) ^(xt) ^(xu) ^(xv) ^(xw) ^(xx) ^(xy) ^(xz) ^(ya) ^(yb) ^(yc) ^(yd) ^(ye) ^(yf) ^(yg) ^(yh) ^(yi) ^(yj) ^(yk) ^(yl) ^(ym) ^(yn) ^(yo) ^(yp) ^(yq) ^(yr) ^(ys) ^(yt) ^(yu) ^(yv) ^(yw) ^(yx) ^(yy) ^(yz) ^(za) ^(zb) ^(zc) ^(zd) ^(ze) ^(zf) ^(zg) ^(zh) ^(zi) ^(zj) ^(zk) ^(zl) ^(zm) ^(zn) ^(zo) ^(zp) ^(zq) ^(zr) ^(zs) ^(zt) ^(zu) ^(zv) ^(zw) ^(zx) ^(zy) ^(zz)

The Sun's structure has layers. One of these layers is the Chromosphere. The Chromosphere is the outer layer of the Sun (Figure 1). This layer has a thickness of about 2500km (NASA 2013). It also consists of gases emitted by the Photosphere (NASA 2013). This layer cannot be seen with the naked eye because of the white-light emitted by the Photosphere (Eddy 1981). The temperature of this layer is approximately 4500 to 10,000 Kelvin (NASA 2013). The density of the Chromosphere is a millionth times that of the Photosphere (Suplee 2004). The Chromosphere consists of an outer covering layer called Plasma. Plasma is 1,500km thick and is known to carry currents (Suplee 2004). Plasma also emits magnetic fields, but when these magnetic fields are too strong another form of plasma is released, Conductive Plasma (Eddy 1981).

(b) check this

(c) not relevant in short essay

(d) Diagram of sun showing the diff layers

(e) will discuss the sun's structure, and (otherwise I think you are also discussing solar system, stars etc)

(f) not yet mentioned so its confusing. Think about order in which you present these

(g) not capital all the time

(h) how many?

(i) on earth

(j) on its exterior

(k) climate on

(l) which

(m) and

(n) solar system, stars etc

(o) corona

(p) star of

(q) times that

(r) Plasma

(s) Plasma

(t) Plasma

(u) Plasma

(v) Plasma

(w) Plasma

(x) Plasma

(y) Plasma

(z) Plasma

(aa) Plasma

(ab) Plasma

(ac) Plasma

(ad) Plasma

(ae) Plasma

(af) Plasma

(ag) Plasma

(ah) Plasma

(ai) Plasma

(aj) Plasma

(ak) Plasma

(al) Plasma

(am) Plasma

(an) Plasma

(ao) Plasma

(ap) Plasma

(aq) Plasma

(ar) Plasma

(as) Plasma

(at) Plasma

(au) Plasma

(av) Plasma

(aw) Plasma

(ax) Plasma

(ay) Plasma

(az) Plasma

(ba) Plasma

(bb) Plasma

(bc) Plasma

(bd) Plasma

(be) Plasma

(bf) Plasma

(bg) Plasma

(bh) Plasma

(bi) Plasma

(bj) Plasma

(bk) Plasma

(bl) Plasma

(bm) Plasma

(bn) Plasma

(bo) Plasma

(bp) Plasma

(bq) Plasma

(br) Plasma

(bs) Plasma

(bt) Plasma

(bu) Plasma

(bv) Plasma

(bw) Plasma

(bx) Plasma

(by) Plasma

(bz) Plasma

(ca) Plasma

(cb) Plasma

(cc) Plasma

(cd) Plasma

(ce) Plasma

(cf) Plasma

(cg) Plasma

(ch) Plasma

(ci) Plasma

(cj) Plasma

(ck) Plasma

(cl) Plasma

(cm) Plasma

(cn) Plasma

(co) Plasma

(cp) Plasma

(cq) Plasma

(cr) Plasma

(cs) Plasma

(ct) Plasma

(cu) Plasma

(cv) Plasma

(cw) Plasma

(cx) Plasma

(cy) Plasma

(cz) Plasma

(da) Plasma

(db) Plasma

(dc) Plasma

(dd) Plasma

(de) Plasma

(df) Plasma

(dg) Plasma

(dh) Plasma

(di) Plasma

(dj) Plasma

(dk) Plasma

(dl) Plasma

(dm) Plasma

(dn) Plasma

(do) Plasma

(dp) Plasma

(dq) Plasma

(dr) Plasma

(ds) Plasma

(dt) Plasma

(du) Plasma

(dv) Plasma

(dw) Plasma

(dx) Plasma

(dy) Plasma

(dz) Plasma

(ea) Plasma

(eb) Plasma

(ec) Plasma

(ed) Plasma

(ee) Plasma

(ef) Plasma

(eg) Plasma

(eh) Plasma

(ei) Plasma

(ej) Plasma

(ek) Plasma

(el) Plasma

(em) Plasma

(en) Plasma

(eo) Plasma

(ep) Plasma

(eq) Plasma

(er) Plasma

(es) Plasma

(et) Plasma

(eu) Plasma

(ev) Plasma

(ew) Plasma

(ex) Plasma

(ey) Plasma

(ez) Plasma

(fa) Plasma

(fb) Plasma

(fc) Plasma

(fd) Plasma

(fe) Plasma

(ff) Plasma

(fg) Plasma

(fh) Plasma

(fi) Plasma

(fj) Plasma

(fk) Plasma

(fl) Plasma

(fm)

Box 8.8b: First page of final draft of Ntombizodidi's essay

The Centre of our Solar System

The sun is the centre of our Solar System. This ball of fire consists of gases and is a star. According to Suplee (2004) the sun has been burning for more than 6 billion years. The sun is made up of different layers (Eddy 1981), and in this essay we will be discussing the structure of the sun, the generation of energy by the sun and the significance of sunspots.

The core is the inner most layer of the sun. The core has a temperature of 15 million Kelvin and a density 12 times that of solid lead (Gribbin 1993). The core has particles that are stripped of their electrons which form a part in the conversion of mass into energy (Gribbin 1993).

The radiation zone is the layer after the core. This zone has a temperature of 500 000 Kelvin (Gribbin 1993). The density of this layer is 1% that water (Gribbin 1993). The diameter of the radiation zone is 1 million kilometres from the inside to the outside.

Following the radiation zone is the convection zone. The convection zone and the radiation zone do not conduct movement at the same time thus creating magnetic fields which in turn allow energy to be stored up (Suplee 2004). The convection zone has a diameter of 150 000 km (Gribbin 1993). In the convection zone heating and cooling takes place. Gribbin (1993) states that materials at the bottom of the convection zone become heated and rise through the convection zone, it then comes

Box 8.9: Lecturer feedback comments provided on students' reflective responses to questions in the 2010 cohort

(a) Student learning strategies

You are so right Nomgcobo; consistent hard work and maintaining focus is what will help you achieve the kind of success that I am sure you are aiming for. Perhaps it might be useful to also consider what to do when strategies don't work for you. How do you cope with such situations?

Mncedisi you have described a number of interesting strategies that obviously work for you – well done on identifying those! You are so right about trying to teach someone else as a way of verifying your own understanding. Would you mind if I share this idea with the rest of the class? Finally, I am pleased that you also ask yourself questions and that you continue to reflect on and grapple with material. Insights come at the most unexpected moments!

Good description of time management Nokhanyo! Making summaries is also useful. Have you considered setting questions for yourself to answer? I hope you will also start asking yourself other more challenging questions that will lead you to think more deeply about the subject matter at hand. What I have in mind here is questions that start with 'What if....'. You never know where that will take you!

(b) How students respond to feedback

Mncedisi you have identified an important area of feedback which needs to be followed up viz. where a student is actually confused about requirements. In such a case, what do you think you should do? I am leaving this as a question for you to consider because I really want you to come up with the answer! On the whole it is gratifying to see that you do not take the feedback as a personal criticism but rather as an attempt to help you work towards the standards required for a set task.

Rolihlahla you have touched on several important issues regarding feedback: firstly well done on noting that feedback acknowledges both your strengths and weaknesses. You would be surprised at how many students miss that point! Secondly, I like the way you exchange papers with a fellow student. In so doing you are actually exploring the power of peer education. Finally you act on the feedback in your next assignment. Remind yourself that you made these intelligent observations about your learning when you were only in first year!

What interesting observations Ntatu! I had no idea that you sometimes avoided looking at feedback. I always remind students that REmarks are more important than marks because you can learn much more from the former. Also, do look at the positive comments that you receive as you can learn as much from these.

Nomsa the feedback that we lecturers give on your work is never intended as a slap in the face, as you maintain! I am also glad that you take the initiative to discuss the feedback with your lecturers. However, it is unlikely that the lecturers think you are dumb as such! I think the most significant aspect of your response to feedback is that you realise that the responsibility rests with you to reflect on the feedback and then continue the dialogue about your work with the lecturer concerned.

(c) Advice to give a new SESP student

Nomgcobo you have touched on some key issues viz. the value of the mentorship programme in helping you adapt to university life, approaching your learning with a prepared and critical mind, and finally noting the importance of this year in real preparation for the rigours of the rest of the degree. These are valuable insights!

Thank you Likhaya for sharing your initial outrage at what you thought was racism and for moving on from that point to a whole new perception of the aims of the programme. You do realise now that this is in fact an 'access programme' and yes it is about nurturing and encouraging potential. You have made some powerful observations about yourself (that you had to adjust to a steep learning curve, not to fall into the trap of denialism) and about learning at university (that you have to be a contributor to knowledge). These are valuable insights!

Framing of feedback in ISCM appears to be weakened in two main ways. Firstly, in a planned effort to develop independence, feedback on assignments early on in the course is individual and detailed, but as the course progresses feedback becomes more global and through supported peer- and then self-assessment exercises (mentioned in section 7.2.1.2). Secondly, framing can be weakened when feedback is general and requires student active engagement for improvement, which in itself is not necessarily problematic:

Interviewer: The marker didn't help you much here [with their feedback]. They only indicate the problems, but don't say how you can change it. Did this help you at all?

Student: Yes it helped because I find most information. This 'so' [pointing to a comment that says: So?] meant I was not clear so I tried to refer to the question. I tried to write and take more facts. This helped me because I had to try and answer the question more carefully (Student interview on essay writing, Nikelwa)

However, it is acknowledged that feedback that does not provide direction for improvement may not be helpful to some students, and a careful critique of the feedback in ISCM would likely be useful. As one student commented:

The tutor . . . when he corrects you wrong in a tutorial he needs to explain the reason why so that you can be able to work on your mistakes. (Student evaluation, 2012)

Overall the analysis indicates relatively **stronger framing** (+F) in the ISCM course in terms of the intention of providing relevant, usable, personal and timely **feedback**. There is some evidence, however, that in reality the feedback is not always explicit nor is it always clear to students, indicating weaker framing than intended. Progressive weakening of framing of feedback in the second semester is a deliberate strategy to strengthen student independence and criticality of own work.

8.5 Assessment practices discussion

Expectations associated with assessment practices can be transmitted to students firstly through the way a task is set or how a question is asked, secondly through articulation of evaluative criteria, and thirdly through provision of feedback (Shalem and Slonimsky 2010, p762). These three concepts are used to explicate ISCM assessment practices in terms of the two main drivers of ISCM that have been identified in curriculum and pedagogic analysis: becoming and being (a) a scientist and (b) a science learner. Overall the analysis indicates ISCM assessment practices legitimate becoming and being a scientist, but not a science learner.

8.5.1 Framing of assessment practices: Becoming and being a scientist

Science is a vertical discourse with a hierarchical knowledge structure which operates with base concepts embedded in context (SG+), but as theories and propositions become increasingly generalised and abstracted they are removed from context (SG-). It also has a high correlation

between concepts and phenomena (strong empirical referents; SD+). These principles of hierarchy, abstraction and empirical referents need to be transmitted to science students through pedagogic practice, and their mastery tested in assessment practices.

Analysis indicates that ISCM assessment practices operate across the semantic density range, with disciplinary knowledge representing relatively the strongest semantic density, scientific literacies knowledge relatively less strong density, and generic academic practice knowledge relatively the weakest semantic density. However, with a strong focus on disciplinary and scientific literacies knowledge there is a bias towards stronger semantic density, which is appropriate for a course that is preparing students for access in science courses.

Analysis also indicates that ISCM assessment practices operate across a wide semantic gravity range, with recall-type questions representing relatively the strongest semantic gravity and creation-type questions representing relatively the weakest semantic gravity, with comprehension- application-, analysis- and evaluation-type questions representing progressive weakening of semantic gravity between the two extremes. However, the general dominance of comprehension-type questions in tests and examinations in ISCM would be signalling to students a valuing of knowledge fairly well rooted in context. This would likely engender segmented-like, context-bound learning (Maton 2009; 2014a). Nonetheless, the trend of increasing abstraction (i.e. weakening semantic gravity) through tasks that focus on application, analysis, evaluation and creation during the course of the year should serve to encourage more integrated, cumulative and abstract learning (Maton 2009; 2014a). Evidence in the next chapter indicates students cope equally well with questions based on relatively stronger or weaker semantic gravity, which would suggest that they are being well supported in ISCM in the gradual shift towards more abstract learning.

As mentioned, it is not only the assessment task or question that signals to students what is legitimated in a particular context; so too do evaluative criteria and feedback. Framing is stronger when evaluative criteria and feedback are made explicit to students and weaker when they are implicit. Bernstein (2000) maintains, as do other authors (Morais, Neves and Pires 2004; Rose 2004; Neves, Morais and Afonso 2004), that stronger framing of evaluation criteria can lead to students acquiring the necessary recognition and realisation rules of the context. Likewise, the importance of feedback in terms of enabling access is emphasised repeatedly in educational research (see Taras 2001; Black et al. 2003; Falchikov 2005; Ellery 2008a; Shalem and Slonimsky 2010; Mgqwashu 2012). Although most of these authors are not using Bernsteinian terminology, they are essentially arguing for stronger framing of feedback.

The analysis in this study indicates that stronger framing, in terms of both explicit articulation of evaluative criteria and consistent and regular provision of feedback, is a key means of signalling

legitimacy to students in ISCM. Since the majority of assessment tasks in ISCM draw on either disciplinary or scientific literacies knowledge or knowledge practices, the associated criteria and feedback are also biased towards an epistemic base. In this regard, despite some unintentional weaker framing when epistemic criteria and/or feedback are not well understood by students or are absent, in an overall sense the assessment tasks and provision of criteria and feedback in ISCM are focused on supporting the development of students becoming and being scientists. By the same token, the next section shows that the assessment processes in ISCM are less effectively directed towards supporting the development of science learners.

8.5.2 Framing of assessment practices: Becoming and being a science learner

The pedagogic concern for ISCM students becoming and being independent science learners (also called learning-context knowers) is not directly assessed in any high-stakes assessment tasks. As such, being an effective science learner is only evidenced indirectly through, for example, good answers in tests and examinations (based on appropriate study practices), timely completion of tasks, or completion of required advance preparation for a practical or enrichment session. It is only in low-stakes reflective tasks in tutorials that students are required to actively consider and articulate aspects of their own dispositions and learning practices and whether and how they may be valued in a higher education science learning context. Questions in this regard relate primarily to their own attitudes towards, for example, working with feedback or doing independent work, and have as their focus the development and possible improvement of learning practices. In terms of these reflections, marks are seldom awarded and evaluative criteria are not articulated. However, the feedback is designed to be useful as it is dialogic and personal, and focuses on their development as science learners.

8.6 Final comments on pedagogy and assessment

This and the previous chapter were aimed at answering the second research question, that asks how pedagogic and assessment practices are framed and legitimated to enable access. In pedagogy and assessment, recontextualising agents make choices about what knowledge is taught (selection); in what order it is taught (sequence); how much time is spent on aspects (pacing); and what is valued in the assessment processes (assessment tasks, evaluation criteria and feedback), all of which form part of the instructional discourse, as well as choices about the social order of the regulative discourse, such as staff–student interactions, and student conduct and practices. Comparison with empirical literature in this regard suggests that framing of pedagogic and assessment practices in ISCM should, by many counts, be supporting student learning in science, especially students from backgrounds that may not have prepared them well for success in higher education. This support appears to be particularly appropriate for the epistemologically oriented, or science, aspects of ISCM, but the axiologically oriented aspects of

the course, related to being a learner in the sciences (learning-context knower), is not supported by any direct assessment. As such, the extent to which ISCM pedagogic and assessment practices are enabling student learning, both epistemologically and axiologically, becomes clearer in the following two chapters, where student responses to ISCM (Chapter 9) and mainstream assessment tasks (Chapter 10) are examined.

Chapter 9: Student response to ISCM educational practices

9.1 Introduction

Chapter 6, aimed at answering the first research question, examined how knowledge and knowers are legitimated in the ISCM curriculum. Chapters 7 and 8, both of which focused on the second question, looked at how pedagogy and assessment practices are framed and legitimated. This chapter, in turn, is aimed at answering the third research question of 'How do students interpret and respond to ISCM educational practices?', and in part the fourth question of 'In what way do ISCM and mainstream educational practices enable or constrain epistemological access?' This is achieved largely through the lens of students' acquisition of recognition and realisation rules in order to be able to produce a legitimate text – as predicated by the particular context.

It was suggested in Chapter 4 that acquisition of recognition and realisation rules can be at two levels: at a cognitive (epistemic-context) level with epistemological underpinnings influenced primarily by the instructional discourse and at a social (learning-context) level with axiological underpinnings influenced primarily by the regulative discourse. These two levels are used to frame student acquisition in this chapter. Student response to assessment is examined firstly by conducting an analysis of a range of student assessment task texts, and secondly by probing further their response through follow-up interviews and through analysis of student written evaluations and reflective texts. The discussion focuses on student acquisition of coding orientations at the two different levels and suggests that, because they exist in hierarchy, realisation at the learning-context level, in terms of becoming and being a science learner, is necessary for realisation at the epistemic-context level, in terms of becoming and being a scientist. It is suggested that the difficulty of acquiring learning-context realisation may be linked to a code clash as well as to competing demands between two different codes that are being legitimated in ISCM.

9.2 Acquiring cognitive (epistemic-context) competence

9.2.1 Acquiring epistemic-context recognition and realisation rules

Bernstein's (2000) concepts of recognition and realisation rules were utilised to examine student responses to a range of assessment tasks (tests, examinations, assignments, tutorials, practicals) at different levels of cognitive complexity. Recognition rules (RC) are the way in which 'individuals are able to recognise the speciality of the context that they are in' and realisation rules (RL) enable them to generate 'the expected legitimate text' (Bernstein 2000, p17). These are referred to in this section as epistemic-context recognition rules (RC(ec)) and

epistemic-context realisation rules (RL(ec)) as they are associated with principled and procedural knowledge that has epistemic underpinnings. This is in keeping with the terminology developed for epistemic-context social relations (SR(ec)). A relatively simple external language of description was developed in Chapter 5 (see Table 5.7 (laminated)), with three main categories: *no recognition* (no understanding of context (concepts, values, conventions and procedures) necessary to produce appropriate text); *recognition but incomplete realisation* (good understanding of context but only presents some correct concepts and values and applies some appropriate procedures and conventions to produce partially suitable text); and *recognition and realisation* (presents correct concepts and values and applies appropriate conventions and procedures to produce suitable text).

To provide an indication of students' RC(ec) and RL(ec), a series of examples that encompass the full range of cognitive complexity (across the semantic gravity scale) and different knowledge types (across the semantic density scale) in ISCM assessment tasks are presented (Boxes 9.1–9.6). These are drawn from assessment task data of the period 2010–2014. Each box has the following elements: (a) assessment task question, (b) criteria or conceptual or procedural knowledge expected by the lecturer, and (c) three text samples (includes allocated marks), one of each where a student exhibited (i) no recognition, (ii) recognition but incomplete realisation, and (iii) recognition and realisation. The comment I make in the text accompanying each Box with respect to the levels of student recognition and realisation is essentially an empirical elaboration of the external language of description as described in section 5.5.4 of the methodology chapter.

In a June examination, students were asked to state what a nuclear chain reaction is – a question requiring **recall of principled Physics knowledge** (Box 9.1). Students had not been given a definition in lectures, but the concept of a nuclear chain reaction had been discussed in detail in class. The answer required comment on a fission process in which a neutron splits a heavy nucleus and the products of the reaction contribute to further reactions in a self-sustaining and exponential manner. The allocation of 3 marks indicated that a brief description was required. In the given example, the student exhibiting no recognition used the incorrect concept of fusion instead of fission, and did not describe the essential elements of the process. A student with recognition but incomplete realisation exhibited some understanding of the exponential nature of the reaction, but no mention was made of neutrons and how products initiate the next reaction. They also used poor scientific expression. The example of good recognition and realisation indicates the student understood the concepts, although the assessor felt the answer could have been expressed better.

Box 9.1: Student epistemic-context recognition and realisation in assessment task requiring recall of principled Physics knowledge (DK)

Question: State what is a nuclear chain reaction. (3 marks)

Expected concepts: A chain reaction is a series of reactions where the products of one reaction contribute to the reactants of another reaction in a self-sustaining fashion. A nuclear chain reaction is a fission reaction where a single neutron splits a heavy nucleus into two lighter nuclei with the release of two or three neutrons. The neutrons generated by the process can initiate fission of other atoms in an exponential way.

No recognition:

A nuclear chain reaction is the fusion of the atom of Uranium. (0/3; Noma)

Recognition, but incomplete realisation:

A nuclear chain reaction is a reaction that takes place in the atomic form of elements. A disturbance (so to speak) which cause energy realise in one atom as this linked to for example 3 other atoms and then 9 atoms and so it goes on with more atoms more energy is realised this is a chain reaction. (1/3; Nokhanyo)

Recognition and realisation:

A chain reaction is a self-sustaining reaction in which one product stimulates further events. The nuclear chain reaction it's where a neutron bombarded into a Uranium substance, make it unstable and split into two and the neutrons released cause another nuclear reaction. Nuclear chain is the series of events that influence the next event. (2.5/3; Sanele)

A November examination question that required students to provide a description on how a 'hot spot' can give rise to a chain of islands (Box 9.2) is an example of a **comprehension** task drawing on **principled Geology knowledge**. The expected concepts related to hot spots, volcanic islands, rising hot mantles, plumes and shifting lithosphere plates, and other expected criteria related to a good description/definition of a hot spot and a logical and coherent explanation of sequential processes. According to the phrasing of the question, it was implied that a paragraph answer was expected. In this case, the student with no recognition drew on the wrong concepts and no explanation was provided. The student with recognition but incomplete realisation essentially worked with the right concepts, but showed only partial understanding by mentioning incorrect facts (the volcanoes are not rift-related) and did not make clear the process of island chain formation. In addition, since their answer was a single sentence, it lacked coherence. The student with both recognition and realisation not only drew on all the required concepts but also developed a coherent and logical description of processes – obtaining full marks for their answer.

Box 9.2: Student epistemic-context recognition and realisation in a comprehension task drawing on principled Geology knowledge (DK)

Question: Briefly explain how a 'hot spot' can give rise to a chain of islands. (8 marks)

Expected concepts and criteria: A hot spot is a stationary place in the mantle where high temperatures cause melting resulting in plumes of hot mantle rising to the earth's surface to produce a volcano. If the hot spot is beneath the ocean, a volcanic island is formed. However, the lithospheric plates (crust) at earth's surface are constantly shifting. With this shift the volcanic island moves away from the hot spot, forming a non-active volcanic island. But the hot spot remains active and a new volcano (and island) is formed on 'new' section of plate that has moved across the hot spot. In this way a 'chain' of islands can form. (Answer needed to follow general writing conventions.)

No recognition:

The hot spot volcano is formed by the release of the volatile compounds such as water and carbon dioxide from the rock of the subducting plate. (0/8; Anathi)

Recognition, but incomplete realisation:

A "hot spot" is where a mantle plume is brought towards the surface, what happens is that a hot magma is pushed closer and closer to the lower mantle, out of the mid-ocean ridge, it causes the formation of rift-related volcanoes and the motion of plates continues, the "hot spot" is now chains of islands such as Hawaii for instances are formed because the oceanic crust gets subducted beneath the continental crust at one place, moving the position of the continents around. (4/8; Nofanele)

Recognition and realisation:

"Hot spots" are areas where plumes of magma are constantly rising below the plates. The plumes of magma rise and when they connect with the plate this forms a magma chamber which ultimately forms a volcano. The volcano formed is very active because it is constantly supplied with heat from the plumes. The formation of a volcano creates a volcanic island. However, due to plate tectonics the plate moves and the volcano becomes dormant but since the plumes have formed a new area on the plate another volcano forms and this continues on and on and thus a chain of volcanic islands is formed. (8/8; Ntlonipho)

In a June examination, students were asked to explain how they would prepare 1 litre of 0.50 M (moles/L) NaCl solution (Box 9.3). This required **application of principled and procedural Chemistry knowledge**. It was noted that a number of students did not understand the question well, which needed more context and perhaps could have been phrased: 'If you were working in a laboratory and asked to prepare a 0.50 M (moles/L) NaCl solution, explain how you would go about it'. Nonetheless, students were expected to apply their knowledge of molecular mass and molarity to a particular situation, perform correctly the appropriate calculations (showing units) and provide a brief description of the physical process of making up the solution. In this case, the student with no recognition drew on the incorrect concept of molar ratio of NaCl and did not realise that a calculation was required. The student with recognition but incomplete realisation understood which concepts were needed but calculated incorrectly. It was also not clear how or why they would titrate. The student with both recognition and realisation met all the required criteria but the assessor did indicate use of a comma (instead of a decimal point) was incorrect in science convention.

Box 9.3: Student epistemic-context recognition and realisation in an application task drawing on principled and procedural Chemistry knowledge (DK)

Question: Explain how you would prepare 1 litre of 0.50 M (moles/L) NaCl solution. (5 marks)

Expected concepts and procedures:

$$M(\text{NaCl}) = 22.99 + 35.45 = 58.44 \text{ g/mol}$$

$$m = nM = 0.5 \text{ mol} \times 58.44 \text{ g/mol} = 29.22 \text{ g}$$

Weigh 29.22 g NaCl and add it to 1L water to make a 0.50M solution of NaCl.

No recognition:

I can prepare it by using molar ratio of NaCl which is 1:1, then it means Na⁺ has a concentration of 0,50 M and Cl⁻ has a concentration of 0,50M, therefor I can take half of 0,50 Molarity from each and combine them to get 1L of 0,50M. (0/5; Kanelo)

Recognition, but incomplete realisation:

$$M(\text{NaCl}) = 22.99 + 35.45 = 58.44 \text{ g/mol}$$

$$M = nm = 0.50 \text{ mol} \times 58.44 \text{ g/mol} = 22.2 \text{ g NaCl}$$

Therefore I would prepare 1L of 0.50M by adding 22.2g of NaCl and titrate. (3/5; Zola)

Recognition and realisation:

$$M = nm = 0,50 \text{ mol} \times 58,44 \text{ g/mol} = 29,22 \text{ g} = 29.2 \text{ g of NaCl (3SF)}$$

I will need 29,2g of NaCl to add to 1L of water to make a 1L solution of 0,50 M. (5/5; Nosine)

In a tutorial, students were provided with a set of information (hypothesis, experimental design, quantitative results) based on a simple experiment on fish behaviour (Box 9.4). They were asked to provide a conclusion for the experiment based on critical use of quantitative data. This was therefore an **analysis** task that required students drawing on **scientific literacies principled and procedural knowledge** related to experimental design and manipulating and interpreting data. The expected criteria included appropriate quantitative data manipulation and interpretation. Since this could be done a number of different ways, their conclusion needed to be supported by their data and also to link back to the hypothesis. Bonus marks were awarded if suggestions for improvement were made. In the examples given, the student with no recognition had only used data from one fish to support their conclusion, which was unclear and nor was it linked to the hypothesis. In the first example of recognition but incomplete realisation the student correctly manipulated the data. Their conclusion was 'correct' but they needed to (a) indicate better which was the control group and which the experimental group, (b) discuss the decrease in swim time of the control group, (c) use correct units (either minutes or seconds), and (d) be more tentative in their conclusion. In the second example of incomplete realisation, the student used a good method for the interpreting data, but their reading of the data was completely incorrect. Their concluding statement was 'correct' according to the data they produced, but not for the given data. Since this was a complex analysis exercise no student achieved recognition and realisation in their first attempt.

