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INVESTIGATING MATHEMATICS TEACHER LEARNING WITHIN AN IN-SERVICE COMMUNITY OF PRACTICE: THE CENTRALITY OF CONFIDENCE

ABSTRACT. This paper is part of a broader study that draws on Wenger's (Wenger, E.:1998, *Communities of Pratice: Learning, Meaning, and Identity*, Cambridge University Press, New Work) social practice perspective to investigate teacher learning. The study extends Wenger's complex model of interrelated components of learning (as meaning, practice, identity and community) to describe and explain teacher learning that occurs within a mathematics senior-phase in-service program that was stimulated by curriculum change. The study uses qualitative ethnography in which the researcher performs the dual role of both coordinator and researcher of the in-service practice. In a longitudinal study the phenomenon of confidence emerged in teachers' descriptions and explanations of their learning. In this paper I explore this phenomenon both empirically and theoretically. The extension of Wenger's (1998) theory to include the overarching and interacting component of confidence is embedded in and derived from data analysis of 10 teachers' learning, over a 2-year period, during a time of radical curriculum change. Since it would be incoherent within this framework to draw on psychological explanations of confidence I set out to explore confidence from within a social practice frame in a way that is grounded in data of the teachers in this study. The paper offers a concept of confidence in relation to teacher learning as 'learning as mastery', and confidence as both a product and a process of learning. Teachers can at once state their confidence as mathematics teachers, and their confidence to admit to what they do not know and still need to learn. It is argued that this is a primary condition for ongoing learning in a profession like mathematics teaching. In addition, the paper provides a critique of the applicability of Wenger's work to the context of teacher education and in particular highlights the absence of the notion of confidence within his work.

KEY WORDS: communities of practice, confidence, in-service mathematics teacher learning, social practice

1. INTRODUCTION

In this paper I argue that the notion of confidence is pivotal in understanding and explaining mathematics teacher learning. This argument emerges from a wider study of mathematics teachers' learning, through a 2-year senior phase (grade 7–9) in-service teacher education program, structured to enhance participation in a community of practice, in relation to current South African curriculum change. This program is set in context later in the paper. Both the program and the study were framed by Wenger's (1998) model of four interrelated learning components, namely, meaning, practice, identity and community. Given this frame, confidence was not initially an

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object of interest or concern. Over the period of teacher's participation in the in-service education and training project (INSET) 'confidence' entered teachers' discourses in *individual* questionnaires and interviews rather than inside the collective practice. It therefore begged further examination. It is this examination and its results that are in focus in this paper. The argument for confidence, as a central learning component, brings with it a critique and elaboration of Wenger's (1998) work and so a dual contribution of this paper to the field in relation to the questions:

- To what extent is social practice theory (in particular the work of Lave and Wenger, 1991 and Wenger, 1998) helpful in explaining the nature of teacher learning in relation to their participation in a mathematics INSET project?
- What is the role of 'confidence' in mathematics teacher learning and how should it be conceptualised and understood from Wenger's (1998) social practice (as opposed to a psychological) perspective?

In addressing the first question I provide a critique of the applicability of the work of Lave and Wenger (1991) and Wenger (1998) to the specificity of teacher learning. In addressing the second question I provide a selection of data of ten grade 7–9 teachers of mathematics, who participated in the study, from which I theorise the role of 'confidence' in their learning.

Lave and Wenger's (1998) and Wenger's (1998) social practice perspective of learning is increasingly being drawn on to describe and explain student and teacher learning in the field of *mathematics* education. (See for example, Adler, 1996, 1998, 2001; Boaler, 1997, 1999; Boaler and Greeno, 2001; Lerman, 1998; Santos and Matos, 1998; Stein and Brown, 1997; Watson, 1998a). Furthermore, some mathematics educators are increasingly arguing the usefulness of their work for analysing mathematics *teacher* education (Adler, 1998; Lerman, 2000). However, many acknowledge that Lave and Wenger's (1991) perspective has not yet been developed into a full-blown theory of learning and that there are many difficulties that arise when applying such perspectives to learning mathematics or learning to teach mathematics (Adler, 1998; Watson, 1998b). This widespread use by fellow mathematics educators, accompanied by the acknowledgement that more work needs to be done to recontextualise their perspective within the field of mathematics and mathematics teacher education led me to explore the usefulness of their work, and Wenger's subsequent (1998) work for this study.

However, this choice of perspective should not imply a rejection of perspectives that emphasise the relationship between social and cognitive aspects of learning. Wenger (1998, p. 4) himself acknowledges that his perspective 'is not a replacement for other theories of learning that address

different aspects of the problem'. Indeed, it is useful to conceive of ways of bringing more cognitive perspectives of learning together with social perspectives in analysing mathematics teacher learning and the role of confidence in such learning. See, for example, Cooney et al. (1998) for a description of the evolution of pre-service mathematics teacher beliefs and how these relate to the 'voices of significant others' (community) and a 'search for affirmation', which is framed within a constructivist perspective that 'endorse both the psychological and social construction of knowledge' (p. 307). The intention of this paper however, is primarily to highlight the significant role of confidence in the learning of the mathematics teachers in this study from within a social practice frame.

Before commencing with an analysis of confidence, as it emerged in the data, I searched a range of social practice literature for studies on the notion of confidence. Similarly I searched literature relating to confidence within mathematics or mathematics teacher learning for studies that appropriated the concept within social practice perspectives. Both searches indicated 'gaps' in the literature, the latter search showing a wide range of research on confidence from constructivist and socio-constructivist perspectives focusing primarily on mathematical confidence in relation to gender differences. Thus, clearly more work needs to be done to conceptualise the role of confidence (which as a term has tended to be heavily steeped within psychological approaches), in a range of mathematics learning contexts, within the broader field of social practice theory. This paper makes a contribution in this respect and highlights the need for further empirical and theoretical research.

In this paper, confidence is considered both a product and process of the mathematics teachers' learning, and it is argued that as with Wenger's other four components (meaning, practice, identity and community) it is 'deeply interconnected' and 'mutually defining' (p. 5). Confidence is conceptualised as an additional component of learning and as such as an individual teachers' movement from the periphery of various overlapping mathematics and/or education communities towards more central participation, identification and belonging within these communities. This conceptualisation differs from more cognitive definitions, which link confidence to internalised knowledge and beliefs. For example, Broekmann (1998, p. 18) defines confidence as 'the knowledge or belief that one can learn to do (that which is expected of one)'. This linking of confidence to being a learner concurs with the findings in this paper. However, in this paper confidence is not considered internalised knowledge or belief. Rather confidence is part of an individual teacher's ways of learning through experiencing, doing, being, and belonging. As such it is deeply interconnected with learning as changing meaning, practice, identity and community.

Above, I have argued that the work of Lave and Wenger (1991) and Wenger (1998) are increasingly used in *mathematics* education research, which leads one to consider the extent to which the findings of such research are particular to the mathematical contexts within which the research takes place or whether the findings extend to learning in other education settings. Thus, I expand briefly on the particularity of the role of *mathematics* in relation to the findings