Box 9.4: Student epistemic-context recognition and realisation in an analysis assessment task drawing on scientific literacies principled and procedural knowledge (SLK)

Exercise 3: Vitamin supplement for fish

Fenji believes that fish that eat food with a vitamin supplement will be able to swim faster through a maze (see diagram provided of a maze) than those fish fed with regular food. She performs an experiment to test this. At the beginning of the experiment she makes 20 fish swim through a maze and records the time it takes for each one to swim to the end. She then feeds half the group (10 fish) on food with the vitamin supplement for a week, and the other half are fed on regular fish food. After 1 week, she records the swim time for each fish as they swim through the maze (Table 1).

Table 1: Swim time (in minutes) of two groups of fish ((a) without and (b) with vitamin supplement) at beginning and at end of experiment.

(a) Fish without vitamin supplement		
Fish	Before	After
1	1:06	1:00
2	1:54	1:20
3	2:04	1:57
4	2:15	2:20
5	1:27	1:20
6	1:45	1:40
7	1:00	1:15
8	1:28	1:26
9	1:09	1:00
10	2:00	1:43

(b) Fish with vitamin supplement		
Fish	Before	After
1	1:09	1:08
2	1:45	1:30
3	2:00	2:05
4	1:30	1:23
5	1:28	1:24
6	2:09	2:00
7	1:25	1:19
8	1:00	1:15
9	2:04	1:57
10	1:34	1:30

Question: Look carefully at the results. What should Fenji's conclusion be? Support your answer with quantitative facts. Remember to think critically in your answer. (8 marks)

Criteria: Provide an appropriate calculation (e.g. mean) or comparison of data (number fish swimming faster/slower) for the two groups. Tentative conclusion should match the data and link back to the hypothesis. Suggestions for improvement of experiment (to achieve a better conclusion) could be provided (bonus marks).

Suggested answer provided to students: In the experimental treatment, 8 out of the 10 fish swam faster in the second attempt in the maze (mean of 10.9 seconds faster) after eating vitamin supplemented food. In the control treatment, 8 out of 10 fish also swam faster the second time (mean of 6.6 seconds faster) after eating ordinary food. Since the control treatment fish also swam faster, it seems unlikely that the food source was influencing swimming speed through the maze - it was probably linked to an element of 'learning'. However, since the experimental fish had a faster mean time to swim through the maze than did the control treatment fish, the experiment could be conducted again with a larger sample size to see whether one could come to more conclusive results.

No recognition:

Femji's conclusion should be that at the beginning of the experiment before she fed the fish the food with vitamin supplements and regular food, the fish swam much slower than when they were fed with food with supplements and regular food for example fish 3 in the special group took 2 minutes and 4 seconds before it was fed supplements and 1 minute and 57 seconds to complete the maize after it was fed supplements (special food). (1/8; Gugulethu)

Recognition, but incomplete realisation:

- Special food group mean (before) = 1.49 min/sec
- Special food group mean (after) = 1.38 min/sec
- Regular food group mean (before) = 1.48 min/sec
- Regular food group mean (after) = 1.41 min/sec

Fenji's conclusion should state that the fish that is fed special food is faster than the fish fed regular food. Based on the calculation above the mean of the time taken by the control group to complete the maze after they were fed is more than the time taken by the experimental group. The fish with the special food takes 1.38 min/sec after being fed to complete the maze while the fish with regular food takes 1.41 min/sec. (4/8; Thandiwe)

Recognition, but incomplete realisation:

The hypothesis was proved to be otherwise therefore needs to be revisited. With special food group only 4 out of 8 fishes swam faster than before meaning the rest which is 6 turned out to be slow. In regular food group when calculating the difference in their times you see that 8 out of 10 fishes became slower than before with only [2] that swam faster. So, all-in-all the food that has vitamin supplement doesn't necessarily mean if you feed fish with it, it will make the fish swim faster. (4/8; Nonkululeko)

Recognition and realisation:

No students achieved more than 4 marks out of 8 in their first attempt.

In a November examination, students were provided with an article on human influence on climate and were expected to evaluate the article for its use in an academic essay (Box 9.5). This therefore was an **evaluation** task drawing on **scientific literacies procedural knowledge**. Students were expected to critically comment on the credibility of the article, intended readership, relevance of information, and approach to referencing of sources. Students could argue either way provided their arguments were well justified and well articulated. In the example of no recognition, the student focused on locating relevant factual information (temperatures) only, instead of on evaluating the usefulness of the article. The student with recognition but incomplete realisation exhibited some understanding of evaluation through examining credibility of sources but they focused too narrowly on in-text citations and referencing. Also, their final sentence was an incorrect statement and too specific for the context of the question. The student with good realisation met the required criteria and the only feedback they received was that their sentences were too long.

Box 9.5: Student epistemic-context recognition and realisation in an evaluation assessment task drawing on scientific literacies procedural knowledge (SLK)

Question: Imagine that you were writing an academic essay on “Global Climate Change in the 21st Century”. Critically evaluate the usefulness of this article for your purposes.

Evaluative criteria: Credibility of article, credibility of sources in article, intended readership, relevance of information, language used (including plenty of quotations), and provision of end-text sources for further reference. Students can argue either way, provided arguments are well justified. It would be expected that general writing conventions would be followed.

No recognition:

This article will be useful since it will provide the temperature change for the end of the 21st century. It will also help me since it describe temperature during the early, mid and later 21st century. (0.5/5; Anathi)

Recognition, but incomplete realisation:

The scientific knowledge they used is highly credible and the scientific evidence to support their claims. However, the sources they cited are not well in-text referenced, and the website they accessed, in the reference, it does not show the time at which it was accessed. This puts doubt on how credible their sources is. There is no sufficient background knowledge with regards to climate change due to human impact, and how human population impacts on climate change. (2.5/5; Lelethu)

Recognition and realisation:

This report will be of good help to get a general idea particularly on the topic and to understand how the global climate has changed over time, however it will not be a very credible report to include because the readership of this article is the general audience and not necessarily the scientific community, the writing style of the report is professional but not necessarily up to standard in a sense that there is no in-text referencing, therefore there is no weight on the report and does not guarantee that the information provided is true. Therefore the information in this report is only useful to get a general sense to the topic. (4.5/5; Nofanele)

A test question that required students to develop a good data collection sheet for two dependent variables in the HKE course component provided opportunity for a **creation** level task drawing on **scientific literacies principled and procedural knowledge and academic practice knowledge** (in the form of a set of ‘rules’; Box 9.6). Students were given a short text

that described the results of a study in which the effect of childhood obesity on ill-health was examined. Gender- and age-specific guidelines were provided to help counter the unhealthy profiles. The criteria upon which they were assessed required students to identify the independent and dependent variables and provide a data collection table (correctly formatted according to a range of conventions and 'rules' as outlined in Box 9.6). In the example of a student exhibiting no recognition, the variables were incorrectly identified, virtually none of the table drawing conventions were followed and no space was provided in which data could be entered. The student with recognition but poor realisation had correctly identified the variables and had followed some conventions for table construction. However, the table heading was insufficient, no units were indicated, the frequency column was inappropriate, and there was no accommodation of additional information or replicates. The student who showed both recognition and realisation answered well according to all the expected criteria, with the exception of not providing space for replicates and no indication of units.

Box 9.6: Student epistemic-context recognition and realisation in a creation assessment task that draws on scientific literacies principled and procedural knowledge (SLK)

Question: Draw up a good data collection sheet for two dependent variables in the study. (10 marks)

Criteria and suggested answer: Needed to identify independent (age, gender, level of fitness) and dependent (blood pressure units, cholesterol level, skinfold thickness) variables from text. Data table needed (a) full heading placed above table, including date, (b) independent variable in first column, (c) dependent variables in following columns, (d) column headings, with units, (e) space to accommodate replicates, (f) possibly space to accommodate basic calculations (e.g. mean), (g) space for additional observations, (h) as little repetition as possible. Suggested format of table:

Table 1: Data table to determine risk of CVD using blood pressure and cholesterol levels for children 9 years and under (collected March 2012)

Age	Age replicates	Blood pressure (units)		Cholesterol levels (units)	
		measure	mean	measure	mean
2	1				
	2				
	3				
3	1				
	2				
	3				
4 etc	etc				

Other observations: _____

No recognition:

Gender	Age
Boys	2 to 6
Females	
Boys	Under 6

(0/10; Mfuneko)

Recognition, but incomplete realisation:

Data collection sheet

Age	factor			frequency
	Blood pressure	Cholesterol levels	Skinfold thickness	
1-4				
5-7				
8-11				

(5/10; Anathi)

Recognition and realisation:

Data collection sheet.

Date: 22 August 2013

Title of research: New guidelines for exercise in children; blood pressure and cholesterol levels of European children aged 2-9 years

Gender	Age group	Adverse CDV profile factors	
		Blood pressure	Cholesterol levels
boys			
girls			

Additional Information: _____ (9/10; Thembeke)

Because of the external language of description developed for epistemic-context recognition used in this study, examples of no recognition (RC(ec)-) are linked to either partial understanding or poor use of **concepts** and **values** (as presented in Boxes 9.1, 9.2, 9.2 and 9.6), or poor understanding or use of **procedures** and **conventions** (as presented in Boxes 9.1–9.6). However, an analysis of marks for all examination questions over the period 2010–2014 indicated that students in ISCM are generally able to recognise the context of questions in assessment tasks (RC(ec)+). This is particularly the case when the task question is framed by clear instructional action (e.g. describe, explain, distinguish, apply) and concept words, and mark allocation or instructions give an indication of scope of expected answer. Students therefore mostly draw on the right concepts and also seem to have a good sense of what is required (i.e. good recognition) in terms of conventions and procedures associated with writing (e.g. full sentences, logical flow of ideas, acknowledgement of sources) and calculating (e.g. show working, use appropriate units, work to correct significant figures and decimal places). For example, when asked in an interview their understanding of the criteria (phrased as ‘what will get you marks’) for a question related to writing a paragraph with in-text citations based on a scientific article, the student replied:

I would get marks for the construction of a paragraph . . . has an introduction where you start off from a broad thing then goes down to the specific things of what they want in the question . . . full sentences . . . grammar and spelling, and I think most importantly if you did answer the question rather than just write, and if you understood the question . . . then the in-text referencing, if you understand you know how it is done. (Student interview, Sandla)

When asked their understanding of what criteria would be used to judge an answer on provision of a scale bar for a diagram, another student correctly answered:

When you are drawing the scale [bar], I think the marker will look if we did all the steps, the calculations before drawing the scale [bar] . . . that your measurement was accurate because in science obviously you have to be accurate and precise . . . use relevant units . . . rounding off, and to indicate that you’re rounding off not just round off. (Student interview, Fezeka)

However, despite ISCM students having relatively good epistemic-context recognition rules, they often cannot produce an appropriate text, indicating relatively poor acquisition of epistemic-context realisation rules (RL(ec)-). In the same mark analysis for 2010–2104, poor RL(ec) was not obviously linked to students coping better at any particular level of cognitive complexity. In other words, as a group they managed equally well (or not) at the lowest level of recall and the highest level of creation, and at all other levels in between. Likewise, poor RL(ec)

was not obviously linked to knowledge type or knowledge practice (principled or procedural, or disciplinary or scientific literacies knowledge).

Again, because of the definition of epistemic-context realisation used in this study, poor realisation is also related to poor implementation of procedures and conventions or an incomplete understanding of the concepts and knowledge base and values. **Poor implementation of procedures and conventions** that occur in questions at a lower cognitive level tend to be of a more technical nature, such as making mistakes in calculations, rounding off poorly, using significant figures inappropriately, measuring inaccurately, referencing poorly, and selecting information incorrectly (examples in Boxes 9.1, 9.2 and 9.3). Poor implementation of procedures in questions at a higher level cognitive level tend to relate to difficulties in applying, evaluating or being critical (examples in Boxes 9.4, 9.5 and 9.6).

In terms of a poor knowledge base, students frequently had poor understanding of concepts and did not know or present sufficient information to achieve their marks (see examples in Boxes 9.1 and 9.2). The **high cognitive demand** and **abstract nature** of work can be problematic for some:

. . . it was hard for me to catch up with work because of the . . . standard level [of the work]. It was too much for me to handle. (Student written evaluation, 2010)

As one student commented, developing understanding at this level was difficult:

I won't lie, it's the first subject that I can say it was quite difficult for me . . . last year when I was doing my matric, I didn't see how deep is science but in ISCM I saw how deep is science . . . in terms of being critical and put your understanding towards your work (Student interview, Kanelo)

Furthermore, the abstract nature of knowledge was especially difficult if it was not contextualised for students:

Like sometimes there are lectures, it's all about the theory, there's no examples . . . if there are examples I will understand. (Student interview, Kanelo)

Apart from poor procedural implementation and poor knowledge base, a third aspect of poor RL(ec) that emerged in the interviews is associated with poor **assessment task (test and examination) techniques**. The most common examples of this are running out of time during tests and examinations, leaving out sections of questions or parts of questions by mistake, and not reading the question carefully. In the following quotation the student indicated a good test technique of leaving a difficult question until the end, but simply ran out of time:

. . . by the time I came back to actually think of it [the question] . . . that's when the time was up so I couldn't really do it . . . I don't think I write slow but the thing is I just have a

huge meeting in my mind when I answer questions . . . I spend a lot of time thinking. Ja, that's where I lose most of my time. (Student interview, Zola)

In terms of reading a question carefully, the student indicates in her comment below that she had registered the words proton and neutron but had not read the need to relate these to forces in the nucleus as required by the question:

. . . what I got I just picked up on the protons and the neutrons in the nucleus what [role] do they play and what do they do, and not the forces . . . that's why I answered it this way. (Student interview, Anele)

She later said:

I'm not able to unfold the question properly and therefore answer the question in the way that is needed. (Student interview, Anele)

9.2.2 Acquiring epistemic-context knower dispositions and values

Bernstein (2000) and Morais, Neves and Afonso (2005) argue that being able to produce legitimate texts requires not only having RC(ec) and RL(ec) but also epistemic-context knower dispositions appropriate for the context (see Figure 4.2 in theoretical chapter). The analysis of ISCM pedagogy indicates that through explicit instruction there is relatively strong framing of epistemic values and development of scientific knower dispositions. As a result, student comments in the interviews and evaluations indicate understanding of their own ontological development as scientists in a general way:

This course has taught me many things now I am able to think as scientist, write as one and speak scientifically. (Student written evaluation, 2012)

For some it is simply a matter of wearing laboratory coats and working in laboratories with appropriate equipment:

It's very nice, experiencing the lab coat! It makes you feel like a scientist. Ja, and using real apparatus for the experiments. (Student interview, Mandisa)

Despite attempts at explicit instruction in the classroom, the independent research project appears to play a crucial but more implicit role in developing appropriate epistemic knower dispositions and values. For example, the following student was showing an appreciation of the value of being objective and drawing on evidence from other studies:

Conducting this experiment was a challenge itself, reason being the fact that it was a scientific experiment and science has to have facts. One always has to relate one's assumptions or findings to what "existing science" says. This was not always easy to do because sometimes we just didn't know the explanations to what we had collected. (Student written reflection, Nokhanyo)

Another was using a reflective approach in order to develop a coherent, evidence-based explanation for the outcomes of their project:

It was difficult to put all this information together and explain as to why we were getting what we got. It was also hard to, for instance, look at the behaviour of the plants and explain in reference to our hypothesis. We addressed this challenge by going back to look for information on how different environmental conditions affects types of plants like petunia and types of soils (since we were focusing on soil texture) and of not forgetting to consider our hypothesis. (Student written reflection, Vela)

Others mentioned being curious and interested in science, which can promote learning and discovery:

One thing I learnt about Science during this experiment was that Science is not as difficult as people perceive it to be but it can be fun and interesting if only you do it out of commitment and curiosity because there is always something new in Science . . . and if you do it for marks, you might just give up and lose out a whole lot of information along the way. But when doing it out of interest you might end up discovering new things in Science that no Scientist ever saw before. (Student written reflection, Nokhanyo)

Likewise,

Science is about being inquisitive and wanting to know (Student written reflection, Nomsa)

Quite a few commented on getting unexpected results, with some linking this to the epistemic values of being critical and maintaining an open mind:

The research . . . taught me how to conduct an experiment as a scientist and learn more of how to be a critical thinker and deal with the surprises that one can come across through the research. (Student written reflection, Sanele)

Similarly,

Participating in this project taught me to think out the box and approach scientific questions and facts with an open mind. (Student written reflection, Nomgcobo)

And others linked unanticipated results to the need to be honest, something that was obviously not necessarily required at school:

In high school you would lie about your results but with university you have to provide evidence for your findings and conclusion . . . you have to honest when you are conducting and experiment. (Student written reflection, Ntatu)

In the same vein, another student noted:

In the experiment the one challenge which was the most prominent was the one which we got unexpected results. . . . In this case we had to think back to the lecture we had with X [a guest lecturer] who told us we must leave space to be surprised. That

strengthened us to put more faith in the research and the way we conducted it. If we manipulated the treatment [i.e. cheated] that would mean we are not running the experiment in fare way. In high school we would manipulate it . . . (Student written reflection, Nokhanyo)

The role of the independent research project in terms of building students' confidence and motivation in becoming scientists was also commented on by students:

When we were told we were going to do this research I did not think I can pull this off but the guidelines given to us were very helpful and I had doubt in myself but as time went by I noticed that this is a challenge that I going to overcome. That made me realise I can conduct an experiment in a scientific way. I had never thought that I would be able to . . . so this whole process has changed me as a science student and that is in a good way. (Student written reflection, Mncedisi)

The student comments show that whilst at one level we can be explicit in terms of articulating epistemic values to assist in producing legitimate texts, at another level the underpinning epistemic values such as being honest, critical, objective, precise, and accurate (amongst others) are not simply intellectual and epistemological in nature but also reflect ontological aspects of developing an embodied way of being. This supports the contention at the end of Chapter 7 in which I suggest we are in fact 'cultivating' rather than 'training' science knowers.

9.2.3 Producing legitimate epistemic-context text: Summary

The end-result of acquisition and possession of epistemic-context recognition and realisation rules as well as knower dispositions and values is the capacity to produce legitimate science texts as shaped by the evaluative criteria for the context. Epistemic knowledge, values and procedures all contribute to such texts and their acquisition is influenced primarily by the more explicit instructional discourse, although student interviews and reflections indicate implicit acquisition of knower dispositions also plays a role. Analysis indicates that students in ISCM appear to be relatively successful at RC(ec) and epistemic-context knower disposition acquisition, but are less successful at RL(ec) acquisition. Probing in student interviews indicates that underpinning constraints to RL(ec) can be linked to poor assessment tasks techniques, poor use of science norms and conventions and the high cognitive demand and abstract nature of the work. However, from the students' perspective, one of the main reasons for their exhibiting poor RL(ec) was linked to both their own levels and type of engagement with the course and course material. They were therefore indicating that the epistemologically-oriented aspects of the course, related to science, were being affected by the axiologically-oriented aspects of the course, related to their own learning processes. These axiologically-oriented aspects are described in the following section.

9.3 Acquiring social (learning-context) competence

9.3.1 Acquiring learning-context recognition and realisation rules

It was suggested in Chapter 3 that, in general, cultural conditioning in the working-class home and school environments in South Africa, as in the rest of the world, is different from that required in a higher education context. Although ISCM can guide in terms of developing required practices such as working autonomously, through explicit modelling and scaffolding of practices in the instructional discourse, uptake in this regard is very much linked to a student's dispositions and attitudes towards independent work and how they engage with necessary practices. Students' approaches to and engagement with the science learning context is therefore the focus of attention in this section of analysis. Since this aspect of their work is not assessed directly, insights could only be gained through student interviews.

Morais and Antunes (1994) use the concepts of recognition and realisation in relation to the regulative discourse in terms of learner behaviour (cooperation, participation and obedience) in primary school classrooms. The same approach is applied here, except the regulative discourse in ISCM primarily relates to the norms, values, attitudes and practices underpinning becoming science learners in an academic context. In order to distinguish this from epistemic-context recognition and realisation of the more narrow assessment context, this is referred to here as learning-context recognition (RC(lc)) and realisation (RL(lc)). This is in keeping with the terminology developed for learning-context social relations (SR(lc)).

The external language of description for RC(lc) and RL(lc) developed in Chapter 5 (see Table 5.8 (laminated)) relates primarily to learner autonomy. No recognition signifies no understanding of the need to work independently and be responsible for one's own knowledge. Recognition but incomplete realisation implies good understanding of the need to work independently and to be responsible for one's own knowledge, but this is not achieved consistently. Good realisation suggests independent work, responsibility for own knowledge and development of own understanding. In Bernstein's model, the end point of acquiring recognition and realisation is the production of legitimate text, based on the desired outcomes of the context. In this regard the legitimate 'text' of the broader learning context is therefore, as has been mentioned, being an autonomous science learner.

9.3.1.1 Autonomous science learner recognition

The norms and values underpinning student conduct in a university context are very different from those of a school context. In order to establish levels of recognition in this regard, students are required to articulate their understanding of these differences in a reflective exercise (usually associated with provision of feedback for a test) in the first semester of the ISCM

course. The paraphrased comments in Table 9.1 are from written texts of two student groups (2010 and 2012). The differences can be grouped into three main categories of expectations. In terms of *knowledge* expectations, whereas students recognise that at school the concepts are relatively easy, seldom applied or requiring judgment, and the pace and work load is relatively low, at university concepts are more difficult, often applied and requiring judgment and the work load and pace is greater. Students also recognise the shift in *responsibility*: at school teachers are responsible for students' knowledge acquisition and therefore work in ways that assist them in this regard, but at university students are responsible for their own knowledge development, which requires them to take notes, attend lectures, ask questions, learn to read cues and work independently. Thirdly, in terms of *learning*, students recognise the need to study to understand at university, which they articulate as requiring careful time management, rather than relying on the last-minute rote learning which served them well at school.

Table 9.1: Student perceptions of differences between school and university learning environments

Category	School	University
Knowledge	Lower expectations:	Higher expectations:
	Concepts quite easy	Many difficult concepts and ideas
	Work load and pace less	Work load high (all at the same time) and pace greater
	Rewarded for effort - even if not correct	Rewarded for knowing; need to be accurate and correct
	Knowledge not applied	Knowledge often applied
	Don't make your own judgment or do own research	Come up with own thoughts, questions, judgments and conclusions
Responsibility for knowledge	Teacher responsibility:	Student responsibility:
	Notes provided in class	Lecturer just talks
	Teacher writes on board for copying	Students write own lecture notes, pay attention, listen carefully, ask questions
	Teacher explicit on scope of test	Never sure what is important/everything is important
	Teacher does more work, learners less	Students do all the work
	Teacher ensures students understand	Students responsible for own understanding
	Many contact hours with teacher	Students have to work independently: compile own notes, consolidate outside of lectures, do own research if don't understand
	Teachers help learners manage time (frequent tests, less work, extra classes)	Students have to manage own time. No extra classes
	Students must be interactive with lecturers	
Learning	Learning to pass:	Learning to understand:
	Memorise everything	Study to understand (but must also memorise)
	Learn the day before for a test	Prepare more in advance for a test

If a student can articulate well the norms, values and practices of the learning context of the university (and ISCM), as mentioned in the previous paragraph, they would have good learning-context recognition (RC(lc)+). Like epistemic-context recognition (RC(ec)), many students in ISCM seem able to articulate these expectations and therefore exhibit fairly good learning-context recognition (RC(lc)+). One student commented on recognising they could no longer rely on authority (teacher) for knowledge, they would need to develop understanding at university themselves:

... because the lecturer is not like teaching you the school work where they tell you each and every detail but they give you the key notes then you have to go back to the library, or wherever you get the information and try to think what it's trying to tell you ... I think the lecturers are highlighting what you must [know], and everything that is said there is important, then you have to follow it ... I know that after the lecture I have to go and do the work again. (Student interview, Fezeka)

Another made a similar point:

This semester I did a bit of self-introspection and then I compared varsity with high school and I saw that I would do well in tests and exams in high school simply because it's a matter of me being used to being taught and explained things to. So I sort of feel like now, ok, there are lecturers here to help us, but I also have to know what is important. I have to be a level higher than high school in the way I think and in the way I study ... this self-introspection it was triggered by my [poor] performance. (Student interview, Nickelwa)

However, despite this recognition, many have not been able to realise appropriate ways of working and therefore exhibit poor learning-context realisation (RL(lc)-). This is elaborated on in the following section.

9.3.1.2 Autonomous science learner realisation

Student interviews indicated that constraints to attaining learning-context realisation in the ISCM course can be examined according to how students work in contact sessions in class, and how they work outside of class, and are discussed in turn below.

a) Contact sessions

Although autonomous learning is essentially about individual work that takes place outside of the contact sessions (lectures, tutorials and practicals), part of it relates to how students engage during contact sessions as well. Attendance in ISCM classes is generally very good, most likely a result of a combination of regular use of a class register (at least in semester one) and personal follow-up when attendance slippage is noted. Because tutorials and practicals require active student engagement and allow for opportunities for small group discussions in a mother tongue,

students seldom commented on difficulties in these contexts. However, indicating relatively poor learning-context realisation (RL(lc)-), a number of students indicated that working in lectures could be problematic in terms of note-taking:

I am having difficulty taking notes . . . because sometimes I don't get the point and the problem is you have to write while the lecturer is talking so sometimes they say things too fast. (Student interview, Sandla)

Similarly, another said:

Interviewer: Do you normally feel that you are confident in them [lectures]?

Student: No! Sometimes I get lost in the lecture . . . because she's talking about this and the next and moving on. (Student interview, Mandisa)

Others commented that asking questions in class was problematic:

I don't like asking questions . . . usually I have a whole lot of questions but I don't ask them because . . . I sometimes feel that they maybe be stupid and then people might laugh at me. (Student interview, Siyamthanda)

Some mentioned that working in English was challenging:

. . . in my school we were taught in English né, but we as learners we couldn't speak English. Like with our teachers we used to speak our mother tongue. Ja so it has been hard to come here and speak [English all the time] . . . it's getting better . . . but it's hard. (Student interview, Nobuntu)

Finally, quite a few made comments that indicated they were misreading cues:

. . . 'light-year', I didn't think it was very important. Yes, I heard it in lectures but I didn't think that it was essential. We didn't use it when we were measuring like in practicals or in class, or in tutorials that much. So I thought okay 'light-year' no they won't ask it. (Student interview, Khuselwa)

Likewise, another said:

. . . I didn't know [learn] this because when she [the lecturer] answered that question she didn't spend a lot of time with it, she just browsed through it. (Student interview, Anele)

Because of the repetitive nature of teaching in the school environment, when material is only addressed in a single context at university (lecture, practical or tutorial), and despite explicit instruction with regard to knowing and understanding *all* material covered in contact sessions, students do not grasp this, as indicated in the last two quotations. In another example of misreading cues, when a lecturer 'suggests' to students they should read a resource, students interpret this as a matter of choice, whereas the lecturer is in fact expecting them to have read and engaged with the material. Furthermore, different lecturers can have different expectations about depth of knowledge required in a particular situation, and may this not be clearly articulated to students.

b) Independent engagement outside of contact sessions

Most of the comments in terms of student difficulties in engaging with the course relate to learning beyond the class context. Not only is there often insufficient student engagement, but also the type of engagement with course material can be a constraint, indicating relatively poor learning-context realisation (RL(lc)-). Some students appreciate the need to **learn for understanding**:

I did prepare for lectures and the pracs, but sometimes . . . I just read for the sake of reading but not understanding exactly what's happening. (Student interview, Lulama)

. . . I think I just did it [learning] for marks not for knowledge. (Student interview, Khuselwa)

Others comment on how proper understanding helps in knowledge application in another context:

. . . we did lots of inductive reasoning examples so I learned these examples and not what is in the inductive reasoning. But now I think if I know what is inductive reasoning I would be able to come to with my own understanding and apply it on the questions. (Student interview, Khuselwa)

Some students recognise they simply need to **learn more** and better:

I need to develop a strategy that will enable me to *remember* facts easily (Self-reflection on test, Liwa)

There is also an appreciation that, in technical tasks such as calculations, practise is needed:

I understand the concept and method of calculating but I made a confusion in the test . . . I should *practise* more often to familiarise myself with the conversions. (Self-reflection on test, Mbuyiselo; my italics)

A number indicated they were **not working with resources** or feedback made available to them. One student indicated they were not using the model answers that had been provided:

Interviewer: Did you look at the model answers?

Student: I won't lie ma'am, I did not. (Student interview, Siyamthanda)

Another indicated that, at least initially, they did not engage with feedback provided on tutorials:

Interviewer: When you get a tutorial back, what do you normally do with that tut?

Student: At first I didn't look at the tuts again . . . (Student interview, Lulama)

Yet another simply chose to ignore a handout that was difficult to understand:

Interviewer: Did you engage with it [handout on sub-atomic particles]?

Student: Not really, because I just used my [lecture] notes. But I didn't really understand it [the handout], but I made sure that I at least will have to write something that's in my [lecture] notes, so I used my notes. (Student interview, Zola)

Inappropriate use of resources is also a contributing issue. Learning at school, particularly in their final year, revolves around use of past examination papers for guidance. This strategy served them well at school as particular sets of knowledge and processes are assessed every year. Unfortunately a slavish reliance by students on past papers as a guide can mislead in the university context as course material changes yearly and, in ISCM in particular, lecturers constantly look for new ways to test understanding. As one student commented on being misled by past examination papers:

When I was studying I always referred to the past exam papers . . . I was expecting the question in terms of previous papers. I think it was different now, the way the question popped out in the exam. (Student interview, Kanelo)

Likewise, another commented:

Interviewer: You battled to do the actual conversion so can you tell me why?

Student: Ja, I can say it was a matter of practice because as I have said I was using question papers and then I was kind of following the pattern in the question papers and then seeing that this kind of question never came out, I never minded it. So the last time I saw the question was in class and I never bothered practising . . . (Student interview, Nikelwa)

A contributing component to poor engagement is **misreading** the **context**, such as valuing of different learning-context interactions. The formal lectures are viewed by a number of students as the main source of learning material, with work done in practicals and tutorial sessions as less worthy of attention:

With the first test I didn't actually go through each and every prac. (Student interview, Mandisa)

The same trend for enrichment sessions was noted:

I did not really go through the enrichments when I was learning. (Student interview, Paki)

9.3.2 Acquiring autonomous science learner dispositions and values

Similar to working in an epistemic context, acquiring learning-context recognition and realisation rules requires possession of appropriate knower dispositions and values favourable to the context. In this regard student comments in the previous section have already indicated poor acquisition of dispositions and values related to being responsible for developing own understanding (by rote learning rather than for understanding) and working in self-regulated ways (by not using available resources, not learning the basics, not practising calculations, not using time well, etc.).

Explanations offered by students as to why they were having difficulty being autonomous learners can be grouped in two categories: aspects of lack of motivation as well as difficulty in changing entrenched study habits. In terms of **lack of motivation**, quite a few students commented on being disappointed or resentful about being in a separate foundation programme, and that this had an effect on attitude and motivation and therefore performance. As one student stated:

At first I was quite disappointed to be in the programme because I did not understand how or what exactly was it so I didn't take my tuts seriously. (Student interview, Paki)

Another commented on only starting to work after failing:

When I found out I would have to do foundation I was crushed. I thought it a waist of my time and could not understand how it is beneficial to me because I wanted to do the computer route . . . I only really started working when I was failing the tuts and the one test. (Student written reflection, Mzingisi)

Some students are very motivated and do work hard, but become despondent when they don't see expected results:

I always motivate myself: it's possible but if only I work hard. But sometimes I feel like ja, it's beyond me . . . the reason I'm saying I find it beyond me is because in some pre-tests, like I got marks that are like, are so low sometimes and then I will feel like, I feel 'off' . . . sometimes I don't feel like I was supposed to get those kind of marks. (Student interview, Kanelo)

In this regard, another student spoke about achieving poor results causing them to panic:

. . . because when you get into something that you are not used to you first find it difficult and then especially when it's in a higher level and then you start asking yourself different questions of how am I going to do this – sometimes you panic. (Student interview, Mandisa)

Many students recognise the need to develop a good work ethic, but some find the social conditions and freedom at university present them with problems:

I start watching episodes [of TV series], like just one before I study, but I just click for another and then when you look you see its three in the morning and it's too late [to study] . . . (Student interview, Mandisa)

The issue of **difficulty of changing entrenched study practices** was raised by a number of students, and in this regard they often commented on volume of work and, often linked to this, difficulty in managing time:

I did well at school, very well, I was often first or close in my class . . . my pattern was to study very hard just before tests – sometimes for hours . . . [but here at university] I always run out of time 'coz there are tests and assignments and homework and stuff and

it all takes too much time . . . I guess I should be working more consistently like every day like you tell us [laughs] . . . (Student interview, Mandisa)

. . . sometimes you get too much work because . . . we deal with HKE at the moment and we have to deal with academic literacy at the same time and so trying to balance them is kind of a mission sometimes so there are times when I feel very overwhelmed. (Student interview, Sandla)

In this regard some still only focused on specifically-allocated tasks, and did not work independently of their own volition:

The lesson that I learnt in the first semester, you need to study consistently. You don't wait until swot week, because last semester I was just doing homeworks and not putting much effort in, telling myself I'll study hard on swot week. But now I know like swot week isn't made for study hard, it's just to make sure you know everything. (Student interview, Kanelo)

I am used to being spoon fed so things are a little challenging. (Student written evaluation, 2012)

Although the **mentoring programme** that runs during the first semester is not a formal part of the ISCM course, students constantly acknowledge the important role it plays in their own personal development. For one student this related to the achieving of balance in their life:

The mentoring programme has helped me get a better understanding of what university is all about and now I can balance my social and academic life. (Student written evaluation, 2012)

For another it related more to helping develop appropriate academic behaviours and practices:

At first I thought the mentoring programme was useless, as time went by I saw how important it is. My mentor helped me a lot in preparations for my tests and in showing me ways to behave here at university. (Student written evaluation, 2012)

The affective component of mentoring is important for many. As one student commented:

The mentoring programme has assisted me to manage . . . you realise that you are not alone and that someone also cares about your education and wellbeing. The mentors have encouraged us and in a way shared their own experiences of studying in BScF. (Student written evaluation, 2012)

9.3.3 Producing legitimate learning-context (science learner) text: Summary

The legitimate 'text' that demonstrates acquisition of recognition, realisation and knower dispositions of an axiological, social nature in ISCM would be working as an autonomous science learner. In this regard, students in ISCM generally demonstrate relatively good recognition (RC(lc)+) through their good articulation of the learning context (high volumes of intellectually demanding material, working independently and being responsible for their own knowledge

and developing real understanding) and their need to work consistently, appropriately and independently in order to be successful. To exhibit good realisation (RL(lc)+) they need to work effectively both in the formal (contact) learning contexts as well as outside of them. Students indicate that, in class, issues around note-taking, asking questions, and use of the English language were raised most frequently as being problematic. In terms of their work outside of class, students mainly commented on aspects of engaging inappropriately in the course (not learning for understanding, not learning enough, not working with or poor use of resources and feedback, and misreading of cues), and possible reasons for this were lack of motivation and difficulty in changing deep-rooted study practices. Overall, the analysis indicates that learning-context realisation (RL(lc)) appears to be the most problematic aspect of their work in ISCM.

9.4 Good RC and RL at epistemic- and learning-context levels

The previous sections have mostly highlighted the difficulties some students are facing in ISCM. However, a number of students are doing well in their studies. The following is a series of comments made by one of the high achievers of 2014, who shows a high level of engagement, and her good marks suggest she has recognised and realised both the epistemic- and learning-context needs of the course:

I do consolidate with my work and make sure that I did understand it and that I did fill in the gaps and ask how did the prac go with the lesson that we had and why did we do the actual prac and why did you need to know this

For example the lesson that we just had on Monday, the solubility equilibrium, I was like . . . how does knowing calculating equilibrium help us, why do you actually need to do it and why do you need to know the solubility? . . . So I went online, because I didn't understand what we got in the lecture so I could get more information and it did help me because I was like I won't sleep if I don't understand this because I will fall behind if I didn't, so I fill in the gaps

Having Ms [X] really helped me because it improved my writing and unpacking what you need to know really helped because you actually need to read it twice or three times and the aim is to understand it and you have to unpack everything and be a critical thinker and that is a skill that I learnt from her.

Interestingly this student had already studied for one year at another tertiary level institution prior to coming to Rhodes University SESP:

Interviewer: Those are very useful questions that you are asking. Have you always studied like that?

Student: No! I learnt here. At [X Institution] I crammed everything and at the end of the year I was like, how am I gonna be a manager, I don't remember what I did? I was just

cramming all through. But I was getting the marks but I was just cramming! (Student interview, Anele)

The fact that she is now changing her approach may indicate ISCM is being influential in this regard, but probably also that changing practices and values is a process that takes time.

9.5 Discussion

This chapter is aimed at answering the third research question, which asks how students respond to ISCM educational practices. It uses Bernstein's (2000) conceptual model of student performance, that suggests student acquisition of recognition and realisation rules, as well as knower dispositions favourable to the context, is necessary for producing the required legitimate text or performance.

Empirical studies focusing on how pedagogy influences acquisition of recognition and realisation are usually done in a holistic way (see Iverson 2002; Morais, Neves and Afonso 2005; Jónsdóttir and Macdonald 2008). However, because of two distinct regulative underpinnings in ISCM, one with epistemological orientation and the other with an axiological orientation, analysis in this study was done at two separate levels. Legitimate performance at the epistemic-context level requires knowledge, literacies, practices and dispositions related to being a scientist, and at the learning-context level requires knowledge, practices and dispositions related to being an autonomous science learner.

This discussion therefore focuses on acquisition of the epistemic-context and learning-context levels of recognition rules and realisation rules and knower dispositions. A code clash as well as competing demands between codes (or code conflict) are suggested as a possible constraint to such acquisition.

9.5.1 Epistemic-context RC and RL and knower dispositions for being a scientist

In this study, acquiring coding orientations for the epistemic context refers specifically to students understanding the context of assessment questions or tasks. In other words, they need to recognise and realise both the scientific knowledge dimension (concepts, values, procedures and conventions: relating to semantic density) and the cognitive demand dimension (from low demand such as recall to high demand such as creation: relating to semantic gravity) of the assessment task. Much of the instructional discourse in ISCM focuses on these two dimensions. As mentioned in the previous two chapters, the strong framing of selection and sequencing of knowledge, evaluative criteria and feedback, and expected conduct and practices based on epistemic values, and the weaker framing in pacing and staff-student relations in ISCM should be promoting acquisition of epistemic-context recognition (RC(ec)) and realisation rules (RL(ec)).

In interviews, students generally could articulate well expectations relating to the knowledge and cognitive dimensions, exhibiting relatively good epistemic-context recognition (RC(ec)+). However, despite a visible pedagogy, they are less successful at providing appropriate answers to questions in high-stakes tests and examinations, exhibiting relatively poor epistemic-context realisation (RL(ec)-). Only in the assignments which have a draft feedback phase, or tutorials and practicals where staff and peer interaction is possible, do students show relatively good epistemic-context realisation (RL(ec)+), suggesting the need for continued support in this regard. The interviews indicated that poor epistemic-context realisation in tests and examinations could be partly attributed to poor implementation of science procedures and conventions, poor test and examination techniques, and a poor knowledge base that was linked to the high cognitive demand and abstract nature of the work, but was *primarily* attributed to poor realisation at the learning-context level in terms of being a science learner. In other words, students perceived poor learning-context realisation was the main inhibitor of success in ISCM assessment. This is discussed in the following section.

Based on data from this study, it is difficult to comment on the specific role of epistemic-context knower dispositions in promoting RC(ec) and RL(ec). However, reflections from the independent research project show that students recognise epistemic values that underpin science, such as the importance of being objective and relying on empirical evidence. They also comment on dispositions necessary for being a scientist, such as being curious, interested, critical, open-minded and honest. The independent research project, due to the way it is implemented with students as apprentice scientists, has proved to be an extremely useful learning-context intervention as it provides space for immersion in science practices that inculcate not only what scientists know and do, but also how they think, value and act (Ellery 2011). In other words, the tacit approach to dispositions and values in the independent research project helps engender the cultivated gaze of a scientist, a feel for science and a way of 'being' (Dall'Alba and Barnacle 2007), which I am arguing in this dissertation is an important part of enabling access. Gamble, although working in a context of craft work, too recognises the 'generative potential of tacit knowledge' through modelling behaviours and apprenticeship (2010, p138). I believe this would be a fruitful area of future research, particularly in the sciences.

9.5.2 Learning-context RC and RL and knower dispositions for being a science learner

In this study, learning-context recognition (RC(lc)) refers to student understanding of the ISCM and broader academic science learning context and learning-context realisation (RL(lc)) refers to being able to function as an autonomous science learner. In the chapter on pedagogy (Chapter 7), explicit instruction, active student engagement and modelling and scaffolding of

approaches and practices (stronger framing of student learning conduct expectations and selection and sequencing of knowledge) and a responsive approach to student needs and encouragement of interaction and criticality (weaker framing of pacing and staff–student relations) are considered aspects of ISCM pedagogy that support development of autonomous science learners.

As in epistemic-context recognition (RC(ec)), students generally exhibit good learning-context recognition (RC(lc)), as indicated in their good articulation of requirements to be successful in a university learning context in science. However, also as in epistemic-context realisation (RL(ec)), students are less able to translate their recognition into appropriate action and therefore exhibit relatively poor learning-context realisation (RL(lc)). Knowing what is required in terms of study habits but not translating it into reality is mentioned in other studies as well, and aspects such as perceived relevance, volume of work and cognitive load are mentioned as possible influences (see van Etten, Freebern and Pressley 1997; Adendorff and Lutz 2009). The interviews in this study indicate that practical difficulties in class, as well as insufficient and inappropriate engagement with course material outside of class, were major problem areas. In this regard, rote learning instead of developing understanding and lack of or inappropriate use of resources were mentioned. So too was misreading of cues, which often have a cultural base. Students often mentioned knower dispositions and recognised the need to be motivated, confident, responsible and independent to be successful. They also commented on the difficulty in changing entrenched study habits, which is the focus of discussion in the following section.

Because student acquisition of epistemic-context coding orientations appears to be dependent upon acquisition of axiological learning-context coding orientations, we can say that they exist in hierarchy. This indicates that, although a focus on epistemic-context level work is necessary in a science course as this is the level at which the evaluative criteria of the epistemic–pedagogic device operate (i.e. assessment is primarily epistemologically-based), a focus on axiological, learning-context level work is crucial for student access and success. Whilst this section has mentioned possible reasons for poor learning-context realisation (RL(lc)-), these are mostly, in critical realism terms, operating at the level of the empirical and actual as they are based on student perceptions and experiences of the course. However, these perceptions point to a possible code clash, and competing demands between two different codes, which indicates the influence of underpinning mechanisms that, in critical realism terms, are operating at the level of the real. These are discussed below.

9.5.3 Code clash and competing demands: Constraints on learning-context realisation

A code clash is defined as a disparity between the code characterising how one thinks and acts and the code that underpins the basis for success in the current context (Lamont and Maton

2008). In Chapter 7 it was suggested that both an epistemologically-oriented knowledge code and an axiologically-oriented learning-context knower code are being legitimated in ISCM. I suggest that there is a code clash between the students' learning-context knower code orientations that they bring from school and those required in ISCM.

As already mentioned, students perceive that the school learning context is one in which the teacher is responsible for knowledge and that learning itself is based on memorisation rather than on understanding (Table 9.1). Similar observations are made in an article based on students from similar backgrounds to those in ISCM, where school classrooms are characterised by, amongst other things, a teacher-centred and spoon-feeding culture, oral communication, little careful text work or analysis of concepts, poor academic language proficiency and a slow pace of working, and rote and instrumental learning (Pym and Kapp 2011, pp5–6). Using the definition of learning-context social relations developed in this study, this type of school learning environment would be characterised as weaker learning-context social relations (SR(lc)-); essentially representing a relativist code for the learning context. As such, many ISCM students appear to be using their school-based learning-context relativist code, in which they are dependent upon others (the teacher) for their knowledge development, and are not sufficiently realising the learning-context knower code required of ISCM, in which they are expected to be self-regulated, critical learners. A number of other studies have shown how prior socialisation practices can make students less predisposed towards acquiring the coding orientations of a new context (Morais and Neves 2001; Lubienski 2004; Rose 2004; Hoadley 2007; Chen 2010).

I contend that this learning-context code clash is aggravated by ambivalent messages within ISCM itself. Firstly, both an epistemic-context knowledge code and a learning-context knower code are legitimated and, in essence, represent competing demands that give rise to code conflict. Students who choose science as a field of study are generally disposed towards a knowledge code which requires working with concrete facts and proceduralised methods, and will likely focus their efforts on epistemic relations rather than on social relations. Furthermore, since epistemic aspects in ISCM are assessed directly and social aspects associated with learner development are not, epistemic demands will naturally take precedence despite what appears to be an explicit pedagogic approach related to learning-context requirements. I therefore suggest students are focusing on the epistemic-context knowledge code and not recognising sufficiently the need to also focus on the learning-context knower code.

Secondly, whilst on the one hand staff in ISCM offer huge amounts of support to students in the transition, which in essence is a similar approach to that of a school environment and is therefore validating weaker learning-context social relations (giving rise to a learning-context

relativist code), on the other hand ISCM is also attempting to engender a self-regulated science learner and is validating stronger learning-context social relations (giving rise to a learning-context knower code). Whilst I am aware of this tension between providing support and expecting independence in class, it is one I have not yet been able to resolve satisfactorily. This tension is recognised too by students, as indicated by their comments in interviews:

You shouldn't be this helpful to students because some of us really take, I don't want to lie, I did take advantage of it. (Student interview, Siyamthanda)

. . . we were studying but we knew oh X [ISCM lecturer] is there. She's going to explain things I don't have to go read it up, you know [laughs]. (Student interview, Nomgcobo)

This code clash is further exacerbated by the fact that, although ISCM students did not achieve sufficient matriculation points to enter mainstream directly, most were highly successful and amongst their school's top achievers. They achieved this success at school primarily through rote learning and seldom through developing good conceptual understanding, and were affirmed and rewarded for these efforts. Fundamentally changing attitudes, values and practices that have shaped who they are and have earned them previous success must be especially difficult. As one student comments:

. . . something that I would say that I'm struggling with a little bit, is working, not working the way I used to work, like adapting to the way we work here. It's something that I'm still working on . . . the way of understanding the work and answering questions. (Student interview, Zola)

The overall result of this likely code clash is that students are exhibiting poor acquisition of realisation rules of the ISCM learning context, without which they will not have attained epistemological access. Developing such realisation is a social change process, and the difficulty of making such changes is reflected in student narratives in this chapter. The same narratives are reflected in the following chapter, which examines student response to science courses once they move into mainstream.

Chapter 10: Student response to first year mainstream science courses

10.1 Introduction

The previous chapter examined how BScF1 (SESP students in first year of study) students interpret and respond to ISCM educational practices. This chapter examines BScF2 (ex-SESP students doing mainstream courses in their second year of study) students' response to educational practices of four mainstream first-year courses and is aimed at contributing to answering the final research question, which asks 'In what way do ISCM and mainstream educational practices enable or constrain epistemological access?'

For each of the four courses, Cell Biology 101, Chemistry 101, Earth Sciences 101 and Physics 101, the first part of this chapter provides a brief description of course structure and content and a cognitive process level analysis of assessment practices. Student response to these courses is analysed using pass rate and student perception data, which, in critical realism terms, are at the level of the actual and empirical respectively. However, analysis of constraints and enablements of student acquisition of recognition and realisation rules, in the second part of the chapter, is at the level of the real. The discussion focuses on measures of 'success' based on student performance and on qualitative experiences of BScF2 students that enable access. It also considers practices and conditions that serve to constrain or exclude, and links this to the inequitable outcomes in mainstream courses based on race and/or class. The final call is for better curriculum articulation across the entire four-year degree programme.

10.2 Four mainstream courses: Overall structure, content and assessment practices

One of the main purposes of ISCM is to enable access and success in mainstream courses in the physical, chemical, life and earth sciences (Curriculum Development Report 2007). Excluded here are mathematical and computer science courses for which ISCM does not specifically prepare students as the other two courses in the SESP serve this function. What follows is a very brief description of four of the main (based on BScF2 student numbers) first-semester, first-year courses (Cell Biology 101, Chemistry 101, Earth Sciences 101 and Physics 101) and a cognitive process level analysis of their assessment practices. Data are from 2014 course outlines and assessment task documents (both test- and examination-papers and student scripts) as well as from staff interviews (course coordinators and augmenting educational specialists).

At this point it is worth mentioning relatively recent developments in terms of offering learning support for students in mainstream courses. Traditionally such academic development (AD)

support was provided in some courses by post-graduate students through additional tutorial sessions in which attendance was voluntary¹. Since 2013 some mainstream courses have been designated as 'augmenting courses' in a project funded primarily by the Teaching Development Grant. Augmenting courses are generally 'gateway' courses, or required courses in a degree programme which experiences high failure rates. Students enrolled on an augmenting course attend the regular course, which is supplemented by additional, small-group, interactive sessions taught by lecturer-level educational specialists, thereby providing support for learning in the regular course. This represents a fundamental shift away from the previous AD model, which had a somewhat ad hoc focus on content, to one that attempts to provide broader and more cohesive learning and literacies support within a disciplinary context (Staff interviews, RA14 and RA15). Student attendance at additional tutorial sessions, which is regulated by 'due performance' (DP) requirements, is based on assessment performance early in the course. However, all BScF2 students are required to attend. Designated augmenting courses have been phased in, starting with Cell Biology in 2013, Earth Sciences in 2014 and Chemistry in 2015².

10.2.1 Cell Biology 101

Cell Biology 101 is compulsory for students intending to study Botany, Zoology, Entomology and Pharmacy, and is a recommended course for a number of other disciplines. The Zoology and Botany departments are responsible for coordinating the course and four lecturing staff from these two departments and the department of Biochemistry, Microbiology and Biotechnology provide academic input (Table 10.1). It has four lectures and one practical per week, with the fifth lecturing period being used for tests or lectures when days are lost to public holidays. Because of the large class size (n= 361 in 2014) and limited facilities and staff capacity the same practical is run three times a week. Disciplinary principled and procedural knowledge (DK) dominate teaching topics, which relate to aspects of cell theory, structure and function of the cytoskeleton, DNA and protein synthesis, cell division, Mendelian genetics and inheritance, respiration, and photosynthesis. One week is spent on scientific literacies procedural knowledge (SLK), when academic writing is addressed both in lectures and the practical session. RUConnected is used extensively by some staff members, mainly as an electronic notice board

¹ This was referred to as an Academic Development Programme (ADP) and was a hangover from the old academic support programme (ASP) days of the 1990s when AD was 'decentralised'. These posts are now used by some departments as sinecures for post-graduate students with no funding (pers. comm. Prof Boughey (Acting DVC, RU), November 2015).

² Prior to the 'augmenting course' initiative Chemistry had a well-established and structured system of AD support provided by a full-time lecturer-level practitioner in which students could attend additional tutorials throughout the year. If a student failed Chemistry 101 they repeated it in the second semester (called Chemistry 1R). This system remains in place and runs alongside the augmenting initiative in Chemistry.

and for posting lecture handouts and other resources such as YouTube and other video clips and voluntary 'homework'.

Table 10.1: Summary of main aspects of four mainstream courses in 2014

	Cell Biology 101	Chemistry 101	Earth Sciences 101	Physics 101
Departments responsible	Zoology and Entomology, and Botany	Chemistry	Geography and Geology	Physics
Staff involved	1 senior lecturer, 3 lecturers	2 professors, 2 senior lecturers	2 professors	2 lecturers
Course structure: weekly sessions	4 lectures (test in 5 th period) 1 practical	4 lectures, 1 practical 1 tutorial	4 lectures, 1 practical 1 tutorial/test	4 lectures (or test), 1 practical 1 tutorial
Main topics	Cell theory, structure and function of cytoskeleton, DNA and protein synthesis, cell division, Mendelian genetics and inheritance, respiration, photosynthesis, academic writing	Symbols and chemical numeracy, nuclear chemistry, atomic structure, chemical equilibrium, analytical chemistry, phases, physical equilibrium, colligative properties, organic chemistry	Earth systems, SA weather, SA climate, climate change, rock weathering, pedogenesis, erosion, drainage basins and rivers, landscapes, internal earth structure, earthquakes, minerals, rocks, magnetism, plate tectonics, geological time, origins of life, natural resources, mapwork, rock identification, plagiarism, locating sources, essay writing	Oscillations and waves, electric fields, magnetic fields, modern Physics, electronic practicals
Weekly academic support for BScF2 students	2 compulsory tutorials with augmenting course lecturer	2 compulsory tutorials with augmenting course lecturer	2 compulsory tutorials with augmenting course lecturer	1/2 optional tutorials with a post-graduate student
Textbook	1 prescribed	1 prescribed	2 prescribed (can use either)	1 prescribed
Assessment and mark breakdown	All pracs 15% 2 class tests 15% 2 prac tests 30% 1 theory exam 40%	3 MCQ tests 5% 1 class test 5% 4 prac tests 20% 1 theory exam 70%	All pracs 16.7% All tuts (+essay) 16.7% 4 tests 16.7% 1 theory exam 30% 1 prac exam 20%	All pracs 4% 1 prac report 3% 4 tests 26% 1 theory exam 45% 1 prac exam 22%

MCQ=multiple-choice questions; prac=practical; exam=examination

Assessment practices in 2014 were based on practicals (15% of total mark; Table 10.1), practical tests which took the place of the practical examination from previous years (30%), two class tests (15% each) and a theory examination (40%). An analysis of mark allocation according to cognitive process levels was completed for the first test, any major assignment, and the theory and practical examinations (or examination equivalents) for each of the courses, including Cell Biology (Table 10.2). It is acknowledged that this is not a full picture of assessment procedures in each of the courses, but it does provide some indication of trends. In

Cell Biology recall-type questions occurred in all assessments examined, but formed the largest proportion (42%) in the first test. Comprehension-type questions were most common, forming 87% of the final examination. Only in the practical test were application-type questions asked (30%).

Table 10.2: Percentage marks allocated to six cognitive process levels in selected assessment tasks of four mainstream courses in 2014

Cognitive process level	Cell Biology			Chemistry			Earth Sciences			Physics			
	Test 1	Test Pr*	Exm* Th*	Test 1	Test Pr	Exm Th	Test 1	Ess*	Exm Th	Exm Pr	Test 1	Exm Th	Exm Pr
Creation								100					
Evaluation											13	3	8
Analysis								✓			15	17	
Application		30		20		19	33	✓	17	33	73	81	75
Comprehension	58	53	87	77	100	79	29	✓	71	67			17
Recall	42	18	13	3		2	38		12				

*Th = Theory; Pr = Practical; Exm=examination; Ess=Essay

10.2.2 Chemistry 101

The Chemistry 101 course is a prerequisite for many courses in the Science Faculty. It is taught by four senior-level staff from the Chemistry Department (Table 10.1) in four lectures, one tutorial and one practical a week. The topics relate to basic chemical literacy and numeracy, nuclear chemistry, atomic structure, chemical equilibrium, analytical chemistry, phases, physical equilibrium, colligative properties, and basic organic chemistry; all disciplinary principled and procedural knowledge (DK). The practicals and tutorials serve to consolidate lecture content and provide practice in calculations. Practical are run three times a week to accommodate all students (n=379 in 2014). RUCConnected is used by all lecturers for posting lecture handouts, and some use it to provide additional resources, solutions to tutorials and notices.

In terms of assessment, three multiple-choice tests as well as a larger test made up 10% of the final mark (Table 10.1), four practical tests accounted for 20% and the theory examination 70% of the final mark in 2014. Straight recall-type questions were virtually absent, comprehension questions dominated, and application questions made up 20% or less of marks in the main assessment tasks that were analysed (Table 10.2).

10.2.3 Earth Sciences 101

Earth Sciences 101 is a prerequisite for students doing Geology, Geography and Environmental Science majors. It is taught by two professors, one each from the departments of Geology and

Geography (Table 10.1). The lecture topics include aspects of weather, climate, pedogenesis, landscape structure and processes, internal earth structure and processes, minerals, rocks, magnetism, plate tectonics, geological time, origins of life and natural resources; mainly disciplinary principled knowledge (DK).

In addition to the four lectures and one practical per week, students attend a weekly tutorial, run by senior post-graduate students or academic staff, that relates to aspects of scientific literacies procedural knowledge (SLK; essay writing, plagiarism, providing feedback) and disciplinary knowledge (DK; current earth science topics, essay assignment topic). Because of class size (n=190 in 2014), practicals are run three times a week and are used for developing disciplinary procedural knowledge (DK) of mapwork skills in the first term and understanding broader geological processes and rock identification in the second term. RUConnected is used extensively for posting of information, lecture handouts, practice quizzes, and resources, and two of the four class tests are completed online.

The assessment tasks in Earth Sciences in 2014 included practicals (16.7% of total marks), tutorials (including a 1000-word essay; 16.7%), four class tests (16.7%), one theory examination (30%) and one practical examination (30%; Table 10.1). The cognitive process level mark breakdown indicates that lower cognitive level recall-, comprehension- and application-type questions were common in the tests and examinations, but the essay assignment required high cognitive level working (Table 10.2).

10.2.4 Physics 101

Physics 101, taught by the two lecturers in the Physics Department (Table 10.1), is not a prerequisite for any other courses and in 2014 there were 36 students in the class. The lecture topics are based on principled disciplinary knowledge (DK) of oscillations and waves, electric fields, magnetic fields, and modern Physics, and all practicals draw on disciplinary principled and procedural knowledge (DK) of electronics. There are four lectures and one practical and one tutorial per week, with tutorials being facilitated by staff members in small groups of 10 or less. These are used primarily for students to practice solving Physics problems and to ask questions. Academic development support is provided by senior undergraduate or post-graduate students and attendance is voluntary. RUConnected is used for solutions to tutorials and tests and the occasional link to relevant blogs and YouTube sites.

In 2014 the mark breakdown for assessment tasks was practicals (4%), a practical report (3%), four tests (26%), a theory examination (45%) and a practical examination (22%; Table 10.1). Unlike the other courses discussed thus far, the Physics cognitive process level breakdown of marks for assessment tasks indicated that lower level comprehension questions only formed a

small part of some assessment tasks (17% in examination), and that application-type questions predominated in all assessment tasks (Table 10.2). Analysis- and evaluation-type questions were also relatively common (for example 15% and 13% respectively in test 1).

10.3 Student response to educational practices in four mainstream courses

This section examines how BScF2 students responded to educational practices in each of the four courses in 2014. It first provides an account of student performance based on marks attained for the 2014 group of students and for a broader group of students over a longer time period. Secondly, it examines student experiences drawing on student interview data.

10.3.1 Performance based on marks

Marks attained are one of the main measures used in higher education to gauge student performance. These are examined in turn for each of the four mainstream courses.

Fifteen of the 361 students registered for Cell Biology 101 in 2014 were BScF2 students (Table 10.3). Of these 15 students, 11 passed (73% compared with 87% of direct-entry students) and four failed, with the mean percentage mark attained by the BScF2 group being 55%. Data of student performance in Cell Biology over a long period (2005–2014) revealed that on average BScF2 students perform as well as African direct-entry students³ (percentage pass 69% for BScF2 compared with 68% for direct-entry Africans; Table 10.4). This is on a par with percentage pass of direct-entry Indians (69%) but less than that of coloureds (76%) and considerably less than that of whites (87%).

Table 10.3: Performance based on marks of BScF2 students in four first-year mainstream courses in 2014 (Data from Data Management Unit, Rhodes University, February 2015)

	Cell Biology 101		Chemistry 101		Earth Sciences 101		Physics 101	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Students	15	4*	20	5*	7	3*	4	8*
Passed	11	73#	15	75#	4	57#	3	75#
Failed	4	27#	5	25#	3	43#	1	25#
Mean mark		55		52		52		53

*percent of whole class; #percent of BScF2 students.

³ Comparisons of BScF2 students with direct-entry African students are made here on the assumption that the majority will come from similar socio-economic backgrounds. It is, however, acknowledged that this may not be the case for all.

Table 10.4: Performance based on marks of BScF2 and direct-entry BSc1 students (by race) in four first-year mainstream courses for the period 2005–2014 (Data from Data Management Unit, Rhodes University, February 2015)

	Cell Biology 101				Chemistry 101				Earth Sciences 101				Physics 101			
	BScF2		BSc1*		BScF2		BSc1*		BScF2		BSc1*		BScF2		BSc1*	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
African	102	69	318	68	159	78	419	76	72	71	249	62	14	71	106	76
Coloured	1	100	21	76	1	100	22	86	0	0	7	57	0	0	5	80
Indian	0	0	32	69	0	0	38	74	0	0	19	84	0	0	13	77
White	0	0	696	87	0	0	811	83	0	0	531	91	0	0	192	94

N=number; *direct-entry mainstream students

Of the 379 students in Chemistry 101 in 2014, 20 were BScF2 students (Table 10.3). Seventy-five percent of BScF2 students passed Chemistry with the mean mark being 52%. Longer-term data indicate that the percentage pass for BScF2 students is on average just slightly better than direct-entry African students (78% BScF2 and 76% respectively, Table 10.4). This is higher than the percentage pass for Indians (74%) but lower than the percentage pass for coloureds (86%) and whites (83%) during this period.

In 2014 there were 190 students in the Earth Sciences 101 course, of whom seven were BScF2 students (Table 10.3). Only four (57%) of the seven passed Earth Sciences in 2014, compared with 74% of all direct-entry mainstream students. The mean mark for the BScF2 group was only 52%. Longer term data (2005–2014; Table 10.4) shows better performance by the BScF2 students (71% pass rate) compared with their counterparts (direct-entry African students, 62% pass), but white students still performed markedly better than all other groups (91% pass rate), and Indians also did well (84% pass rate).

Of the 36 students doing Physics 101 in 2014, four were BScF2 students, of whom three (75%) passed and the mean mark was 53% (Table 10.3). The 2005–2014 data (Table 10.4) indicates that the BScF2 group did most poorly (71% pass rate) compared with direct-entry Africans (76%), Indians (77%), coloureds (80%) and whites (94%).

In summary, in 2014 between 73 and 75% of BScF2 students passed Cell Biology, Chemistry and Physics, but only 57% passed Earth Sciences. Whilst the 2014 data for the former three courses were within 3% of the longer-term pass percentages, the 2014 performance of Earth Sciences students was 14% lower than the longer-term pass percentage, which represents a relatively large difference. Student interviews in this regard indicate the main constraints in 2014 in Earth Sciences were a heavy work load and fast pace of many lectures.

The percentage pass data from 2005–2014 show that, despite lower entry points, the BScF2 students, except in Physics, performed better than their direct-entry African peers. However, *all* African students (BScF2 and direct-entry) performed substantially worse than their white peers in all four courses. The causes and implications of these trends are considered in the discussion⁴.

10.3.2 Student experiences

A recognition and realisation analysis based on test scripts and follow-up interviews showed similar trends to those in the previous chapter: relatively good recognition at both epistemic- and learning-context levels, but relatively poor realisation at both levels. To avoid a repetitious narrative I have not presented these data here. However, because the interviews revealed that aspects of pedagogic practices and course conditions, different to those in ISCM, were shaping acquisition of epistemic- and learning-context realisation rules in mainstream, I have presented these data instead.

10.3.2.1 Pedagogic practices and conditions constraining realisation in mainstream

Student interviews provided insight into the pedagogic practices and conditions that shape student acquisition of coding orientations (i.e. of epistemic- and learning-context recognition and realisation rules, but here the focus is particularly on realisation) of the four mainstream courses. Five central issues influencing acquisition emerged from the data: (a) high volume, pace and work load, (b) high cognitive demand, (c) aspects of assessment practices, (d) unresponsive staff, and (e) large class size. These constraints are considered in turn.

Firstly, representing stronger framing (+F) of pacing, the **high volumes** and **pace of work**, especially when the material was new, caused problems for many students. Students, for example, commented on the volume of work in individual courses:

It is a lot of work, you feel like there is too much work . . . over loading of information actually because sometimes you feel like you can't read all this work in this specific given time. (Student interview, Siphon)

Similarly,

. . . overall the amount of volume for Cell Biology is HUGE. (Student interview, Zanele)

Other comments related to the pace of work:

He flashes these beautiful slides for one second and you trying to write something down and then it's gone already. (Student interview, Noxolo)

⁴ Percentage marks for African students in all faculties of RU cluster in the early- to mid-50s, which is indicative of poor access to what is being legitimated (pers. comm. Prof Boughey (Acting DVC, RU) October 2015).

In the same vein, another student noted:

Yoh [he] was moving very fast! Because when I was doing Foundation what they teach you is to listen, understand and apply. So what you are trying to do . . . you are trying to listen to what they are saying, make sense of it and write it at the same time so that you can remember. So at the speed that he was teaching at . . . you couldn't do all this. (Student interview, Alakhe)

A common experience, however, related to the need to engage with so many courses at the same time. One student, for example, commented that:

. . . in Physics after two weeks we always have a test. It's usually on Friday, so I have to push [learn] a lot from Monday on Physics. Trying to minimise my time to other subjects such as Maths and Com Sci, maybe I take just one hour for Maths, or even not do Com Sci some days . . . I work from 6 [pm] up to, up to 2 [am] everyday but I'm still not getting it. (Student interview, Andile)

This was especially so when tests and assignments were scheduled close together:

This is the day I had two tests on the same day, Earth Sciences and Cell Bio . . . so I decided to spend too much of my time on Earth Science. Now when I had to study Cell Bio . . . actually I didn't finish . . . I got to a point when I ran out of time. (Student interview, Siphon)

Secondly, the issues of high volume and rapid pace were exacerbated when the course was of **high cognitive demand**, a reflection of stronger framing (+F) of selection of knowledge.

Comments from two students in this regard:

It [Physics] is difficult because you have to really think . . . you have to apply your knowledge in real life situations . . . we have to read a chapter twice in order to understand, whereas in Maths you can cover two chapters in maybe an hour, and understand. (Student interview, Bongani)

. . . it's *really* challenging work. It's like, like *really* hard to understand . . . (Student interview, Andile; original emphasis)

Thirdly, constraints to acquiring epistemic-context realisation were associated with various aspects of high stakes test and examination **assessment tasks**. The first key issue related to tight time allocation (+F of pacing):

When you are writing [the test in Earth Sciences] on a computer and it is counting down you start panicking . . . even though it [time] is enough, but it did panic me. (Student interview, Alakhe)

This tight time was often linked to multiple-choice questions (MCQs):

Especially in multiple-choice [in Physics] . . . I have to do a lot of thinking of which the time is very little. I'm slow in nature . . . I do things slowly. (Student interview, Andile)

Another aspect of assessment was being unsure of knowing requirements (-F of evaluative criteria). As one student commented:

In the tests we get 3 mark questions but in the exam there were more bigger questions for 15 marks. The questions were more difficult . . . I also don't think I knew what I should write, like was it the whole explanation or just some of it . . . (Student interview, Babalwa)

Likewise, another said:

For me, the biggest factor that caused me to bomb out in the exam was not knowing the amount of detail I had to go into answering the questions . . . I had so much information and I just didn't know how to structure it in the exam and express and let the marker understand the point I'm trying to make. (Student interview, Zanele)

Fourthly, in each course **poor relations** with at least **one lecturer** were mentioned by the majority of students. By not being cognisant of the needs of certain groups of students a lecturer's engagement with students can easily serve to exclude. The rapid pace of lecturing has been mentioned earlier, but another aspect was poor rapport of lecturer with the students, which manifests as stronger framing (+F) of hierarchical staff-student relations:

He doesn't motivate us . . . he keeps on telling us that he got his Degree and Master's and all this stuff so it's up to us. (Student interview, Nomgcobo)

Linked to poor rapport was the apparent lack of understanding, or care, of the needs of student in the classroom:

He didn't answer questions, he would refer you to his office. Just come to my office . . . what if some [other] people in the class also didn't understand the same things, so he doesn't explain to the whole class, just that one person who goes to his office but like, we don't have time to visit him all the time. (Student interview, Gugulethu)

Poor logistical arrangements, representing a weaker framing (-F) of staff-student relations in relation to commitment to course rules, were a frustration for some:

He's been saying every week they [lecture handouts] are gonna be posted up and I came to check today, I got an email saying they are posted but I didn't see them on RUConnected. Every time he does this. (Student interview, Ntлонipho)

This was particularly trying for those who felt it was affecting their work, such as not being able to prepare in advance:

He only says he uploads them [notes] at the end of the week, which is a bit difficult as well, 'cause if you have the slides before you can actually prepare . . . before you go to class so you get some background information and you're not as lost. (Student interview, Nofanele)

Lastly, virtually all students interviewed commented on being intimidated, at least initially, by the **large class size** in Cell Biology, Chemistry and Earth Sciences. This could relate to noise and disruptions:

It's huge [the class] . . . sometimes you just have to deal with people talking during a lecture. (Student interview, Ntlonipho)

It also could relate to being daunted by the apparent ease at which peers were asking questions:

I first felt very intimidated by everyone . . . everyone asking their questions, everyone answering nice questions and so on. (Student interview, Noxolo)

Very few ever felt confident enough to ask questions in class, but would instead ask the lecturer questions immediately after the lecture or in their office. However, for those that did ask questions, it was not a straightforward or easy process:

I have to breathe three times before I can raise my hand and it is a bit overwhelming in that sense. (Student interview, Ndileka)

The consequences of these constraints are considered further in the discussion in terms of their potential to exclude certain groups of students more than others.

10.3.2.2 Pedagogic practices and conditions enabling realisation in mainstream

The above section outlined pedagogic practices and structural conditions that may constrain acquisition of realisation rules in mainstream courses, and this section outlines those that enable. In this regard, (a) use of practicals and tutorials, (b) provision of augmenting course tutorials, (c) provision of learning resources, (d) responsive lecturing staff, and (e) prior engagement with topic are all mentioned as being useful. With the exception of prior engagement with topic, all are aspects of pedagogy that have potential for change in current courses.

Although some comments were made about long and difficult practicals, a number of students viewed **practicals** and **tutorials** as useful in their learning. In a sense these represent weaker framing of pacing (-F) as they provide additional time to acquire insights. Two student comments in this regard were:

The [Chemistry] practicals are not so long or difficult . . . they help as they are very related to what we do in lectures. (Student interview, Noxolo)

They [Physics tutorials] really really help. They are so helpful because then you have a chance to ask questions and discuss other stuff in class. (Student interview, Anathi)

The **tutorial** component of the **augmenting course** was similarly useful in developing understanding around content knowledge and represents weaker framing of pacing (-F) by providing additional time on tasks:

Ms X explains things that the lecturer hasn't necessarily explained well in class . . . she knows which part to tackle as opposed to the lecturer who just gives you everything . . . normally in the end we don't have any questions because she has explained everything. (Student interview, Ndileka)

The augmenting course tutorials also provided space for asking questions and active participation:

If you are like me, I'm very shy so I can't ask the questions during the lecture, I'm very, very shy so I keep my questions for Mr X [of the augmenting course tutorials]. (Student interview, Siyabulela)

Similar to the observation made in ISCM that high levels of support militated against students developing independence, a few students mentioned this with respect to the augmenting course tutorials:

If you don't go back over the stuff by yourself you can attend ADP [augmenting course tutorials] and they will work for you. It means you can be lazy. (Student interview, Gugulethu)

Students found the **resources** (lecture handouts, quizzes, diagrams, homework tasks, YouTube videos) made available by lecturers through RUConnected extremely useful in terms of both developing understanding on the topic and also providing an indication of the type and level of questions that may be asked in assessment tasks. This represents stronger framing of both knowledge selection (+F) as well as of evaluative criteria (+F), both of which should support student access:

So I do go and do the quizzes so that I can get to understand how the questions be constructed and get to understand what does the lecturer like the most because I can get to think like they think. (Student interview, Alakhe)

For some, lecture (PowerPoint) handouts helped note-taking in class:

He actually had notes provided for us, like slides and stuff so we could just look at the slides and bring them to class and just fill in the missing things on the slides. So that sort of made it easier in a way. (Student interview, Ntlonipho)

The staff-student relations, mentioned as a constraint in the previous section, were also mentioned as an enablement, particularly for those **lecturers** who are **responsive** to student needs during lectures through repeating concepts and adjusting pace (-F for pacing):

. . . the first lecturer was okay. He went quite slowly, he made sure that everyone was on the same page. He would explain everything in detail, he took his time to explain everything, sort of like we were in Foundation. He was making us comfortable, welcoming us into the mainstream course. It helped us adjust. (Student interview, Thandiswa)

Students also commented on how useful it was when lecturers provided guidance or cues on what was expected (+F for assessment expectations). Two student comments in this regard are:

He gives us signposts that, okay, it's very important to know this diagram . . . sometimes he says this is very important and sometimes he just goes over and over the concept. (Student interview, Noxolo)

Dr X, even like in the first lecture, he would specify, okay this is a question you will most likely find in an exam or test. He did that most of the time. (Student interview, Ntlonipho)

One aspect not under the control of mainstream courses but mentioned by many students related to **prior engagement with a topic**. If a student had encountered a topic before, either at school or in BScF1, they found it much easier to engage with and understand:

It did actually help quite a lot [having done basic Chemistry concepts in ISCM] because if I had not been in the Foundation programme I think I would have had to learn twice as hard as I am now because it would all be new and I'd still have to adjust to the new environment so it would be quite difficult. (Student interview, Thandiswa)

10.3.2.3 Poor acquisition of learning-context realisation rules

Because acquisition of epistemic-context and learning-context rules exist in hierarchy, the learning-context rules, which are key, are considered specifically here. Students who were performing poorly in assessment tasks in the courses at the time of the interviews commented on their own inappropriate work attitudes and practices, which suggests they had good learning-context recognition (RC(lc)+), but poor realisation RL(lc)-. Most of them spoke specifically about **lack of proactive engagement**. In this regard one student spoke of needing to learn beyond the PowerPoint handouts:

I used my lecture slides. I know lecture slides are just . . . a summary of a summary, so I guess it's probably the reason why I didn't really do well in that question. (Student interview, Siyabulela)

Another recognised the need to work more consistently:

Student: I only consolidate when I have finished a session like when it is all done then I start consolidating. I don't do it daily.

Interviewer: Ok and do you find that that is enough?

Student: I don't think it is enough . . . no but I am too lazy to do it every day. (Student interview, Alakhe)

Some were also relying on **rote learning** for tests and examinations:

I tended to memorise and not understand my theory . . . the theory paper was asked in depth and the amount of detail and volume of work was lots and not *understanding* was my let down. (Student interview, Zanele; original emphasis)

The predominance of recall and low-level comprehension questions in early tests in some courses could possibly be engendering rote learning at the expense of developing conceptual understanding. By way of illustration, in Earth Sciences students were asked the length of time since the last glacial maxima in a multiple-choice question. Had the student developed understanding at a broad level that glacial maxima and minima take place over periods of tens of thousands of years he would have correctly chosen the 18 000 years option. However, the comment from the student indicates that whilst learning he did not use the values of relevant numbers to grasp the essence of concepts:

There were so many numbers we had to learn . . . I wasn't sure if I should choose the number on the answer sheet like many million years ago or billion years ago so I just chose 140. I think it's just a number that came to my mind because I remember seeing it somewhere . . . (Student interview, Siyabulela)

10.3.2.4 Good acquisition of learning-context realisation rules

A number of students indicated they were working as autonomous learners, signifying acquisition of learning-context recognition and realisation rules. In other words, they had developed the necessary learning-context knower code and were acting as 'ideal' knowers. In this regard, some spoke of **good time management**:

So I spend most of my time on the subject that I think that I have a problem with. So that's how I actually structure my time. (Student interview, Siphon)

Linked to time management, some spoke of the importance of regular lecture attendance:

Ja, I never skip. I can't afford to skip one lecture. (Student interview, Nofanele)

Others spoke of **developing understanding** through working **independently**:

I go through the lecture notes, like the slides, then try to bring them with the textbook and try to relate them and then make up my notes from those, from that combination. (Student interview, Siphon)

The need to work independently was based on the sense that not everything they needed to know came from the lecturers:

. . . [in mainstream] they don't teach you everything. Most of the work you teach yourself. (Student interview, Andile)

One student articulated that developing understanding need not necessarily be for marks, but for her own good:

Ja, because they give us like homework assignments, I do them, hand them in, ja even though they don't mark it . . . so I can't sit there like I'm not going to do it because it's not getting marked, it's for my own good. (Student interview, Nofanele)

To develop understanding one student used the strategy of **asking herself questions**:

I just know that consolidation is very important and then whether you understand what was going on and then whether I am asking myself questions of various things of what to expect in a test and what not to expect and what is important and what isn't important. (Student interview, Noxolo)

Another **consulted** with peers:

I have a group of three, they are first years this year and there are others from Extended Studies. So we meet sometimes and we just try to explain to each other what it really means and what is exactly the thing that he [the lecturer] is talking about in that topic, what we don't understand (Student interview, Nofanele)

Quite a few students spoke about the importance of **utilising resources**. The value and use of YouTube was mentioned by virtually every student, and is often the first resource consulted. The visual nature and clear oral explanations of YouTube videos seem to assist in their understanding:

Interviewer: So if you get something that you don't understand in a course, what do you do about it?

Student: Now what I do is I go to YouTube and then YouTube explains better. If YouTube doesn't help, then again the augmentation they really help. (Student interview, Mfuneko)

YouTube was also mentioned as a means of accessing the textbook:

. . . the textbook does bring something, but you think maybe I need someone else to explain it to me first. So you go to, on YouTube it explains it in the best of ways. It's really an incredible world out there. You come to think, okay wow! This person is giving me this aspect and a better way to explain it than the lecturer was doing, or the textbook . . . ja, I go to the textbook only after YouTube (Student interview, Ndileka)

There were indications of how much acquisition of learning-context realisation rules was a **process** students were engaging with in ongoing and reflective ways:

In first term I was just trying to adjust at . . . so now whatever I did first term I can see now compared to what I need to do different . . . now I am working differently . . . everyday consolidation, asking questions and practising answering questions . . . and am very confident that I am going to pass because I know where I went wrong. (Student interview, Noxolo)

Reiterating the process aspect of acquisition of pedagogic realisation rules, a number of students were **reflecting** back and drawing on their experiences in ISCM. This could relate to keeping up by consistently consolidating their work:

[Ms X in ISCM] always told us about consolidating our work – that stayed with me. I realised when you don't consolidate your work piles up and you panic when you about the write a test and everything is just crazy . . . and the results show. (Student interview, Gugulethu)

It also related to discussions around their 'right' to ask questions:

Yes I do ask questions. I remember when [Ms X in ISCM] was telling us . . . we HAVE to ask questions if we don't understand. We have to stop them [lecturers] and ask. Ja, so to me it was like I expected this that it will happen [that she asks questions]. (Student interview, Nofanele)

For one of the students, being critical was a message he carried into mainstream:

[Ms X in ISCM] showed that you would have to use your critical thinking. Everything was always – you need to be critical! (Student interview, Alakhe)

10.5 Discussion

ISCM is aimed at enabling epistemological access to a range of mainstream science disciplines. This chapter examines the extent to which BScF2 students have access to and can succeed in the four mainstream courses of Cell Biology 101, Chemistry 101, Earth Sciences 101 and Physics 101. The first part of the discussion uses student performance according to marks as a measure of 'success' and considers ways in which both ISCM and mainstream courses could be contributing in this regard. The second part considers the way in which pedagogic practices and codes that are legitimated in the four courses could be serving to exclude certain groups of students. In recognition of the necessity for curricula that serve the needs of the majority of students, the final part of the discussion calls for better curriculum articulation across the degree.

10.5.1 Student access and 'success' in mainstream

The most common and easiest measure of 'success' is that of student performance according to marks, with a pass constituting success. This was used here as an initial indicator to examine the overall performance of BScF2 students in four first-year mainstream science courses.

As already indicated, analysis of longer-term data of student performance in these courses indicates that, with the exception of Physics, BScF2 students as a whole performed as well if not better than direct-entry mainstream African students. The exception in Physics will be due to a range of issues not examined here, of which one contributor could be poor preparation by ISCM for high cognitive level questions in tests and examinations as well as poor support in mainstream for dealing with such questions. Notwithstanding Physics, according to Scott (2012, p39), this trend of better performance by Extended Curricula Programmes (ECPs) students has been recorded in a number of institutional reports, indicating the opportunities such programmes can offer in terms of providing a sound academic foundation. Therefore, based on overall performance data, and the fact that BScF2 students have lower matriculation points than direct-entry students, it can be assumed that ISCM is contributing to promoting access to a range of mainstream courses.

In Chapter 9 I argue that acquisition of learning-context realisation rules (RL(lc)), are key to success in higher education science – an area in which BScF1 students were particularly poor at the time of their interviews (six or seven months into their first year). However, BScF2 student interviews, approximately eighteen months after arrival at the academy, indicate much improved learning-context realisation for many through their exhibiting good time management, working independently, developing own understanding, consulting with staff and peers, and utilising resources well. This supports the contention that acquisition of learning-context realisation rules is not only achieved through direct and explicit teaching, but is also a process that takes time and requires opportunities for practice and reflective engagement. As one student indicated, he had not appreciated the significance of consolidating his work regularly until he was in mainstream:

In Foundation it feels like ok this is extra work, this consolidating . . . yeah, and you don't actually know why you doing it . . . now when you actually doing mainstream that's when you start seeing, ok yeah I should have focused more on that when we were doing it in Foundation . . . (Student interview, Ntlonipho).

Analysis of BScF2 student experiences indicates that certain pedagogic practices in mainstream courses are supporting acquisition of mainly epistemic-context recognition and realisation rules. Those that emerged in the study are (a) the use of practicals and tutorial sessions, including augmenting course tutorials, for active participation, (b) the availability of appropriate and accessible resources, and (c) good staff–student relations, particularly where staff are mindful of student needs.

However, despite the relatively good performance of BScF2 students when compared with their direct-entry peers, and despite some positive accounts of acquisition of epistemic- and learning-context recognition and realisation rules, a number of questions still remain. For example, why are approximately a quarter of BScF2 students not passing? Why is the mean mark of BScF2 students only in the low 50s? Why are BScF2 students and other direct-entry African students doing worse, and sometimes considerably so, than direct-entry students from other race groups, particularly whites? These race- (or class-)related inequitable outcomes are of major concern and the following section argues, based on Bernstein's (2000) contention that pedagogic practices have the power to exclude, that current mainstream practices are better geared towards middle-class students.

10.5.2 Constraints to access and success

Analysis of student experiences highlighted five possible constraints to student access and success in the mainstream science courses considered here. With the exception of large classes, which is a structural constraint, the other four constraints are aspects of pedagogy that have the

potential to be differentially framed to better suit coding orientations of students. It was mentioned in Chapter 7 that changing the framing of modalities in pedagogic practice can assist in making coding orientations of the course more visible and more accessible. Of relevance here, the literature points to a flexible pacing in teaching and assessment (-F; Bernstein 2000; Morais, Neves and Pires 2004; Neves, Morais and Afonso 2004; Rose 2004), explicit use of evaluative criteria (+F; Morais, Neves and Pires 2004; Rose 2004; Neves, Morais and Afonso 2004), a weak hierarchy between staff and students (-F, of staff-student relations; Morais, Neves and Pires 2004) and good commitment to course rules (+F, of staff-student relations; Hoadley 2005) likely favouring 'educationally-disadvantaged' working-class students.

However, current framing of pedagogic modalities in the four mainstream courses shows opposite trends: an inflexible and rapid pacing of work including assessment tasks (+F), poor provision and use of criteria in assessment tasks (-F), poor rapport and engagement by some staff with students and not being cognisant of their needs (-F), and poor commitment by some staff to course logistics (-F). These trends suggest poor levels of support for students who need it most. I also suggest, as do Leibowitz et al. (2009), that even structural constraints such as large classes can be partially countered by empathetic staff. As one lecturer said: 'I hang around after the lecture so that those who find it difficult to ask in lectures can do so later . . . it's often the black students' (Staff interview, RA10).

The more general analysis of course structures indicates that legitimization of certain code and code structures have the potential for exclusion. The focus on disciplinary principled and procedural knowledge in the four mainstream courses indicates legitimization and valuing of stronger epistemic relations (classified as ER++ in this study). Scientific literacies knowledge, representing less strong epistemic relations (ER+), is valued in a limited number of tutorials in only two of the four courses. It appears that none of the courses have any focus on academic practices (ER-) or everyday knowledge (ER--). Social relations too appear to be marked by their absence, although only an in-depth study would confirm these trends. Nonetheless, by all accounts these courses appear to legitimate a **knowledge code**, a (scientific) **trained gaze**, and a strongly theoretical curriculum with a **rhizomatic code**, which fits the profile of a 'typical' higher education science disciplinary course.

That there is a 'typical' profile is not without reason. The privileging of epistemic relations, especially disciplinary knowledge, and having high volumes of material requiring a rapid pace of working can be accounted for by the way science is structured. With its hierarchical knowledge structure there is an imperative to 'cover' fundamental knowledge concepts that form the building blocks for later learning. Because of advances in science, the fundamentals are constantly increasing, which translates to large volumes of disciplinary content and a resultant

fast pace of teaching (see Engelbrecht, Harding and Phiri 2010). Furthermore, the fact that social relations are poorly legitimated in science courses relates to a dominant view that, since science is objective and value-free, learning too is a neutral and value-free process dependent on good transmission of necessary information (Toohey 1999). In addition, content-laden, theoretical curricula are typical of higher education science courses that were developed when the student body was relatively homogeneous and their socio-educational backgrounds provided them with sufficient purchase to make meaning of knowledge presented in this way.

However, having accounted for the focus on disciplinary content in the four mainstream courses, I would like to suggest this makes for a narrow curriculum accessible to a select few. I have consistently argued throughout this dissertation for a broader base and an explicit approach to both the epistemic and social aspects of curriculum and learning in order to promote student access. For example, in the curriculum analysis in Chapter 6 I argue for explicit teaching in a broad-based curriculum that includes not only theoretical but also scientific literacies, and academic practices knowledge. The same argument for a broad base across the semantic density range is used in the assessment analysis chapter (Chapter 8), along with the contention that assessment should also operate across the semantic gravity range to promote cumulative learning. In the pedagogic analysis in Chapter 7, I argue for 'mixed' pedagogies and better legitimation of social relations to enable epistemic-context and learning-context knowers with appropriate gazes. This contention is borne out by student responses to ISCM in Chapter 9.

Therefore, based on analysis of legitimated codes and pedagogic framing modalities in the mainstream courses, and on the arguments that have been developed throughout this dissertation, I posit that current mainstream course structures and practices do not favour working-class African students, hence their comparatively poor performances as reflected in long-term pass rates. A curriculum that takes into account the backgrounds of all students is clearly needed. In this regard one of the augmenting course lecturers, who attends mainstream lectures, made the following poignant comment:

They [African students] are sitting in the class, but they cannot cope with the culture of that [mainstream] class . . . [in SESP] it is more interactive. You know your learners and work with your learners and there is a relationship. But when they [African students] get into that [mainstream] class, last year there were 360 [students] I think . . . and if you look at a lecturer who just comes in and gives a lecture already the lecturer and the students are detached. And how can the learner relate to that? Most of them just sit there quietly and they leave without getting much. And they cannot raise a question because they think everyone else knows, and it's 'probably just myself'. (Staff interview, RA14)

10.5.3 Articulation between ISCM and mainstream courses

Studies have shown that curricula have transitions for which students are 'differentially prepared' (CHE Report 2013, p18). The transition into university is one such transition and, in the case of ECPs with a single foundation phase year, the transition into mainstream is another. This chapter has shown that the curriculum transition from ISCM into mainstream is disjointed in a number of areas. Firstly, whilst ISCM provides a wide support base (across the weaker to stronger range of epistemic relations, social relations, semantic density, and semantic gravity), the four mainstream courses examined appear to have a much narrower focus (stronger epistemic relations, weaker or no social relations, stronger semantic density, weaker semantic gravity in assessment). Secondly, whilst some pedagogic modalities in ISCM and mainstream concur (stronger framing of selection and sequencing of knowledge, and stronger framing of staff–student relations in terms of explicit course rules) there are others that do not (pacing, assessment practices and criteria, staff–student relations in terms of hierarchy). Thirdly, whilst ISCM legitimates social relations, in particular those associated with becoming an effective science learner, mainstream does not.

The SESP is a faculty-wide initiative since students enter a four-year degree, not a single foundation year. Therefore, whilst a course such as ISCM can be viewed as laying a foundation for access to the academy, I contend it cannot and should not bear sole responsibility for such student access and ultimate success. Curriculum initiatives should be developed holistically across the entire degree and articulation between the difficult transition periods given much more careful consideration, which is certainly not the case at present. If we are to address the current inequities in outcomes it will require fundamental systemic change of our curricula to support the majority of students.

Finally, education is about taking on new identities, and it has been acknowledged in this dissertation that this can be a difficult and time-consuming process, especially for those who have been socialised into rules and codes that are different from those required by the educational system. This is discussed in the following chapter, in light of events that have caused such disruptions to South African higher education institutions in recent times.

Chapter 11: Discussion

11.1 South African higher education at the end of 2015

Although it is somewhat unusual to bring new context into the final discussion of a dissertation, I feel it is necessary here because a lot has changed in South African higher education since this study was started. I therefore firstly allude briefly to the watershed political events of 2015, and later consider how the findings of this study speak to the message of these events.

The already mentioned #RhodesMustFall protest movement was initiated in March this year by the student Chumani Maxwele dumping human excrement on the statue of Sir Cecil John Rhodes at the University of Cape Town (UCT). His action served as a catalyst for mainly (but not only) African students and some staff across the country to show their discontent through peaceful and violent protest action centred on a range of issues that are linked, directly or indirectly, to institutional culture based on race (or class) distinctions in higher education. The plethora of social media hashtags that have developed reflect the interests of students at individual universities, but all indicate the need for change. Examples are #OpenStellenbosch (University of Stellenbosch), #TransformWits (University of the Witwatersrand) and #RhodesSoWhite (Rhodes University, RU). October saw the culmination (at least for now) of these protests under the #FeesMustFall banner, resulting in the majority of South African universities suspending operations for three days or more.

The context for the #FeesMustFall movement is that most South African families cannot afford to fund higher education studies but the system is structured such that accessing funds through state or private means is difficult or inadequate. Student financial exclusions are therefore an ongoing concern for many students across the sector. This has resulted in annual disruptive, but relatively small-scale, protests at various institutions that have, in the past, yielded few concrete results. However, the sheer scale, and sometimes ferocity, of events in the latter half of 2015 has meant all stakeholders were compelled to take cognisance of student demands – resulting in government and university leadership teams across the sector agreeing on a 0% increase in student fees for 2016. As I write this final chapter in mid-November, some universities have managed to settle into a semblance of a normal final exam routine, with concessions being made to accommodate students through the exams because of the disruptive environment that has prevailed. Others, however, are still in a state of turmoil and the list of new demands is long. Renewed and ongoing protests are anticipated country-wide in 2016. As the Vice Chancellor of Rhodes University stated recently to staff and students, the face of higher education in South Africa will be fundamentally changed as a result of these actions.

Although the issues around financing higher education are crucial for student access and success, of greater relevance to this study was the earlier dialogue where, under the #RhodesMustFall banner, the initial call for the removal of the Rhodes statue was, in fact, a reaction to institutional racism and perceived lack of transformation. As the UCT Student Representative Council (SRC) president Mahapa said, it was a ‘consequence of an institutional culture that is largely exclusionary’, and that ‘for too long the narrative at the university has silenced the voices of black students and black history’ (quoted in Badat 2015). The Nigerian scholar Adebajo also suggested the demands for the removal of the statue ‘appeared to be a metaphorical call for the transformation of the university’s curriculum, culture and faculty, which many blacks feel are alienating and still reflect a Eurocentric heritage’ (Adebajo 2015). In this regard, and of particular interest in this study, were the calls for ‘decolonisation’ of the institutions and the curriculum, which at RU have been made primarily by the recently formed Black Student Movement (BSM).

Many universities, especially those that were historically white such as RU, have a staff complement that is still predominantly white. As a result, both the institutional culture and their curricula reflect, and speak well to, white, middle-class interests and values. All too often curricula across faculties draw predominantly on theories, case studies, and critical thought from the developed west and north, and are not relevant to the social, political, and economic needs of a developing country such as South Africa, nor do they ‘speak’ to the majority of students from African cultural contexts. At a personal level, the overwhelming message from African and other disaffected groups of students has been the awful sense of alienation, isolation, frustration, inferiority, powerlessness, silencing and loss of sense of ‘self’, where they have to take on a ‘white mask’ (Fanon 1952) in order to be successful at these institutions (see Box 11.1 for student voices). As Soudien (2015, p6) argues in a recent presentation in a curriculum debate, unless we deal with affect and ‘black pain’ of students, we cannot hope to have an education system that is accessible to all and therefore socially just. Since the concepts of access and social justice underpin this study, the question raised at this stage of the dissertation is how the findings of this study can contribute to this urgent debate on curriculum change.

Box 11.1: African university student voices in 2015

When we ever be equal, when will society ever change? If we are black students we are always playing the catch-up game. (Unnamed Rhodes University student, Apartheid 2015 YouTube video, 2015)

The colour of my skin is like a social burden . . . people cannot believe that you dare enter this space. (Unnamed University of Stellenbosch student 1, Luister YouTube video, 2015)

Your sense of self that you came with, where you come from, you get here [University of Stellenbosch] this space . . . First of all you don't see other black people – that in itself sends you a message that this is probably not your place. Secondly, people interact with you in such a way that they expect you to have learned their culture so well that you do as they please. So if you don't, you are chucked out. So you have to choose how I might want to survive, because we are social beings, we need people around . . . (Unnamed University of Stellenbosch student 2, Luister YouTube video, 2015)

I feel very unintelligent because I . . . know how to think but I can't say these things I am thinking because I do not have the perfect accent. The lecturer won't really understand me because I'm going to stutter, I'm going to mix my Xhosa because its very difficult for me . . . (Unnamed Rhodes University student 1, #RhodesSoWhite – Director's Cut YouTube video, 2015)

The big things are institutional culture, course content and curriculum. These are the big things. These are the things that alienate people as soon as they step into a space like this. (Unnamed Rhodes University student 2, #RhodesSoWhite – Director's Cut YouTube video, 2015)

Student demands have centred on curriculum decolonisation rather than transformation; a distinction that is important in the current context. Magubane (2015, p3) states that 'decolonisation is about deconstruction and reconstruction into something different' and that transformation is about working from within to change what already exists. Whilst some acknowledge there has been curriculum transformation in many areas in higher education since 1994, it is generally viewed that these still draw on discourses from the global north and are unsuited to the current context, hence the call for more radical decolonisation.

Because I am sympathetic to students' alienation and believe their frustration is fully justified in the current context, I find it emotionally and politically tempting to align with the decolonisation agenda. However, I also acknowledge I am a product of a middle-class, western, 'objective', scientific system and therefore find it intellectually impossible to imagine a different kind of science with a different kind of knowledge production and values from those described in this study. I therefore do not argue in this final chapter for radical decolonisation, but rather for providing access to powerful science knowledge through far-reaching transformative pedagogies that address issues of diversity and difference. This study has shown that acquiring the literacies of science and the academy requires fundamental shifts at the level of the person, and that these shifts are not neutral. This means that, in order to become the 'objective' scientist and the 'autonomous' learner, as outlined in this study, a student has to become a different person to who they were when they entered the academy. The extent and difficulty of the identity work required, revealed through this study, needs to be recognised, accommodated and

supported in our educational practices, without which students will continue to be excluded from the system. I concede, however, in light of recent events, that this is only the start of an ongoing and urgent conversation in which the voices of the disenfranchised need to be heard, taken seriously, and acted upon as we move forward.

The rest of the chapter therefore focuses on the findings of the study, and then considers the implications of these findings in three main areas. Firstly, in terms of broad conceptual understanding of epistemological access, secondly, in terms of improving education practices in the sciences in light of the above-mentioned political events, and thirdly, in terms of the contribution of this study to the field of educational research.

11.2 Study findings: Answering the research questions

The context of this study was a year-long science foundation course, Introduction to Science Concepts and Methods (ISCM), which has as its main aim enabling epistemological access for its attendant African, mostly working-class students. The main research question therefore asked 'How do educational practices of the Introduction to Science Concepts and Methods (ISCM) course enable and/or constrain epistemological access to a range of mainstream science disciplines?'

This dissertation, which draws on social realist theory in which knowledge itself is an object of study, frames epistemological access both in terms of 'know that' knowledge and 'know how' knowledge practices (Muller 2014), primarily using Bernstein's (see 2000) code theory work and Maton's (see 2014a) Legitimation Code Theory. These theories allow examination not only of underpinning codes or 'rules of the game' of educational practices, but also of how these codes are legitimated in these practices, as well as the effects of these legitimating practices. Of main concern in this study is whether ISCM educational practices have the 'effect' of enabling epistemological access. The sub-questions asked in this dissertation therefore relate to knowledge, knowledge practices, knowers and issues of access. The four sub-questions are:

- 1) How are knowledge and knowers characterised and legitimated in the ISCM curriculum?
- 2) How are pedagogic and assessment practices framed and legitimated in ISCM to enable access?
- 3) How do students interpret and respond to ISCM educational practices?
- 4) In what way do ISCM and mainstream educational practices enable or constrain epistemological access?

The following five sections, which briefly outline the main findings of the study, answer each of the sub-questions and the main research question in turn.

11.2.1 Characterisation and legitimation of knowledge and knowers in the ISCM curriculum

ISCM is a multidisciplinary, integrated and hierarchically-structured science course. It has four main disciplinary components (currently Physics, Chemistry, Human Kinetics and Ergonomics, and Geology) and integration between the different components is achieved through the literacies and academic practices aspects of the course rather than at a disciplinary content level. The hierarchical structure of the intellectual field of science and science disciplines is visible both within and between the different ISCM recontextualised course components.

Working with LCT(Specialisation), a differentiated typology of four knowledge types, each with associated principled (or contextual) and procedural knowledge, was distinguished based on relative strengths of epistemic relations: disciplinary knowledge (ER++), scientific literacies knowledge (ER+), academic practices knowledge (ER-) and everyday knowledge (ER--). A dual categorisation of social relations, which becomes a dominant theme in the dissertation, was developed based on epistemological and axiological concerns. The former focus on epistemic-context social relations (SR(ec)) and the latter on learning-context social relations (SR(lc)). Overall it appears that, according to LCT(Specialisation), ISCM legitimates two codes – an epistemic-context knowledge code and a learning-context knower code.

Whilst stronger epistemic relations could be expected in a science course, the stronger social relations, especially related to the learning context, are more typical of an academic development (or foundation) course. The fact that both are equally valued in ISCM relates to its dual purpose of preparing students for science courses as well as the learning context of science academia. In this dissertation I argue for an epistemic-context (science) knower with a cultivated gaze rather than a trained gaze. I further argue that the learning-context knower that is legitimated in ISCM is also a cultivated gaze. The argument for both knowers having cultivated gazes is based on the social realist assumption that all practices, even scientific practices, are socially and culturally embedded and that becoming and being an active and contributing member of these practices requires some explicit instruction, but, more importantly, immersion and enculturation into the ‘ways of being’ appropriate to the practice. I also argue that this is particularly so for students whose prior socialisation at home and school does not match well with expectations at university.

The LCT(Semantics) analysis indicates a differentiated ISCM curriculum that draws on a range of knowledge and knower types, legitimating a rhizomatic/worldly code. This points to a curriculum that focuses on stronger semantic density, but works across the semantic gravity range. I argue that a broad-based curriculum that operates in three of the four quadrants of the Semantics plane is necessary in a course that tries to serve two functions: enabling access to

powerful propositional and procedural science knowledge typical of a science course, as well as promoting access to learning processes typical of an academic development (foundation) course. The work on student response to educational activities shows that both forms of access are necessary for success.

11.2.2 Framing and legitimating pedagogic and assessment practices for access

In a deliberate attempt to surface what can be hidden aspects of the curriculum, an overt approach to articulating norms and values as well as providing explicit instruction and modelling of practices reveals a visible ISCM pedagogy at both the regulative and instructional discourse levels. Also in an attempt to enable access to the knowledge and knowledge practices of ISCM, pedagogy is framed differentially to accommodate students who have come from home and educational backgrounds that have not prepared them well for higher education studies. In this regard, in the instructional discourse there is stronger framing of selection and sequencing of knowledge, of assessment criteria and feedback, of staff–student relations in terms of course rules, of student conduct and practices as learners, and of student conduct and practices as scientists, and relatively weaker framing in terms of pacing of knowledge and of staff–student relations in terms of being accessible and empathetic.

In terms of the regulative discourse, the two previously-identified aspects of social relations are evident and much more visible (strongly framed) in pedagogy than in curriculum. The epistemologically-oriented social relations related to becoming and being a scientist show a legitimization of knower attributes such as being rigorous, accurate, precise, objective, critical, and honest; thinking analytically; and observing carefully. The axiologically-oriented charged social relations related to becoming and being a successful science learner show legitimization of knower attributes such as being engaged, critical, reflective, confident, independent, responsible, and autonomous.

The assessment practices of ISCM match the rhizomatic/worldly codes that are legitimated by the curriculum – by assessing primarily at the level of stronger semantic density (mainly disciplinary and scientific literacies knowledge) as well as operating across a wide semantic gravity range (ranging from recall- to creation-type questions). In high-stakes assessment tasks, such as report and essay writing when support and feedback is available, weaker semantic gravity questions are common, but stronger semantic gravity comprehension- and application-type questions dominate in the tests and exams. It appears that ISCM assessment practices prepare students well for cognitive level assessment questions they encounter in mainstream Cell Biology, Chemistry and Earth Sciences, but less well for Physics, which works at a relatively weaker level of semantic gravity.

Overall, the framing and legitimation of pedagogic and assessment practices suggest that, according to the literature, ISCM should be promoting access to scientific knowledge and practices to students from 'educationally-disadvantaged' working-class backgrounds. It is less clear whether it is providing access to the learning context as this is not directly assessed.

11.2.3 Student response to ISCM educational practices

Epistemological access, in code theory terms, is about producing legitimate text for a particular educational context. Because both epistemological and axiological concerns underpin ISCM, two types of texts are legitimated. The first is a 'scientific' text that is produced primarily in assessment tasks, and students are evaluated primarily on propositional and procedural disciplinary and scientific literacies knowledge. The second is a 'science learner' text that is not assessed directly but instead requires students to be autonomous learners in an academic context.

Bernstein's (2000) model of acquisition of recognition and realisation rules and knower dispositions allowed 'operationalisation' of epistemological access according to these two texts in relatively concrete terms. At the time of the interviews, students in ISCM exhibited relatively good acquisition of recognition rules for both the epistemic-context level (RC(ec)+), and the learning-context level (RC(lc)+). However, realisation at these two levels was relatively poor.

The argument is made that these two levels of recognition and realisation exist in hierarchy with acquisition of realisation rules at an epistemic-context level requiring acquisition of realisation rules at a learning-context level. In other words, it is difficult to access the epistemic knowledge unless you are the right kind of learner. Explaining poor access in ISCM in this dissertation therefore focuses primarily on social relations associated with becoming a science learner. It is suggested the primary contributor is a code clash between the learning-context knower code that is legitimated in ISCM and the learning-context relativist code that students continue to draw on from their school learning context. I contend that structural aspects of ISCM contribute towards this code clash, one of which is the competing demands of the learning-context knower code and the epistemic-context knowledge code, with students focusing on the latter at the expense of the former.

11.2.4 Access and success in mainstream

Considering that ISCM students mostly enter university with fewer matriculation points than other students in the Science Faculty, their equivalent or better overall pass rates in first-year mainstream Cell Biology, Chemistry and Earth Sciences courses compared with African direct-entry peers suggests ISCM is contributing to promoting access in mainstream courses. However, with the mean mark for BScF2 students being in the low 50s, with approximately 25% of them

failing, and with their poor success rates (along with their direct-entry African peers) compared with other race groups (especially whites), this raises the concern that aspects of mainstream courses may be serving to favour certain groups of students over others.

The somewhat limited analysis of mainstream courses indicates that generally a knowledge code (Specialisation dimension) and a rhizomatic code (Semantics dimension) are legitimated. Whilst these can be considered appropriate codes for science courses, I argue throughout the dissertation for a much broader legitimation base in order to provide necessary support for students whose backgrounds do not match well the requirements at university. The framing of modalities of pedagogic practices in first-year mainstream also seem to be excluding working-class students. The rapid pace and volume of work in class and in assessment practices, non-explicit articulation of assessment criteria and, for some staff, poor staff–student relations and weak commitment to course logistics all appear to be contributing influences.

Whilst this dissertation focuses on the role that ISCM plays in enabling access in science courses, in the final analysis I argue that, although ISCM can play a role in laying a foundation for access to the academy, it cannot bear sole responsibility. I contend that the SESP is only the first year of a four-year degree, not a single foundation year, and that we need to ensure curricula are aligned in order to support students all the way through their degree. Currently, pedagogic practices and codes legitimated in the two phases of their degree, the foundation phase and mainstream phase, appear to be at odds with each other and need much better articulation. Furthermore, for students to take on new identities to become participating, contributing members of scientific academic practices in higher education, it requires time and much emotional effort that requires continued support. This issue is explored further in section 11.3 of this chapter.

11.2.5 Epistemological access in ISCM

The previous four sections have outlined the findings of this study. Being a *science foundation* course, the recontextualising agents interpreted ISCM as playing two roles: promoting access to scientific and disciplinary knowledge as well as to the processes of learning. Although it is not necessarily unusual to recognise that academic success is influenced by both the mastery of knowledge within a discipline or field *and* the capacity to learn within broader discursive academic practices (Mann 2006; McLean, Abbas and Ashwin 2013; Edwards 2015), the identification in a single study of what appears to be two forms of access based on these two components seems to be somewhat uncommon, and certainly unusual in LCT analysis. These two forms of access are conceptualised together as enabling epistemological access, and how they play out in the current ISCM course is summarised in Figure 11.1.

As has been mentioned, the regulative discourse in ISCM is underpinned by epistemological and axiological concerns. Epistemological concerns are discussed first and relate to students engaging with, and understanding the norms and values of, science or science disciplines (left side of diagram; Figure 11.1). The instructional discourse supports this concern in a number of ways. Firstly, this occurs through the curriculum, where disciplinary and scientific principled and procedural knowledge (DK and SLK), which have stronger epistemic relations, form the main focus of ISCM work. Academic practices knowledge (APK), which exhibits weaker epistemic relations, also contributes by forming initial 'building blocks' for some of the scientific literacies work. In terms of social relations, epistemic dispositions and practices are valued but not strongly legitimated. Secondly, visible and explicit pedagogic practices also support this epistemological concern through a stronger framing of selection and sequencing of knowledge, strong hierarchy in staff–student relations (related to 'rules' of course), and explicit articulation of expectations of student conduct and practices as scientists, as well as a weaker framing of pacing and aspects of weaker hierarchy in staff–student relations (related to encouraging questioning and critique). Thirdly, assessment is aligned with this concern by generally exhibiting stronger framing of evaluative criteria and feedback. The assessment practices, which operate across all knowledge types and knowledge practices as well as across all cognitive criteria categories, support this epistemological concern.

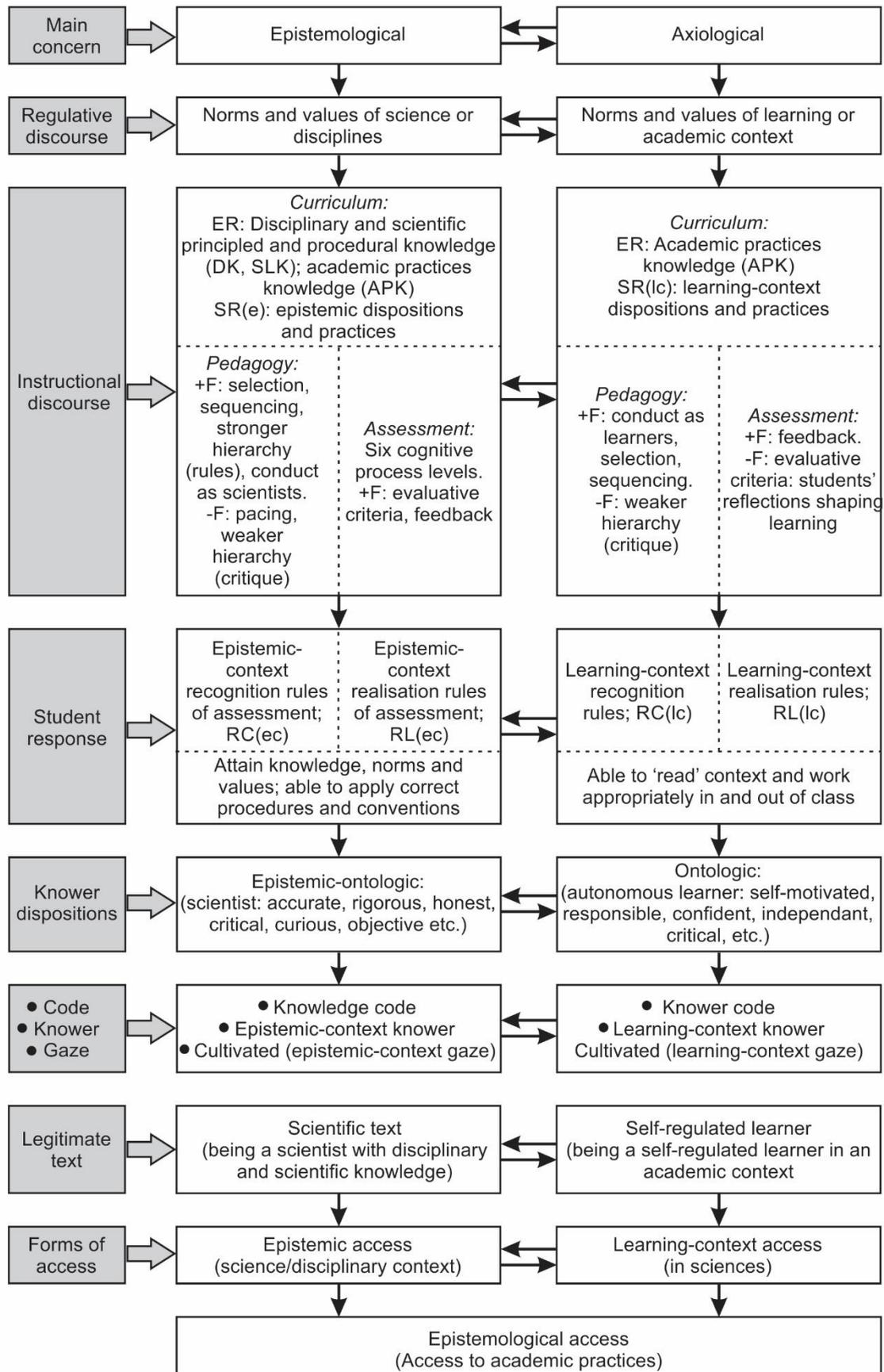


Figure 11.1: Elements of access in ISCM based on findings of study

Also associated with epistemological concerns is student acquisition of epistemic-context recognition and realisation rules (RC(ec) and RL(ec) respectively) to produce legitimate text (Figure 11.1). Acquisition therefore requires students to have a good disciplinary and/or scientific knowledge base, to be able to apply appropriate procedures and conventions of the discipline or field based on epistemic norms and values, and to have good assessment techniques – much of which can be actively and effectively taught in an appropriate educational context. However, the model indicates that knower epistemic-ontologic dispositions associated with the discipline and field, such as being accurate, rigorous, honest, critical, curious and objective, are also key aspects to legitimate text production. I argue in this dissertation that attaining these dispositions is not a matter of training but rather inculcation and immersion in scientific socio-cultural practices, resulting in an epistemic-context (scientist) knower with a cultivated (epistemic-context) gaze. A student producing legitimate scientific text for the epistemic assessment context as described above, would have **epistemic access** to that context. However, in the context of marginalisation expressed by students involved in the protests discussed in the introduction to this chapter, it is not difficult to see how the attributes of, for example, accuracy, rigour and honesty with data can be hard to achieve in ISCM when a casual, inaccurate and somewhat dishonest approach to data collection prevails in the school context (see student quotes on independent research project in section 9.2.2). Likewise, achieving the legitimated analytical criticality required in science is difficult when memorisation, reproduction and acceptance of authority are the norm in school and even home contexts. These represent fundamental code switches that have the potential to alienate.

The second aspect of the regulative discourse relates to the norms and values of the learning context which, in the case of ISCM, focuses on students becoming autonomous science learners in order to be successful in any science discipline in mainstream once they leave the more supportive environment of a foundation course (right side of the diagram; Figure 11.1). These are the axiological concerns that are more commonly the focus in academic development courses (Niven 2012, Shay 2012). Support for this concern is not that obvious in the curriculum documentation, as both academic practices knowledge (APK) and learning-context dispositions and practices (SR(lc)) are valued but barely visible. Better support is evident in the pedagogy through the stronger framing of expectations of learner conduct in terms of autonomous learning and the selection and sequencing of knowledge, which ensures appropriate practices are modelled and scaffolded, as well as through weaker framing of aspects of staff–student relations, which encourages a critical and questioning approach to their own knowledge development. Only formative assessment tasks are associated directly with this axiological concern and are based on student reflective comments on their attitudes and practices related

to their own science learning. Although evaluative criteria are weakly framed, feedback, which is detailed and personal, is strongly framed.

Student acquisition of recognition and realisation to produce legitimate text for the science learning context is underpinned by learning-context norms and values (RC(lc) and RL(lc) respectively; Figure 11.1). In order to be an effective learner in ISCM, a student needs not only to be able to 'read' the learning context properly, but also to be able to work appropriately in and out of class. The ontologic dispositions that engender such autonomous learning are linked to being self-motivated, responsible, confident, independent and critical. Again, I have argued in this dissertation that these dispositions cannot easily be developed through training, but rather through 'apprenticing through modelling, scaffolding and supported interaction by experienced others' (Chapter 6) in order to facilitate becoming and being an autonomous science learner (learning-context knower) with a cultivated (learning-context) gaze. By being an autonomous science learner a student is producing legitimate text and has therefore attained **learning-context access**. Likewise, in light of the message from recent events, one can imagine how attributes of 'confidence' and 'self-motivation' can be hard to achieve in a context of alienation where African culture is not being legitimated. One can also imagine that in such an environment students might well draw on the 'communality' which has characterised many of their previous experiences in African cultures, eschewing the 'independence' valued by the university. It is worth noting at this stage that I indicate in the more general model of epistemological access in section 11.3.1 that it is at the learning-context level where there is most scope for transformative pedagogies that better accommodate student diversity.

The two end points discussed thus far in Figure 11.1 are epistemic and learning-context access, and the final conceptual move I make is to suggest that, combined, these constitute **epistemological access** in ISCM. This study shows that epistemic access, which provides access to the 'goods' (Morrow 2007, p39) or powerful knowledge and is the primary concern in higher education, is very difficult without access to the learning context. In an ethnographic study on access to language development, Boughey (2005) also recognises two different levels of epistemological access based on a context of situation (first-year philosophy class) and context of culture (of the wider university). As in this study, she maintains that access in the context of situation can be constrained by aspects related to the broader context of culture. Using the idea of a hierarchy of two forms of access, a generalised model of epistemological access in the sciences can be conceptualised. This is outlined in the following section, in which the more general implications of this study are discussed.

11.3 Implications of study for science higher education and educational research

This study is located within the educational fields of science and academic development and has focused on the concept of epistemological access. Although it took the form of a detailed account of a single case, from which generalisation could possibly be difficult, because of the critical realist frame, underpinning causal mechanisms at the level of the real have been identified which, as mentioned in Chapter 5, allow for some generalisation (Sayer 2000; Danermark, Ekström, Jakobsen and Karlsson 2002; Hammersley 2012). I therefore draw on the findings of this study firstly to propose a generalised conceptual model of epistemological access in the sciences or in a science discipline in higher education, and secondly to discuss the implications of this study for issues of access and success in the sciences in South African higher education in general. The final component of this section also considers the implications of this study for the field of educational research.

11.3.1 Conceptual model of epistemological access in science and science-related fields

In this generalised model of epistemological access in the sciences in higher education, I propose that there are two forms or levels of access, and cognisance of both is necessary for student success (Figure 11.2). The first level represents access to the 'goods' or powerful knowledge of specialised discourses of fields or disciplines that have epistemological concerns, and is referred to as epistemic access. Access at this level is not only to theoretical propositional knowledge, but also to underpinning norms, values and practices, and requires that the student becomes a certain kind of person for the given field/disciplinary context. In this regard, knowledge types, knowledge practices and knowers are differentially legitimated depending upon the field or discipline. Since acquiring powerful specialised knowledge is the main purpose of higher education, this epistemic access forms the fundamental core of epistemological access in the sciences.

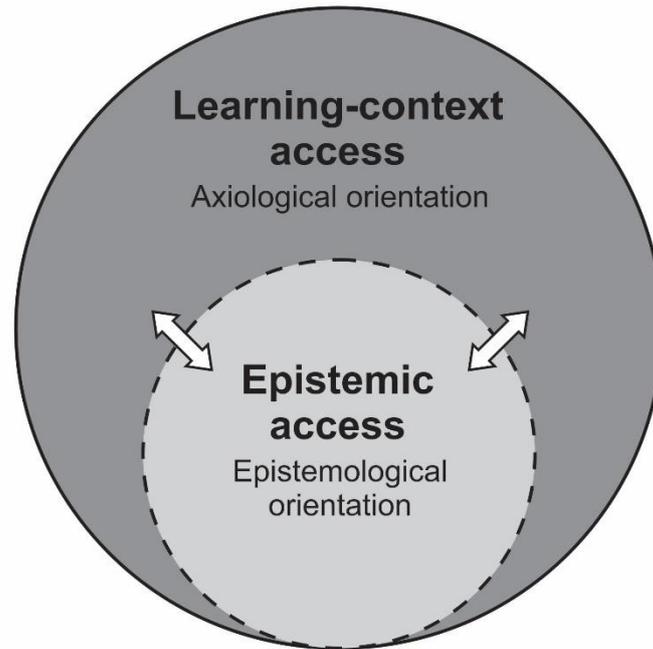


Figure 11.2: Generalised conceptual model of epistemological access in the sciences

However since academic success is influenced by both the mastery of specialised knowledge *and* the ‘capacity to be in control of one’s own learning’ (Edwards 2015, p14), access at the epistemic level may well be constrained, as this study has shown, by poor access at the broader learning-context level. This focus on learning, which has axiological concerns, is about becoming a particular kind of learner in a particular academic context, and is referred to as learning-context access. For example, because ISCM is a science foundation course, the learning-context access is about becoming and being an independent and self-regulated science learner or knower (in preparation for mainstream where considerably less support is available in this regard). In an engineering course, for example, having the ability to solve problems in a range of contexts may instead be a key component of the learning context.

In terms of these two levels I return again to Morrow’s (2009) definition of epistemological access, which he states is about learning ‘how to become a participant in an academic practice’ and that this requires learning ‘the intrinsic disciplines and constitutive standards of the practice’ (ibid. p77). In Chapter 3, I outlined Le Grange’s (2010) and Slonimsky’s (2010) arguments that Morrow was referring to a normative practice that is underpinned by normative, internal rules such as the epistemic values of a field or discipline – the practices thus being of an epistemic discipline or field. In terms of the proposed model this is equivalent to epistemic access, which is only half the picture. The learning context of academia has associated with it a range of practices, many of which do not necessarily have a warranting epistemic logic

but rather are based on a common set of activities. This is a 'regularities' view of practice and the practices associated with academic learning context are an example of this. I am therefore proposing both a normative *and* a regularities view of practice in this model. The reason this is relevant is that the normative (epistemic-context) aspects are, in essence, non-negotiable, but the regularities (learning-context) aspects are influenced by the purpose of the course and the values of the recontextualising agents. As such there is room in the regularities practices to better accommodate students' backgrounds and needs.

At a conceptual level, this model is very similar to the 4-layered nested model of university readiness of Conley (2008) that has been adapted by Wilson-Strydom (2010), and the hierarchal model of contexts of situation and culture used by literacy theorists (see Clark and Ivanič 1997; Boughey 2005¹). I point out these similarities to indicate that a hierarchical and tiered concept of learning and access is not necessarily new. However, I do think this clear conceptualisation of two strongly interlinked components, epistemic and learning-context access, provide a useful frame for considering the complexities of attaining epistemological access in the sciences, and possibly other fields, in higher education. The two components are either usually conflated in the literature or only one or the other is considered in any particular study.

11.3.2 Implications for practice: Transformation of higher education pedagogy

The implications of this study for our understanding of higher education practices in the sciences in the current South African context are considered in this section. The discussion focuses on epistemological access across a science degree rather than at only a foundation level.

Science legitimates specialised disciplinary knowledge. In Chapter 4 I used the arguments of Young (2008a, 2008b) and Wheelahan (2010) and others to show that such knowledge is powerful knowledge as its abstraction from context allows us to think beyond immediate context and personal experience and provides a basis for generalisation. It follows that access of the educationally disenfranchised to this knowledge would serve to empower, and courses that do not offer theoretical knowledge as their core would simply result in further marginalisation. I therefore argue that the 'core' of the epistemological access model should remain inviolate; students need epistemic access to 'transcend the limitations of everyday experience and develop critical awareness of the forces structuring their own lives' (Beck 2014, p72). As Young suggests, this may be the 'epistemological price' we have to pay to better understand the world (2008a, p6). I therefore contend that, for students to become and be scientists and have scientific ways of thinking, it requires some level of socialisation and enculturation. Likewise,

¹ Boughey's work draws on Halliday's Systemic Functional Linguistics, which is now commonly used by LCT theorists.

because of the close links between the learning-context knower and the epistemic-context knower, I also contend that some socialisation is needed at the learning-context level to ensure success in science academia, although I have suggested this level could be more accommodating of students' backgrounds, coding orientations and needs.

Foucault (1969, 1980) would suggest that such socialisation processes are being used to 'tame' the potentially unruly forces in society or, to use a more appropriate and contemporary expression in the South African higher education context, to 'colonise' the minds of students (Fanon 1961; Mamdani 1993; Mbembe 2015). In LCT terms, colonisation could be conceived as expecting students to conform to new coding orientations of the academic context that are different to their prior coding orientations – likely eliciting some form of code clash. As indicated previously, the manifestation of such code clashes is harsh for many and overcoming them requires considerable agential, emotional and other resources (Pym and Kapp 2011), often at the expense of existing identities (De Kadt and Mathonsi, 2003). This raises the question as to how our science courses can ensure access to the powerful science knowledge, but better accommodate student backgrounds, norms, practices and identities, as well as better acknowledge the difficult process of ontological becoming and being in a higher education context, and therefore provide much more appropriate support in this regard. It appears the answer would lie in transformative pedagogies of empathy and care that take into account difference and diversity.

Transformative pedagogies are concerned with making allowances for student educational and cultural backgrounds (see Trifonas 2003; Archer 2010; Fataar 2010) and coding orientations (see Morais, Neves and Pires 2004; Hoadley and Muller 2010), as well as the strengths and agential resources that students bring with them (see Zepke and Leach 2005; Marshall and Case 2010; Case 2013; Ellery and Baxen 2015). Working from a social justice perspective, and referring to pedagogies of 'possibility', Leibowitz (2009) provides a useful frame for how this can be achieved. She draws on Fraser's (2009) three dimensions of social justice to achieve parity of participation for all students through *distribution*, which relates to fair distribution of material resource; *participation*, which relates to opportunities for representation in a pedagogic sense; and *recognition*, which relates to respect for culture and identity and, I would suggest, coding orientations.

In this context, I return to the need to provide access to powerful knowledge and the findings of this study. Because science has a hierarchical knowledge structure and usually legitimates a knowledge code there are certain structural constraints to curriculum and pedagogy in the recontextualisation process. However, since the findings from this study indicate that learning-context social relations are key for success, the same attention needs to be given to them as

epistemic relations. Work in this study has shown that (a) a broad-based curriculum that includes not only disciplinary knowledge but also scientific literacies and academic practices knowledge, and (b) mixed modalities in pedagogy and assessment that accommodate students with 'different' coding orientations (through explicit instruction, using a structured and hierarchical approach, being empathetic to needs of students from a range of backgrounds, and careful consideration of volume and pace of work) are needed to promote better epistemic and learning-context access in the sciences to students from diverse backgrounds.

A detailed study by Case (2013) of student learning and morphogenesis of agency in the chemical engineering field in the South African context has resulted in similar findings to those I have proposed here. Case suggests that specified demands of the field and structural constraints of knowledge mean the course will continue to have a focus on engineering knowledge, but she also argues for 'significant structural and cultural change' that allows for 'true agential morphogenesis' and a 'new basis for legitimation' instead of the current one based in 'surviving' the huge volumes and high pace of work (ibid. pp134–135). Her summary points to a curriculum that 'offers strong fundamentals, more open-ended and up-to-date engagement and a sensible pacing of material' (ibid. p136).

The two-tiered conceptual model of epistemological access in the sciences has thus helped identify not only a normative component of epistemic knowledge, but also a regularities learning-context component without which access and success is unlikely. Traditionally a learning-context component does not form part of mainstream science curricula. As Case (2013) suggests, some space would need to be created in the current content-laden courses to accommodate more inclusive and caring pedagogies and, as has been identified here, learning-context social relations. Whilst this represents a weakening of epistemic relations and strengthening of learning-context social relations, it is not a suggestion to move away from the knowledge code that is central, but rather a shift in emphasis to better accommodate a learning-context knower code. A similar suggestion is made in a recent study on knowledge and knowers in Accounting by Mkhize (2015), and the extent of shift would depend on the context and purpose of the curriculum and the background context of students.

Since attention to learning-context social relations represents a considerable change in our current thinking in higher education in science, accommodating both an epistemic-context knowledge code and a learning-context knower code, it would be a productive and important area of research in the South African context. The idea of an additional year of study in our degrees (see CHE Report 2013) could provide curriculum space to accommodate inclusive curricula and pedagogies, although it needs reiterating that a much more empathetic and caring approach by staff, with greater focus on social relations than at present, is required in this time

of transition. Central to this notion of inclusion is the need to accommodate *all* students, which would obviate the need for separate extended curriculum programmes.

11.3.3 Contribution to field of educational research

This study has implications for the field of educational research in which it is located. Although Bernstein's work has been widely and productively used in educational research for a number of decades, LCT is a relatively new and rapidly growing field. Consequently, it is not that unusual to use LCT in slightly different ways than in previous research, which makes it both an exciting and a challenging theory to work with. There were three main areas of this research that I think contribute to a general broadening of how both LCT and Bernstein's work can be used and understood in the educational field. These three areas were also, understandably, my biggest sites of struggle.

The first contribution is linked to knowledge differentiation. Typically, empirical studies examining curricula based on epistemic relations use a broad-brush knowledge categorisation, with theoretical (disciplinary) knowledge having relatively strong epistemic relations (ER+) and everyday or practical knowledge relatively weak epistemic relations (ER-; see Clarence 2014; Maton 2014a, chpt2; Arbee 2012). However, most curricula exhibit more nuanced knowledge differentiation, and scholarship on professional and vocational curricula has led the way in this regard (see Gamble 2009; Muller 2009; Shay et al. 2011; Wolff and Lockett 2013). Identification of differentiated knowledge types in ISCM opened the space to comment on a differentiated curriculum using the Semantics dimension. Although Shay's (2013, 2014) reading of vocational curricula was used as a guide, the use of the Semantics plane to interpret a curriculum dominated by scientific literacies and disciplinary knowledge type, as in this study, would appear to be novel and also useful as it provides a frame for justification of weakening and/or strengthening of legitimisation of knowledge and knower codes depending upon the purpose of the curriculum.

The second contribution is linked to the recognition of levels of concern in ISCM, based on epistemological (epistemic-context) and axiological (learning-context) orientations. As has been mentioned, although these two sets of concerns are always present in an educational field of practice, studies are usually focused on either one or the other. Therefore, by examining them together it allows for a more holistic and nuanced analysis of educational practices. As such, both an epistemic-context knowledge code and a learning-context knower code are being legitimated in ISCM. The evidence suggests there are competing demands between the two codes and it is proving difficult for students to judge when knowledge code or knower code responses are being called for. Likewise, by distinguishing epistemic- and learning-context levels of student acquisition of recognition and realisation rules in this study, it provides the

necessary subtleties to identify the main site of student struggle – at the level of the learning-context knower. This highlights a somewhat unusual finding for educators in the sciences – that learning-context social relations are key to enabling access and success. Consideration of the two sets of concerns also allow for recognition of a two-tiered conceptual model of epistemological access. It also paved the way for my argument for two forms of cultivated as opposed to trained gaze.

The third contribution relates to the approach used in this study to ‘measure’ and understand epistemological access. Traditionally, epistemological access studies work at the level of the empirical and actual, inferring access by drawing on student experiences of particular educational practices or on student performance data such as pass and throughput rates. Using Bernstein’s concept of acquisition of recognition and realisation rules to examine student texts, and combining it with in-depth interview data as well as student performance data based on marks, provided three sets of empirical and actual data that together gave triangulated insights into codes that were operating at the level of the real and therefore influencing access. I therefore propose that the approach used in this study is a relatively concrete way of ‘operationalising’ epistemological access and is particularly useful as it provides insights into underpinning mechanisms that may be enabling or constraining access.

11.4 Personal concluding comment

This study was initiated because of a strong personal desire to better understand and theorise student learning in the context in which I work, and was underpinned by a social justice agenda of better inclusion of educationally-disenfranchised students into the current higher education system in South Africa. As expected in a doctoral study, it has been an extremely challenging project intellectually, but it has also been one of the most rewarding and transformative experiences in my career as an educationist. Essentially I am a science ‘knower’, but the ‘grapple’ work that I have had to engage in to understand, apply and articulate social theory in an educational context has certainly resulted in considerable shift towards becoming (but perhaps not yet quite being) a social realist educational ‘knower’. The personal aspect of the doctoral study has therefore certainly delivered more than expected. Furthermore, through the use of a depth ontology of a social realist framework and developing alternative external languages of description, I trust that this study will also prove useful in allowing us to think somewhat differently about access and success of students in the sciences, and also have an influence on higher education practice in productive and transformative ways that are required in these demanding yet exciting times.

References

- Adebajo, A. 2015. No. 327: Debate over Rhodes is one of transformation. *Business Day*, 23 March 2015. Available: <http://www.ccr.org.za/index.php/media-release/in-the-media/newspaper-articles/item/1296-debate-over-rhodes-is-one-of-transformation?tmpl=component&print=1> [Accessed 15 November 2015].
- Adendorff, H. and Lutz, H. 2009. Factors influencing the learning process in first-year Chemistry. In B. Leibowitz, A. Van der Merwe and S. Van Schalkwyk (eds) *Focus on first-year success*. Stellenbosch: Sun Media, pp167–180.
- Allie, S., Armien, M.N., Burgoyne, N., Case, J.M., Collier-Reed, B.I., Craig, T.S., Deacon, A., Fraser, D.M., Geyer, Z., Jacobs, C., Jawitz, J., Kloot, B., Kotta, L., Langdon, G., Le Roux, K., Marshall, D., Mogashana, D., Shaw, C., Sheridan, G. and Wolmarans, N. 2009. Learning as acquiring a discursive identity through participation in a community: Improving student learning in engineering education. *European Journal of Engineering Education*, 34(40), 359–367.
- Apple, M.W. 2006. *Educating the 'right' way*, 2nd ed. New York: Routledge.
- Arbee, A. 2012. *Knowledge and knowers in the discipline of Marketing at the University of KwaZulu-Natal*. Unpublished PhD dissertation, Rhodes University, Grahamstown.
- Archer, A. 2010. Shamanism and science: Curriculum as reciprocal and transformative. *Education as Change*, 14(1), 61–75.
- Archer, M.S. 1998. Introduction: Realism in the social sciences. In M. Archer, R. Bhaskar, A. Collier, T. Lawson and A. Norrie (eds) *Critical realism: Essential readings*. Abingdon, Oxon: Routledge, pp189–205.
- Annot, M. and Reay, D. 2004. The framing of pedagogic encounters: regulating the social order in classroom learning. In J. Muller, B. Davies and A. Morais (eds) *Reading Bernstein, researching Bernstein*. London: RoutledgeFalmer, pp136–152.
- Arum, R., Gamoran, A. and Shavit, Y. 2012. Expanded opportunities for all in global higher education systems. In L. Weis and N. Dolby (eds) *Social class and education: Global perspectives*. New York: Routledge, pp15–36.
- Badat, S. 2015. Address at Commerce Faculty graduation ceremony at Rhodes University, 10 April 2015 Available: <http://ruconnected.ru.ac.za/mod/forum/discuss.php?d=61829> [Accessed 11 April 2015].
- Ballard, B. and Clanchy, J. 1988. Literacy in the university: an 'anthropological' approach. In G. Taylor, B. Ballard, V. Beasley, H. Bock, J. Clanchy and P. Nightingale (eds) *Literacy by Degrees*. Milton Keynes: SRHE and Open University Press, pp7–23.
- Barnett, R. 2000. *Realising the university in an age of supercomplexity*. Maidenhead, Berkshire: SRHE and Open University Press.
- Barnett, R. 2004. Learning for an unknown future. *Higher Education Research and Development*, 23(3), 247–260.

- Barnett, R. 2007. *A will to learn: Being a student in an age of uncertainty*. Maidenhead, Berkshire: SRHE and Open University Press.
- Barnett, R. 2009. Knowing and becoming in the higher education curriculum. *Studies in Higher Education*, 34(4), 429–440.
- Barton, D. 1994. *Literacy: An introduction to the ecology of written language*. Oxford: Blackwell.
- Bassey, M. 1999. *Case study research in educational settings*. Maidenhead, Berkshire: SRHE Open University Press.
- Beck, J. 2014. Powerful knowledge, esoteric knowledge, curriculum knowledge. In B. Barrett and E. Rata (eds) *Knowledge and the future of the curriculum: International studies in social realism*. Basingstoke: Palgrave Macmillan, pp65–75.
- Bernstein, B. 1961. Social class and linguistic development: a theory of social learning. In A.H. Halsey, J. Floud and C.A. Anderson (eds) *Education, economy and society*. New York: Free Press, pp288–314.
- Bernstein, B. 1975. *Class, codes and control. Volume III: Towards a theory of educational transmissions*. London: Routledge and Kegan Paul.
- Bernstein, B. 1990. *Class, Codes and Control, Volume IV: The structuring of pedagogic discourse*. London: Routledge.
- Bernstein, B. 1999. Vertical and horizontal discourse: An essay. *British Journal of Sociology of Education*, 20(2), 157–173.
- Bernstein, B. 2000. *Pedagogy, symbolic control, and identity: Theory, research, critique*. Lanham: Rowman and Littlefield.
- Bhaskar, R. 1998. *The possibility of naturalism: A philosophical critique of the contemporary human sciences*. Brighton: Harvester Wheatsheaf.
- Bhaskar, R. 2008 [1975]. *A realist theory of science*. London: Routledge.
- Bhattacharya, A. and Chauhan, K. 2010. Augmenting learner autonomy through blogging. *ELT Journal*, 64(4), 376–384.
- Black, P., Harrison, C., Lee, C., Marshall, B. and William, D. 2003. *Assessment for learning*. Maidenhead, Berkshire: Open University Press.
- Blackie, M.A. 2014. Creating semantic waves: using Legitimation Code Theory as a tool to aid the teaching of chemistry. *Chemistry Education Research and Practice*, 15(4), 462–469.
- Blackie, M.A., Case, J.M. and Jawitz, J. 2010. Student-centredness: The link between transforming students and transforming ourselves. *Teaching in Higher Education*, 15(6), 637–646.
- Bloom, B.S. and Committee of College and University Examiners, 1956. *Taxonomy of educational objectives*. New York: David McKay.
- Bouhey, C. 2000. Multiple metaphors in an understanding of academic literacy. *Teachers and Teaching*, 6(3), 279–290.

- Boughey, C. 2002. 'Naming' students' problems: an analysis of language-related discourses at a South African university. *Teaching in Higher Education*, 7(3), 295–307.
- Boughey, C. 2003. From equity to efficiency: Access to higher education in South Africa. *Arts and Humanities in Higher Education*, 2(1), 65–71.
- Boughey, C. 2005. 'Epistemological' access to the university: an alternative perspective. *South African Journal of Higher Education*, 19(3), 230–242.
- Boughey, C. 2007a. Educational development in South Africa: From social reproduction to capitalist expansion? *Higher Education Policy*, 20(1), 5–18.
- Boughey, C. 2007b. *Constructing foundation work: A critical discourse analysis of the 2006 submissions for funding*. Conference paper, Conversations about Foundation and Extended Curriculum Provision seminar, Cape Town, October 2007.
- Boughey, C. 2008. Texts, practices and student learning: A view from the South. *International Journal of Educational Research*, 47(3), 192–199.
- Boughey, C. 2009. *Extended programmes at Rhodes University*. Internal report, Rhodes University, Grahamstown.
- Boughey, C. 2012. The significance of structure, culture and agency in supporting and developing student learning at South African universities. In R. Dhunpath and R. Vithal (eds) *Alternative access to higher education: Underprepared students or underprepared institutions?* Cape Town: Pearson, pp62–88.
- Boughey, C. and Niven, P. 2012. The emergence of research in the South African academic development movement. *Higher Education Research and Development*, 31(5), 641–653.
- Bourdieu, P. 2010 [1986]. The forms of capital. In I. Szeman and T. Kaposy (eds) *Cultural theory: An anthology*. Hoboken, New Jersey: Wiley-Blackwell, pp81–93.
- Bradbury, J. and Miller, R. 2011. A failure by any other name: The phenomenon of underpreparedness. *South African Journal of Science*, 107(3–4), 1–8.
- Brown, S. and Glasner, A. 1999. *Assessment matters in higher education*. Buckingham: Open University Press.
- Calhoun, C. 2006. The university and the public good. *Thesis Eleven*, 84(1), 7–43.
- Case, J.M. 2013. *Researching student learning in higher education: A social realist approach*. London: Routledge.
- Case, J.M. 2015. A social realist perspective on student learning in higher education: the morphogenesis of agency. *Higher Education Research and Development*, forthcoming, DOI: 10.1080/07294360.2015.1011095.
- Case, J.M. and Marshall, D. 2006. *New ways of characterising the student learning experience: an identification of students' Discourse models*. Conference paper, Higher Education Close Up 3 Conference, Lancaster, July 2006.

- Chanock, K., Horton, C., Reedman, M. and Stephenson, B. 2012. Collaborating to embed academic literacies and personal support in first year discipline subjects. *Journal of University Teaching and Learning Practice*, 9(3). Available: <http://ro.uow.edu.au/jutlp/vol9/iss3/3> [Accessed 10 May 2015].
- Chavez, C. 2008. Conceptualizing from the inside: Advantages, complications, and demands on insider positionality. *The Qualitative Report*, 13(3), 474–494.
- CHE (Council on Higher Education) Report, 2004. *South African Higher Education in the first decade of democracy*. Pretoria: CHE.
- CHE (Council on Higher Education) Report, 2011. *Framework for the second cycle of quality assurance 2012–2017*. Pretoria: CHE.
- CHE (Council on Higher Education) Report, 2013. *A proposal for undergraduate curriculum reform in South Africa: The case for a flexible curriculum structure*. Pretoria: CHE.
- Chen, R.T. 2010. *Knowledge and knowers in online learning: Investigating the effects of online flexible learning on student sojourners*. Unpublished PhD dissertation, University of Wollongong, Australia.
- Chen, R.T. and Maton, K. 2014. LCT and qualitative research: Creating a language of description to study constructivist pedagogy. In K. Maton, S. Hood and S. Shay (eds) *Knowledge-building: Educational studies in Legitimation Code Theory*. London: Routledge, forthcoming, pp1–37 (draft form).
- Clarence, S.L. 2014. *Enabling cumulative knowledge-building through teaching: A Legitimation Code Theory analysis of pedagogic practice in Law and Political Science*. Unpublished PhD dissertation, Rhodes University, Grahamstown.
- Clark, R. and Ivanič, R. 1997. *The politics of writing*. London: Routledge.
- Clegg, S. 2009. Forms of knowing and academic development practice. *Studies in Higher Education*, 34(4), 403–416.
- Cohen, L., Manion, L. and Morrison, K. 2011. *Research methods in education*. Abingdon, Oxon: Routledge.
- Conley, D.T. 2008. Rethinking college readiness. *New Directions for Higher Education*, 144, 3–13.
- Cooper, D. 2015. Social justice and South African university student enrolment data by ‘race’, 1998–2012: From ‘skewed revolution’ to ‘stalled revolution’. *Higher Education Quarterly*, 69(3), 237–262.
- Costley, C. and Gibbs, P. 2006. Researching others: care as an ethic for practitioner researchers. *Studies in Higher Education*, 31(1), 89–98.
- Craig, A.P. 2001. Education for all. *South African Journal of Higher Education*, 10(2), 47–55.
- Creswell, J.W. 2007. *Qualitative inquiry and research design: Choosing among five approaches*, 2nd ed. Thousand Oaks, California: Sage Publications.

- Creswell, J.W. 2013. *Research design: Qualitative, quantitative, and mixed methods approaches*, 4th ed. Thousand Oaks, California: Sage Publications.
- Curriculum Development Report, 2007. *Curriculum development: The Introduction to Science Concepts and Methods (ISCM) course*. Internal Report, SESP, Rhodes University, Grahamstown.
- Dall’Alba, G. and Barnacle, R. 2007. An ontological turn for higher education. *Studies in Higher Education*, 32(6), 679–691.
- Danermark, B., Ekström, M., Jakobsen L. and Karlsson J. Ch, 2002. *Explaining society: Critical realism in the social sciences*. Abingdon, Oxon: Routledge.
- De Beer, K. 2006. Open access, retention and throughput at the Central University of Technology. *South African Journal of Higher Education*, 20(1), 31–45.
- De Kadt, E. and Mathonsi, N. 2003. Writing in English with an ‘African voice’: Ownership, identity and learning. *Journal for Language Teaching*, 37(1), 92–103.
- De Klerk, E., van Deventer, I. and van Schalkwyk, S. 2006. Small victories over time: The impact of an academic development intervention at Stellenbosch University. *Education as Change*, 10(2), 149–169.
- Denzin, N.K. and Lincoln, Y.S. 2008. Introduction: The discipline and practice of qualitative research. In N.K. Denzin and Y.S. Lincoln (eds) *The landscape of qualitative research*, 3rd ed. London: Sage Publications, pp1–20.
- Dhunpath, R. and Vithal, R. 2012. Alternative access to university: Past, present and future. In R. Dhunpath and R. Vithal (eds) *Alternative access to higher education: Underprepared students or underprepared institutions?* Cape Town: Pearson, pp2–25.
- Dickinson, L. 1993. Talking shop: Aspects of autonomous learning. *ELT Journal*, 47(4), 330–336.
- Dison, A. 1997. The acquisition and use of literacies within social contexts: Tsholo Mothibi's story. *Academic Development*, 3(2), 53–74.
- Downs, C. 2005. Is a year-long access course into university helping previously disadvantaged black students in biology? *South African Journal of Higher Education*, 19(4), 666–683.
- Downs, C. 2010. Increasing equity and compensating historically academically disadvantaged students at a tertiary level: Benefits of a Science Foundation Programme as a way of access. *Teaching in Higher Education*, 15(1), 97–107.
- Durkheim, E. 1959 [1912]. *The Elementary Forms of the Religious Life*, Trans. by Karen Fields [1995]. New York: Free Press.
- Easton, G. 2010. Critical realism in case study research. *Industrial Marketing Management*, 39(1), 118–128.
- Edwards, A. 2015. Designing tasks which engage learners with knowledge. In I. Thompson (ed) *Designing tasks in secondary education: Enhancing subject understanding and student engagement*. Abingdon, Oxon: Routledge, pp13–27.

- Ellery, K. 2008a. Assessment for learning: a case study using feedback effectively in an essay-style test. *Assessment and Evaluation in Higher Education*, 33(4), 421–429.
- Ellery, K. 2008b. Undergraduate plagiarism: a pedagogical perspective. *Assessment and Evaluation in Higher Education*, 33(5), 507–516.
- Ellery, K. 2011. Knowing, acting and being: Epistemological and ontological access in a science extended studies course. *South African Journal of Higher Education*, 25(6), 1077–1090.
- Ellery, K. and Baxen, J. 2015. 'I always knew I would go to university': A social realist account of student agency. *South African Journal of Higher Education*, 29(1), 91–107.
- Ellery, K., Ellery, W.N., Rogers, K.H. and Walker, B.H. 1991. Water depth and biotic insulation: Major determinants of back-swamp plant community composition. *Wetlands Ecology and Management*, 1(3), 149–162.
- Engelbrecht, J., Harding, A. and Phiri, P. 2010. Are OBE-trained learners ready for university mathematics? *Pythagoras*, 72, 3–13.
- Ensor, P. 2004. Towards a sociology of teacher education. In J. Muller, B. Davies and A. Morais (eds) *Reading Bernstein, researching Bernstein*. London: RoutledgeFalmer, pp153–167.
- ESU (Extended Studies Unit) Review Purpose Statement, 2011. *Extended Studies Programme: purpose statement*. Internal Report, Rhodes University, Grahamstown.
- Extended Programmes at Rhodes University: Review Report, 2010. *Extended Programmes at Rhodes University*. Internal Report, Rhodes University, Grahamstown.
- Fairclough, N. 2005. Peripheral vision discourse analysis in organization studies: The case for critical realism. *Organization Studies*, 26(6), 915–939.
- Falchikov, N. 2005. *Improving assessment through student involvement: practical solutions for aiding learning in higher and further education*. London: RoutledgeFalmer.
- Fanon, F. 1952. *Black skin, white masks*. Trans. by C. Markmann [1967]. New York: Grove Press.
- Fanon, F. 1961. *The wretched of the earth*. Trans. by C. Farrington [1963]. New York: Grove Press.
- Fataar, A. 2010. Student being and becoming at the university: A response from the perspective of a reflexive sociology of teacher education. *South African Journal of Higher Education*, 24(2), 318–330.
- Fisher, G. and Scott, I. 2011. Background paper 3: The role of higher education in closing the skills gap in South Africa. *Closing the skills and technology gap in South Africa*. Washington DC: The World Bank.
- Flyvbjerg, B. 2006. Five misunderstandings about case-study research. *Qualitative Inquiry*, 12(2), 219–245.
- Foucault, M. 1969. *The archaeology of knowledge*. Trans. A.M. Sheridan Smith [1972]. New York: Pantheon.

- Foucault, M. 1980. *Power/knowledge: Selected interviews and other writings, 1972–1977*. In C. Gordon (ed). Trans. by C. Gordon, L. Marshall, J. Mepham and K. Soper [1980]. Brighton: Harvester.
- Fraser, N. 2009. *Scales of justice: Reimagining political space in a globalizing world*. New York: Columbia University Press.
- Freebody, P., Maton, K. and Martin, J. 2008. Talk, text, and knowledge in cumulative, integrated learning: A response to 'intellectual challenge'. *Australian Journal of Language and Literacy*, 31(2), 188–201.
- Frith, V. and Gunstone, G. 2011. Towards understanding the quantitative literacy demands of a first-year medical curriculum. *African Journal of Health Professions Education*, 3(1), 19–23.
- Gamble, J. 2004. Retrieving the general from the particular: The structure of craft knowledge. In J. Muller, B. Davies and A. Morais (eds) *Reading Bernstein: Researching Bernstein*. London: RoutledgeFalmer, pp189–203.
- Gamble, J. 2006. Theory and practice in the vocational curriculum. *Knowledge, curriculum and qualifications for South African further education*. Cape Town: HSRC Press, pp87–103.
- Gamble, J. 2009. *The relation between knowledge and practice in curriculum and assessment*. Concept paper commissioned by Umalusi. Available: <http://www.umalusi.org.za/docs/research/2009/jgamble.pdf> [Accessed 8 November 2014].
- Gamble, J. 2010. Exploring the transmission of moral order as invisible semiotic mediator of tacit knowledge. In P. Singh, A.R. Sadovnik and S.F. Semel (eds) *Toolkits, translation devices and conceptual accounts*. New York: Peter Lang, pp121–141.
- Garton, S. and Copland, F. 2010. 'I like this interview; I get cakes and cats!': The effect of prior relationships on interview talk. *Qualitative Research*, 10(5), 533–551.
- Gee, J.P. 1989. Literacy, discourse, and linguistics: Introduction. *Journal of Education*, 117(1), 5–17.
- Gee, J.P. 1990. *Social linguistics and literacies: Ideology in discourse*. New York: Routledge.
- Gee, J.P. 1999. *The new literacy studies and the 'social turn'*. Available: <http://files.eric.ed.gov/fulltext/ED442118.pdf> [Accessed 7 September 2011].
- Gee, J.P. 2001. Identity as an analytic lens for research in education. *Review of Research in Education*, 25, 99–125.
- Gee, J.P. 2005. *An introduction to discourse analysis: Theory and method, 2nd ed*. London: Routledge.
- Gee, J.P. 2012. *Social linguistics and literacies: Ideology in discourse, 4th ed*. Abingdon, Oxon: Routledge.
- Geirsdóttir, G. 2008. *Academics as creators of imaginary subjects: On academics' ideas of their disciplinary curriculum decision-making*. Conference paper, Fifth international Basil Bernstein symposium, Cardiff University, Cardiff, 2008.

- Georgiou, H., Maton, K. and Sharma, M. 2014. Recovering knowledge for science education research: Exploring the “Icarus Effect” in student work. *Canadian Journal of Science, Mathematics and Technology Education*, 14(3), 252–268.
- Giroux, H. 2002. Neoliberalism, corporate culture and the promise of higher education: the university as a democratic public sphere. *Harvard Educational Review*, 72(4), 1–31.
- Gosling, D. 2009. *Report on the survey of directors of academic development in South African universities*. Report commissioned by the AD leadership Forum within HELTASA. Stellenbosch: HELTASA.
- Grayson, D.J. 1996. A holistic approach to preparing disadvantaged students to succeed in tertiary science studies (Part I) Design of the Science Foundation Programme (SFP). *International Journal of Science Education*, 18(8), 993–1013.
- Grayson, D.J. 1997. A holistic approach to preparing disadvantaged students to succeed in tertiary science studies (Part II) Outcomes of the Science Foundation Programme. *International Journal of Science Education*, 19(1), 107–123.
- Hall, M. 2006. *Transformation and continuity in the university in Africa*. Overview of the University in Africa Symposium, 21 October, University of Cape Town, Cape Town.
- Hammersley, M. 2012. Troubling theory in case study research. *Higher Education Research and Development*, 31(3), 393–405.
- Hand, B., Lawrence, C. and Yore, L.D. 1999. A writing-in-science framework designed to enhance science literacy. *International Journal of Science Education*, 21(10), 1021–1035.
- Hatch, J.A. 2002. *Doing qualitative research in education settings*. New York: State University of New York Press.
- Heath, S.B. 1983. *Ways with words: Language, life and work in communities and classrooms*. Cambridge: Cambridge University Press.
- Hoadley, U.K. 2005. *Social class, pedagogy and the specialization of voice in four South African primary schools*. Unpublished PhD dissertation, University of Cape Town, Cape Town.
- Hoadley, U.K. 2007. The reproduction of social class inequalities through mathematics pedagogies in South African primary schools. *Journal of Curriculum Studies*, 39(6), 679–706.
- Hoadley, U.K. 2008. Social class and pedagogy: A model for the investigation of pedagogic variation. *British Journal of Sociology of Education*, 29(1), 63–78.
- Hoadley, U.K. and Muller, J. 2010. Codes, pedagogy and knowledge. In M.W. Apple, S.J. Ball and L.A. Gandin (eds) *The Routledge international handbook of the sociology of education*. New York: Routledge, pp69–78.
- Holtman, L. and Marshall, D. 2008. Foundational provisions in the UWC Science Faculty: Widening access and promoting success. In L. Holtman, C. Julie, Ø. Mikalsen, D. Mtetwa and M. Ogunniyi (eds) *Some developments in research in science and mathematics in Sub-Saharan Africa: Access, relevance, learning, curriculum research*. Somerset West: African Minds, pp73–106.

- Holtman, L., Marshall, D. and Linder, C. 2004. Widening (epistemological) access: Two undergraduate science courses. In H. Griesel (ed) *Curriculum responsiveness: Case studies in higher education*. Pretoria: South African Universities Vice-Chancellor's Association, pp185–216.
- Holtman, L. and Rollnick, M. 2010. Research on teaching and learning in access courses. In M. Rollnick (ed) *Identifying potential for equitable access to tertiary level science*. Dordrecht: Springer, pp109–133.
- Humphrey, S. and Robinson, S. 2012. *Resourcing teachers to ride the semantic wave to whole school literacy development*. Joint AARE APERA International Conference, Sydney, 2012. Available: <http://files.eric.ed.gov/fulltext/ED544510.pdf> [Accessed 1 November 2015].
- Iverson, G. 2002. *Instructional and regulative discourses: A comparative case study of two classroom settings designed to ameliorate boys' underachievement in English*. Cardiff University School of Social Sciences, Working Paper Series, Paper 29.
- Jacobs, C. 2005. On being an insider on the outside: New spaces for integrating academic literacies. *Teaching in Higher Education*, 10(4), 475–487.
- Jacobs, C. 2007. Towards a critical understanding of the teaching of discipline-specific academic literacies: Making the tacit explicit. *Journal of Education*, 41, 59–82.
- Jacobs, C. 2013. Academic literacies and the question of knowledge. *Journal for Language Teaching*, 47(2), 127–139.
- Jasper, M.A. 2005. Using reflective writing within research. *Journal of Research in Nursing*, 10(3), 247–260.
- Jones S. 1995. Teach the ones you're with. *American Physical Society News*. Available: <http://www.aps.org/publications/apsnews/199507/teach.cfm> [Accessed 13 July 2013].
- Jónsdóttir, S.R. and Macdonald, A. 2008. *Regulation and innovation: stimulating students' creativity and thinking through innovation education in Ingunnarskóli*. Conference paper, Nordic Symposium on Teacher Education, Iceland University of Education, Reykjavík, 2008.
- Kilpert, L. and Shay, S. 2013. Kindling fires: examining the potential for cumulative learning in a Journalism curriculum. *Teaching in Higher Education*, 18(1), 40–52.
- Kioko, J. 2009. University of KwaZulu-Natal, Faculty of Science and Agriculture: The Centre for Science Access. In *Success stories in Foundation/Extended Programmes*. South Africa: Heltasa, pp12–22.
- Kioko, J., Barnsley, S. and Jaganyi, D. 2012. Science access: An appraisal of graduation and throughput rates. In R. Dhunpath and R. Vithal (eds) *Alternative access to higher education: Underprepared students or underprepared institutions?* Cape Town: Pearson, pp184–202.
- Kloot, B.C. 2011. *A Bourdieuan analysis of foundation programmes within the field of engineering education: Two South African case studies*. Unpublished PhD dissertation, University of Cape Town, Cape Town.

- Kloot, B.C., Case, J.M. and Marshall, D. 2008. A critical review of the teaching and learning philosophies underpinning science and engineering foundation programmes in South African higher education. *South African Journal of Higher Education*, 22(4), 799–816.
- Kolberg, L. No date. *Case Studies and Generalization*. Available: <https://www.bi.no/upload/Hjemmesider/fgl00076/Paper%20DRE%201002.pdf> [Accessed 27 August 2015].
- Kotta L.T. 2011. *Structural conditioning and mediation by student agency: A case study of success in chemical engineering design*. Unpublished PhD dissertation, University of Cape Town, Cape Town.
- Krathwohl, D.R. 2002. A revision of Bloom's taxonomy: An overview. *Theory into Practice*, 41(4), 212–218.
- Krefting, L. 1991. Rigor in qualitative research: The assessment of trustworthiness. *American Journal of Occupational Therapy*, 45(3), 214–222.
- Lamont, A. and Maton, K. 2008. Choosing music: Exploratory studies into the low uptake of music GCSE. *British Journal of Music Education*, 25(3), 267–282.
- Le Grange, L. 2010. Scripture and practices: A reply to Wally Morrow. In Y. Shalem and S. Pendlebury (eds) *Retrieving teaching: Critical issues in curriculum, pedagogy and learning*. Cape Town: Juta, pp76–86.
- Lea, M.R. and Street, B.V. 1998. Student writing in higher education: An academic literacies approach. *Studies in Higher Education*, 23(2), 157–172.
- Lea, M.R. and Street, B.V. 2006. The 'academic literacies' model: Theory and applications. *Theory into Practice*, 45(4), 368–377.
- Leibowitz, B. 2009. Towards a pedagogy of possibility: Teaching and learning from a 'social justice' perspective. In E. Bitzer (ed) *Higher education in South Africa: A scholarly look behind the scenes*. Stellenbosch: Sun Media, pp85–101.
- Leibowitz, B., van Schalkwyk, S., van der Merwe, A., Herman, N. and Young, G. 2009. In B. Leibowitz, A. Van der Merwe and S. Van Schalkwyk (eds) *Focus on first-year success*. Stellenbosch: Sun Media, pp255–269.
- Letseka, M. and Maile, S. 2008. *High university drop-out rates: A threat to South Africa's future*. Pretoria: Human Sciences Research Council.
- Levidow, L. 2005. Neoliberal agendas for higher education. *Neoliberalism: A critical reader*. Ann Arbor: Pluto Press, pp156–163.
- Lincoln, Y.S. and Guba, E.G. 1985. *Naturalistic inquiry*. Beverly Hills: Sage Publications.
- Liu, Y. and Hong, H. 2009. Regulative discourse in Singapore primary English classrooms: Teachers' choices of directives. *Language and Education*, 23(1), 1–13.
- Longden, B. 2006. An institutional response to changing student expectations and their impact on retention rates. *Journal of Higher Education Policy and Management*, 28(2), 173–187.

- Lubben, F., Allie, S. and Buffler, A. 2010. Experimental Work in Science. In M. Rollnick (ed) *Identifying potential for equitable access to tertiary level science*. Dordrecht: Springer, pp35–152.
- Lubienski, S.T. 2004. Decoding mathematics instruction. In J. Muller, B. Davies and A. Morais (eds) *Reading Bernstein, researching Bernstein*. London: RoutledgeFalmer, pp108–121.
- Luckett, K. and Hunma, A. 2014. Making gazes explicit: Facilitating epistemic access in the humanities. *Higher Education*, 67, 183–198.
- Macnaught, L., Maton, K., Martin, J. and Matruglio, E. 2013. Jointly constructing semantic waves: Implications for teacher training. *Linguistics and Education*, 24(1), 50–63.
- Magubane, Z. 2015. Universities enmeshed in the fabric of colonialism. *Monthly Monday*, May 2015. Available: <http://www.uct.ac.za/mondaypaper/> [Accessed 10 October 2015].
- Mamdani, M. 1993. University crisis and reform: A reflection on the African experience. *Review of African Political Economy*, 20(58), 7–19.
- Mann, S.J. 2008. *Study, power and the university*. Maidenhead, Berkshire: Open University Press.
- Marshall, D. and Case, J.M. 2010. d/Discourse in the learning of physics: The design of an introductory physics curriculum. *African Journal of Research in Mathematics, Science and Technology Education*, 14(2), 15–27.
- Martin, J., Maton, K. and Matruglio, E. 2010. Historical cosmologies: Epistemology and axiology in Australian secondary school history discourse. *Revista Signos*, 43(74), 433–463.
- Matlou, D. 2009. Access for success: alternative admission for selected talented science degree students at the University of the Witwatersrand. In *Success stories in Foundation/Extended Programmes*. South Africa: Heltasa, pp2–11.
- Maton, K. 2000. Languages of legitimation: The structuring significance for intellectual fields of strategic knowledge claims. *British Journal of Sociology of Education*, 21(2), 147–167.
- Maton, K. 2009. Cumulative and segmented learning: Exploring the role of curriculum structures in knowledge-building. *British Journal of Sociology of Education*, 30(1), 43–57.
- Maton, K. 2010. Analysing knowledge claims and practices: Languages of legitimation. In K. Maton and R. Moore (eds) *Social realism, knowledge and the sociology of education: Coalitions of the mind*. London: Continuum, pp35–59.
- Maton, K. 2011. Theories and things: The semantics of disciplinarity. In F. Christie and K. Maton (eds) *Disciplinarity: Functional linguistic and sociological perspectives*. London: Continuum, pp62–84.
- Maton, K. 2014a. *Knowledge and knowers: Towards a realist sociology of education*. New York: Routledge.
- Maton, K. 2014b. Building powerful knowledge: The significance of semantic waves. In B. Barrett and E. Rata (eds) *Knowledge and the future of the curriculum: International studies in social realism*. Basingstoke, Hampshire: Palgrave Macmillan, pp181–197.

- Maton, K. 2016. Legitimation Code Theory: Building knowledge about knowledge-building. In K. Maton, S. Hood and S. Shay (eds) *Knowledge-building: Educational studies in Legitimation Code Theory*. London: Routledge, forthcoming.
- Maton, K. and Moore, R. 2010. Introduction: Coalitions of the mind. In K. Maton and R. Moore (eds) *Social realism, knowledge and the sociology of education: Coalitions of the mind*. London: Continuum, pp1–13.
- Maton, K. and Muller, J. 2007. A sociology for the transmission of knowledges. In F. Christie and J. Martin (eds) *Language, knowledge and pedagogy: Functional linguistic and sociological perspectives*. London: Continuum, pp14–33.
- Maxwell, J.A. 2004. Using qualitative methods for causal explanation. *Field Methods*, 16(3), 243–264.
- Maxwell, J.A. 2012. *Qualitative research design: An interactive approach, 3rd ed*. London: Sage Publications.
- May, R.M. 2011. Science as organized skepticism. *Philosophical transactions. Series A, Mathematical, physical, and engineering sciences*, 369, 4685–4689. Available: rsta.royalsocietypublishing.org/ [Accessed 3 September 2015].
- Mbembe, A. 2015. *Decolonizing knowledge and the question of the archive*. Public lecture at Wits Institute for Social and Economic Research (WISER), University of the Witwatersrand, Gauteng.
- McComas, W.F. 2002. The principal elements of the nature of science: Dispelling the myths. In W.F. McComas (ed) *The nature of science in science education: Rationale and strategies*. New York: Kluwer Academic Publishers, pp53–70.
- McKenna, S. 2003. Changing discourses of academic development at a South African technikon 1991 to 2002: Perspectives on higher education. *South African Journal of Higher Education*, 17(2), 60–67.
- McKenna, S. 2004. The intersection between academic literacies and student identities: Research in higher education. *South African Journal of Higher Education*, 18(3), 269–280.
- McKenna, S. 2010. Cracking the code of academic literacy: An ideological task. In C. Hutchings and J. Garraway (eds) *Beyond the university gates: Provision of extended curriculum programmes in South Africa*. Proceedings of Rhodes University Foundation Seminar, pp8–15.
- McKenna, S. 2012. The context of access and foundation provisioning in South Africa. In R. Dhunpath and R. Vithal (eds) *Alternative access to higher education: Underprepared students or underprepared institutions?* Cape Town: Pearson, pp51–61.
- McLean, M., Abbas, A. and Ashwin, P. 2013. The use and value of Bernstein's work in studying (in) equalities in undergraduate social science education. *British Journal of Sociology of Education*, 34(2), 262–280.
- McNeir, G. 1993. Outcomes-Based Education. *Research Roundup*, 10(1), 2–5.
- Mehl, M. 1988. Academic support: Developmental giant or academic pauper? *South African Journal of Higher Education*, 2(1), 17–20.

- Mercer, J. 2007. The challenges of insider research in educational institutions: Wielding a double-edged sword and resolving delicate dilemmas. *Oxford Review of Education*, 33(1), 1–17.
- Merton, R.K. 1973 [1942]. The normative structure of science. In R.K. Merton (ed) *The sociology of science: Theoretical and empirical investigations*. Chicago: University of Chicago Press, pp267–278.
- Mgqwashu, E. 2012. On teaching reading for epistemological access. In R. Dhunpath and R. Vithal (eds) *Alternative access to higher education: Underprepared students or underprepared institutions?* Cape Town: Pearson, pp238–257.
- Mkhize, T.F. 2015. *An analysis of the Certificate of the Theory of Accounting knowledge and knower structures: A case study of professional knowledge*. Unpublished PhD dissertation, Rhodes University, Grahamstown.
- Moje, E.B. and Luke, A. 2009. Literacy and identity: Examining the metaphors in history and contemporary research. *Reading Research Quarterly*, 14(4), 415–437.
- Moll, I. 2004. Curriculum responsiveness: The anatomy of a concept. In H. Griesel (ed) *Curriculum responsiveness: Case studies in higher education*. Pretoria: South African Universities Vice-Chancellors Association, pp1–20.
- Moore, R. 2000. For knowledge. Tradition, progressivism and progress in education: Reconstructing the curriculum debate. *Cambridge Journal of Education*, 30(1), 17–36.
- Moore, R. and Maton, K. 2001. Founding the sociology of knowledge: Basil Bernstein, intellectual fields and the epistemic device. In A.M. Morais, I.P. Neves, B. Davies and H. Daniels (eds) *Towards a sociology of pedagogy: The contribution of Basil Bernstein to research*. New York: Peter Lang, pp153–182.
- Morais, A.M. 2002. Basil Bernstein at the micro level of the classroom. *British Journal of Sociology of Education*, 23(4), 559–569.
- Morais, A.M. and Atunes, H. 1994. Students' differential text production in the regulative context of the classroom. *British Journal of Sociology of Education*, 15(2), 243–263.
- Morais, A.M. and Miranda, C. 1996. Understanding teachers' evaluation criteria: A condition for success in science classes. *Journal of Science Research in Education*, 33(6), 601–624.
- Morais, A.M. and Neves, I.P. 2001. Pedagogic social contexts: Studies for a sociology of learning. In A.M. Morais, I.P. Neves, B. Davies and H. Daniels (eds) *Towards a sociology of pedagogy: The contribution of Basil Bernstein to research*. New York: Peter Lang, pp186–221.
- Morais, A.M., Neves, I.P. and Afonso, M. 2005. Teacher training processes and teachers' competence: A sociological study in the primary school. *Teaching and Teacher Education*, 21, 415–437.
- Morais, A.M., Neves, I. and Pires, D. 2004. The what and how of teaching and learning: Going deeper into sociological analysis and intervention. In J. Muller, B. Davies and A. Morais (eds) *Reading Bernstein, researching Bernstein*. London: RoutledgeFalmer, pp75–90.
- Morrow, W. 2007. *Learning to teach in South Africa*. Pretoria: HSRC Press.

- Morrow, W. 2009. *Bounds of democracy: Epistemological access in higher education*. Cape Town: Human Science Research Council Press. Available: www.hsrcpress.ac.za [Accessed 10 October 2013].
- Muller, J. 2000. *Reclaiming knowledge: Social theory, curriculum and education policy*. London: RoutledgeFalmer.
- Muller, J. 2009. Forms of knowledge and curriculum coherence. *Journal of Education and Work*, 22(3), 205–226.
- Muller, J. 2014. Every picture tells a story: Epistemological access and knowledge. *Education as Change*, DOI: 10.1080/16823206.2014.932256
- Muller, J. and Young, M. 2014. Disciplines, skills and the university. *Higher Education*, 67, 127–140.
- Neves, I., Morais, A.M. and Afonso, M. 2004. Teacher training contexts: Study of specific sociological characteristics. In J. Muller, B. Davies and A. Morais (eds) *Reading Bernstein, researching Bernstein*. London: Routledge, pp168–186.
- Newing, H., Eagle, C., Puri, R. and Watson, C. 2011. *Conducting research in conservation: A social science perspective*. New York: Routledge.
- Niven, P.M. 2005. Exploring first year students' and their lecturers' constructions of what it means to read in a humanities discipline: A conflict of frames? *South African Journal of Higher Education*, 19(4), 777–789.
- Niven, P.M. 2011. Intersecting epistemologies: first-year students' knowledge discourses in a Political Science module. *Teaching in Higher Education*, 16 (6), 641–653.
- Niven, P.M. 2012. *Narrating emergence in the curious terrain of Academic Development research: A realist perspective*. Unpublished PhD dissertation, Rhodes University, Grahamstown.
- Nkomo, M., Akoojee, S. and Motlhanke, S. 2007. Between a rock and a hard place: Understanding the balance between access and efficiency in South African higher education. *Journal of Asian and African Studies*, 42(5), 399–413.
- Olvitt, L. 2012. *Deciding and doing what's right for people and planet: An investigation of the ethics-oriented learning of novice environmental educators*. Unpublished PhD dissertation, Rhodes University, Grahamstown.
- O'Reilly, M. and Kiyimba, N. 2015. *Advanced qualitative research*. London: Sage Publications.
- Po-Ying, C. 2007. How students react to the power and responsibility of being decision-makers in their own learning. *Language Teaching Research*, 11(2), 225–241.
- Pring, R. 2001. The virtues and vices of an educational researcher. *The Journal of the Philosophy of Education Society of Great Britain*, 35(3), 407–421.
- Pym, J. and Kapp, R. 2011. Harnessing agency: towards a learning model for undergraduate students. *Studies in Higher Education*, DOI:10.1080/03075079.2011.582096, 1–13.
- Ramsden, P. 2003. *Learning to teach in higher education*. London: Routledge.

Report of Ministerial Committee, 2008. Report of Ministerial Committee on transformation and social cohesion and the elimination of discrimination in public higher education. Available: <http://www.pmg.org.za/files/docs/090514racismreport.pdf> [Accessed 10 October 2013].

Rhodes University Funding Application Report, 2012. *Department of Higher Education and Training: Application for approval of an extended curriculum programme*. Unpublished report submitted to DoHET, Rhodes University, Grahamstown.

Robertson, I. 2007. *E-Learning practices: Exploring the potential of pedagogic space, activity theory and the pedagogic device*. Learning and socio-cultural theory: Exploring modern Vygotskian perspectives international workshop 2007. Available at: <http://ro.uow.edu.au/llrg/vol1/iss1/5> [Accessed 10 October 2013].

Rollnick, M. 2010. A survey of programmes: A survey of science successes. In M. Rollnick (ed) *Identifying potential for equitable access to tertiary level science: Digging for gold*. Dordrecht: Springer, pp39–66.

Rollnick, M., Lubben, F., Lotz, S. and Dlamini, B. 2002. What do underprepared students learn about measurement from introductory laboratory work? *Research in Science Education*, 32(1), 1–18.

Rose, D. 2004. Sequencing and pacing of the hidden curriculum: how indigenous learners are left out of the chain. In J. Muller, B. Davies and A. Morais (eds) *Reading Bernstein, researching Bernstein*. London: RoutledgeFalmer, pp91–107.

Rouse, J. 2001. Two concepts of practices. In T. Schatzki, K. Knorr Cetina and E. Von Savigny (eds) *The practice turn in contemporary theory*. London: Routledge, pp198–208.

RSA DoACST (Republic of South Africa, Department of Arts, Culture, Science and Technology) 1997. *NARSET report: Issues relating to access and retention in science engineering and technology in higher education*. Pretoria: Department of Arts, Culture, Science and Technology.

RSA DoE (Republic of South Africa, Department of Education) 1997. *Education White Paper 3: A programme for the transformation of higher education*. Pretoria: Department of Education.

RSA DoE (Republic of South Africa, Department of Education) 2001. *National Plan for Higher Education*. Available: http://chet.org.za/manual/media/files/chet_hernana_docs/South%20Africa/National/National%20Plan%20for%20HE%20SA.pdf [Accessed 30 June 2014].

RSA DoE (Republic of South Africa, Department of Education) 2006. *Grants for foundation provision: 2007/8 to 2009/10*. Pretoria: Department of Education.

RSA DoHET (Republic of South Africa, Department of Higher Education and Training) 2012. *Foundation provision in ministerially approved programmes*. Pretoria: Department of Higher Education and Training.

RSA DoHET (Republic of South Africa, Department of Higher Education and Training) 2013a. *White paper for post-school education and training: Building an integrated, effective post-school system*. Pretoria: Department of Higher Education and Training.

RSA DoHET (Republic of South Africa, Department of Higher Education and Training) 2013b. *Report of the ministerial committee for the review of the funding of universities*. Pretoria: Department of Higher Education and Training.

RSA MoHET (Republic of South Africa, Ministry of Higher Education and Training) 2009. *Ministerial statement on higher education funding: 2009/10–2011/12; 2009*. Available: <https://www.uct.ac.za/usr/ipd/APU/NewProgReg/Ministerial%20statement%20of%20Higher%20Education%20Funding%202009-10.pdf> [Accessed 12 March 2014]

Rutherford, M. and Zietsman, 1992. A College of Science: Bridging the gap between school and university. *Research in Science Education*, 22, 341–347.

Sadovnik, A.R. 2001. Basil Bernstein (1924–2000). *Prospects*, 31(4), 687–703.

Santos, B.S. 2010. The university in the twenty-first century: toward a democratic and emancipatory university reform. In M.W. Apple, S.J. Ball and L.A. Gandin (eds) *The Routledge international handbook of the sociology of education*. New York: Routledge, pp274–282.

Sayer, R.A. 2000. *Realism and social science*. London: Sage Publications.

Schwandt, T.A. 2001. *Dictionary of qualitative inquiry*. Thousand Oaks, California: Sage Publications.

Scott, I. 2001. Public funding for Academic Development: Analysis and proposals. Unpublished, individual submission to the Ministry of Education in response to the 2001 Discussion Document, *Funding of public higher education: A New Framework*. Pretoria: Department of Education.

Scott, I. 2012. Alternative access to university: Past, present and future. In R. Dhunpath and R. Vithal (eds) *Alternative access to higher education: Underprepared students or underprepared institutions?* Cape Town: Pearson, pp2–25.

Scott, I., Yeld, N. and Hendry, J. 2007. *A case for improving teaching and learning in South African higher education*. Higher Education Monitor No. 6. Pretoria: Council on Higher Education.

SESP (Science Extended Studies Programme) Annual Reports, 2005–2009. Internal reports, Rhodes University, Grahamstown.

SESP (Science Extended Studies Programme) Review Report, 2011. *Curriculum Review: Science Extended Studies Programme, Rhodes University*. Internal report, Rhodes University, Grahamstown.

Shalem, Y. and Slonimsky, L. 2010. Seeing epistemic order: Construction and transmission of evaluative criteria. *British Journal of Sociology of Education*, 31(6), 755–778.

Shay, S. 2012. Educational development as a field: Are we there yet? *Higher Education Research and Development*, 31(3), 311–323.

Shay, S. 2013. Conceptualizing curriculum differentiation in higher education: a sociology of knowledge point of view. *British Journal of Sociology of Education*, 34(4), 563–582.

Shay, S. 2014. Curriculum in higher education: Beyond false choices. In P. Gibbs and R. Barnett (eds) *Thinking about higher education*. Dordrecht: Springer, pp141–157 (electronic draft form, epp1–23).

- Shay, S., Oosthuizen, M., Paxton, P. and van der Merwe, R. 2011. Towards a principled basis for curriculum differentiation: Lessons from a comprehensive university. In E. Bitzer and N. Botha (eds) *Curriculum inquiry in South African higher education*. Stellenbosch: Sun Media, pp93–112.
- Singh, P. 2002. Pedagogising knowledge: Bernstein's theory of the pedagogic device. *British Journal of Sociology of Education*, 23(4), 571–58.
- Singh, P. 2015. The knowledge paradox: Bernstein, Bourdieu, and beyond. *British Journal of Sociology of Education*, 36(3), 487–494.
- Slonimsky, L. 2010. Reclaiming the authority of the teacher. In Y. Shalem and S. Pendlebury (eds) *Retrieving teaching: Critical issues in curriculum, pedagogy and learning*. Cape Town: Juta, pp41–55.
- Slonimsky, L. and Shalem, Y. 2004. Pedagogic responsiveness for academic depth. In H. Griesel (ed) *Curriculum responsiveness: Case studies in higher education*. Pretoria: South African Universities Vice-Chancellors Association, pp81–101.
- Smit, R. 2012. Towards a clearer understanding of student disadvantage in higher education: Problematising deficit thinking. *Higher Education Research and Development*, 31(3), 369–380.
- Snow, C.P. 1959. *The two cultures*. The Rede Lecture 1959. Cambridge: Cambridge University Press. Available: s-f-fwalker.org.uk/pubsebooks/2cultures/Rede-lecture-2-cultures.pdf [Accessed 10 March 2015].
- Soria, K.M. 2014. Supporting working-class students in higher education. *The Journal of Leadership Education*, 13(1), 14–30.
- Soudien, C. 2015. Of false-starts, blind spots, cul-de-sacs and legitimacy struggles: The curriculum debate in South African higher education. Curriculum panel presentation, University of Cape Town August 2015. Available: <http://ruconnected.ru.ac.za/mod/forum/discuss.php?d=65812> [Accessed 27 August 2015].
- Spielvogel, J.J. 2010. *Western civilization: A brief history, Volume 1, 7th ed.* Boston: Wadsworth Cengage Learning.
- Stake, R.E. 2005. Qualitative case studies. In N.K. Denzin and Y.S. Lincoln (eds) *The Sage handbook of qualitative research, 3rd ed.* Thousand Oaks, California: Sage Publications, pp443–466.
- Street, B. 1984. *Literacy in theory and practice*. Cambridge: Cambridge University Press.
- Street, B. 1993. *Cross cultural approaches to literacy*. Cambridge: Cambridge University Press.
- Street, B. 1995. *Social literacies: Critical approaches to literacy in development, ethnography and education*. London: Longman.
- Street, B. 2006. *Autonomous and ideological models of literacy: approaches from New Literacy Studies*. Available: www.philbu.net/media-anthropology/street_newliteracy.pdf [Accessed 21 February 2011].
- Taras, M. 2001. The use of tutor feedback and student self-assessment in summative assessment tasks: Towards transparency for students and for tutors. *Assessment and Evaluation in Higher Education*, 26(6), 605–14.

- Tashakkori, A. and Teddlie, C. 2003. *Handbook of mixed methods in social behavioral research*. Thousand Oaks, California: Sage Publications.
- Tinto, V. 2006. Research and practice of student retention. What's next? *Journal of College Student Retention*, 8(1), 1–19.
- Tobin, G.A. and Begley, C.M. 2004. Methodological rigour within a qualitative framework. *Journal of Advanced Nursing*, 48(4), 388–396.
- Toohy, S. 1999. *Designing courses for higher education*. Buckingham: SRHE and Open University Press.
- Trifonas, P. 2003. (ed) *Pedagogies of difference: Rethinking education for social change*. New York: Routledge.
- Trow, M. 2006. Reflections of the transition from elite to mass to universal access: Forms and phases of higher education in modern societies since WWII. In J.J.F. Forest and P.G. Altbach (eds) *International handbook of higher education*. Dordrecht: Springer, pp243–280.
- Trowler, P. 2011. *Researching your own institution: Higher education*. British Educational Research Association online resource. Available: <https://www.bera.ac.uk/wp-content/uploads/2014/03/Researching-your-own-institution-Higher-Education.pdf?noredirect=1> [Accessed 26 August 2015].
- Unisa, 2011. Bureau of market research: Information blurb 2011/06. Personal income estimates for South Africa. Available: http://www.unisa.ac.za/contents/faculties/ems/docs/BMR_info_blurb_407.pdf [Accessed 19 September 2015].
- van Etten, S., Freebern, G. and Pressley, M. 1997. College students' beliefs about exam preparation. *Contemporary Educational Psychology*, 22(2), 192–212.
- Vilakazi, H.B. and Tema, B. 1985. White universities and the black revolution. *ASPECTS*, 6, 18–40.
- Volbrecht, T. and Boughey, C. 2004. Curriculum responsiveness from the margins: The case of academic development. In H. Griesel (ed) *Curriculum responsiveness: Case studies in higher education*. Pretoria: South African Universities Vice-Chancellors Association, pp57–80.
- Vorster, J-A. and Quinn, L. 2012. Theorising the pedagogy of a formal programme for university lecturers. In L. Quinn (ed) *Re-imagining academic staff development: spaces for disruption*. Stellenbosch: Sun Media, pp51–70.
- Vygotsky, L.S. 1962. *Thought and language*. Cambridge, Massachusetts: MIT Press.
- Vygotsky, L.S. 1987. The development of scientific concepts in childhood. In R.W. Rieber and A.S. Carton (eds) *The collected works of L. S. Vygotsky. Vol. 1. Problems of general psychology*. New York: Plenum, pp167–242.
- Wait, M, 2008. Teaching Portfolio. Unpublished report, Academic Development Centre, Rhodes University, Grahamstown.

- Walker, M. and Badsha, N. 1993. Academic development and the challenge of curriculum change at the University of the Western Cape: An overview. In M. Walker (ed) *AD dialogues 1: Exploring change: Case studies of academic development*. Cape Town: University of the Western Cape.
- Wheelahan, L. 2010. *Why knowledge matters in curriculum: a social realist argument*. New York: Routledge.
- Whittemore, R., Chase, S.K. and Mandle, C.L. 2001. Validity in qualitative research. *Qualitative Health Research*, 11(4), 522–537.
- Williams, K.F. 2003. *A proposed model for the Rhodes University science foundation programme: An extended curriculum approach*. Internal Report, Rhodes University, Grahamstown.
- Williams, K.F. 2009. 'Guilty knowledge': Ethical *aporia* emergent in the research practice of educational development practitioners. *London Review of Education*, 7(3), 211–221.
- Wilson-Strydom, M.G. 2010. Traversing the chasm from school to university in South Africa: A student perspective. *Tertiary Education and Management*, 16(4), 313–325.
- Wolff, K. 2015. Insights into conceptual and contextual engineering problem-solving practices in the 21st century: some implications for curriculum redesign. *Proceedings of the 3rd Biennial Conference of the South African Society for Engineering Education, University of KwaZulu-Natal, Durban, 4–5 June 2015*, pp189–198.
- Wolff, K. and Hoffman, F. 2014. 'Knowledge and knowers' in engineering assessment. *Critical Studies in Teaching and Learning*, 2(1), 74–95.
- Wolff, K. and Luckett, K. 2013. Integrating multidisciplinary engineering knowledge. *Teaching in Higher Education*, 18(1), 78–92.
- Yin, R. 2009. *Case study research, design and methods*. Thousand Oaks, California: Sage Publications.
- Ylijoki, O-H. 2000. Disciplinary cultures and the moral order of studying: A case-study of four Finnish university departments. *Higher Education*, 39, 339–362.
- Young, M. 2006. Conceptualising vocational knowledge: some theoretical considerations. In M. Young and J. Gamble (eds) *Knowledge, curriculum and qualifications for South African further education*. Cape Town: Human Sciences Research Council, pp104–124.
- Young, M. 2008a. *Bringing knowledge back in: From social constructivism to social realism in the sociology of education*. London: Routledge.
- Young, M. 2008b. From constructivism to realism in the sociology of the curriculum. *Review of Research in Education*, 32(1), 1–28.
- Zepke, N. and Leach, L. 2005. Integration and adaptation: Approaches to the student retention and achievement puzzle. *Active Learning in Higher Education*, 6(1), 46–59.

Appendix 5.1: E-mail correspondence for staff involvement

Dear XXX(staff member)

As you know I have registered this year to start a PhD – in the field of education. My topic is related to the suitability of the current Introduction to Science Concepts and Methods (ISCM) course in the Science Extended Studies Programme in terms of preparing students for success in mainstream – in any of the science disciplines. Attached is my PhD proposal which was recently approved by the Education Higher Degrees I am conducting research as part of my PhD studies. The aim of the project is to characterize the curriculum, teaching, learning and assessment practices in the ISCM foundation course, and ascertain how such practices influence student success.

In order to achieve this it would be very useful to interview you and possibly also make observations in your lecturers and practicals. As a lecturer in ISCM your input will be extremely valuable in the research process and much appreciated! The findings of the research should be useful in informing future teaching and learning practices in ISCM, thereby facilitating students' success not only in their foundation year but in their science studies in general.

If you agree to participate, I would like to interview you twice during 2014 at a time and place that is convenient for you. The interviews should take between 30-60 minutes, and will be audio recorded. Any observations I make of teaching practices will be during lecture or practical periods, where notes will be taken.

If you have ANY questions or concerns about participating in this study, please contact me or my supervisor (Chrissie Boughey c.boughey@ru.ac.za). This project has been approved by the Ethical Clearance Committee of the Education Department at Rhodes University. The intended outcomes of the research are a PhD thesis and a number of academic publications.

Please contact me should you require any more information.

Kind regards



Karen Ellery

Appendix 5.2: ISCM staff interview questions

Staff questions:

Disciplinary staff teach a 'section' of the course – this is called a 'module'

Personal contextual

- 1) How long have you been employed in academia?
- 2) What is your main field of interest?
- 3) Why do you teach on the ISCM course (what led to you being involved)?

Curriculum/ science discipline

- 4) What do you think is/are the purpose/outcomes of the ISCM course?
- 5) What is/are the purpose/outcomes of your module in ISCM? What is the rationale for these outcomes?
- 6) What do you teach? Why? (knowledge, skills, techniques – prompts)
- 7) How does what you teach contribute to the overall purpose of the course?
- 8) Do aspects of your module contribute to basic conceptual understanding in your discipline only, or more broadly to science in general? Explain.
- 9) How do you think the way you work in your module/discipline is similar to or different from working in other disciplines in science? Explain
- 10) What are the main factors leading to a students' success in your department/discipline? Does your module in ISCM prepare them for that? Should it?
- 11) What is your role in the ISCM course, as opposed to xx and xx role? Do you think this integrated way of working could be improved? If so, how?

Pedagogy and assessment

- 12) What do you think is your (the lecturer's) role in terms of student learning?
- 13) What do you think is the student's role in learning?
- 14) What is the function of the lecture and practical sessions in ISCM?
- 15) Are aspects of your module difficult for students? If so, what? Do you do anything about it? If so, what?
- 16) Do you think it is important to take into account student's dispositions and background in teaching your module. If so, why and how?
- 17) What types of texts/resource material do students have to engage within your module? Can students understand these texts? Where do problems lie?
- 18) How is your module assessed? Why?
- 19) Do ISCM assessment practices reflect well assessment practices in your discipline? Explain.
- 20) (If not covered already) Describe one interaction/assessment in ISCM that you think was particularly successful. Why do you think it was so successful?
- 21) What do think could be done differently by yourself or as a whole in terms of improving ISCM so that students are well prepared for your discipline the following year?
- 22) Is there anything that I did not ask that you would like to talk about?

Appendix 5.3: ISCM student interview questions on assessment tasks

Student interview:

General background

1. Where are you from, school?
2. Who live with at home, occupation, highest qualification?
3. NSFAS funding?

Specific test/ assignment

1. Did you know what to expect in the test/exam/assignment? Expand.
2. Did the marks you achieved match your expectations? Expand.
3. Did you experience any problems with the exam? Expand?

Specific questions in test (one of each of DK, SK and AK or prop, proc and values?)

4. In a general sense, **what** did you think we were **testing** / looking for when we asked this question?
5. **What criteria** do you think would we use to give you marks? (OR What would get you marks in this answer?)
6. **Why** do you think we use those **criteria**? (Why do we value those things?)
7. In your opinion do you think your answer satisfied the criteria? Why/why not?
8. **What information** / process do you think was needed in the answer? Did you know the information? Why/why not?
9. **How** do you think you **need to work** in this course to be successful?
10. Are you working in this way? Expand
11. What kind of person do you have to be to be successful in this course? Expand
12. What are the things we (lecturers) value in what you do and how you do it?

13. General question: Are you working differently in ISCM from how you did at school? Expand?
14. How do you feel you are coping?

Appendix 5.4: Student consent form

Student informed consent

Project title: Curriculum structure and pedagogic practices in a Science foundation course: Enablements and constraints to epistemological access
Researcher: Karen Ellery (k.ellery@ru.ac.za 046 603 8864)
Supervisor: Chrissie Boughey (c.boughey@ru.ac.za 046 603 8171)

Dear Student

I am conducting research as part of my PhD studies. The aim of the project is to describe the teaching and learning practices in the Introduction to Science Concepts and Methods (ISCM) course, and see how such practices influence student success in mainstream. In order to achieve this I need to interview students. As a student currently in the course your input will be very valuable in the research process. The findings of the research should help improve both teaching and learning in the course.

I therefore invite you to participate in this research project on a voluntary basis. You may refuse to participate or withdraw from the project at any time with no negative consequences. Your anonymity will be protected (i.e. your real name will not be used and information that could lead to your identification will be left out) in the thesis or in any other documents.

If you agree to participate, I will interview you at a time that is convenient for you. The interview should take less than an hour and will be audio recorded. I would also like your permission to use some of your assessment tasks in the study.

If you have any questions or concerns about participating in this study, please contact me or my supervisor (see contact details at top of page). This project has been approved by the Ethical Clearance Committee of the Education Department at Rhodes University. The intended outcomes of the research are a PhD thesis and a number of academic publications.

I, _____, have voluntarily agreed to be part of the research process as outlined above.

Signature _____ Date _____

Researcher name: Karen Ellery

Signature _____ Date _____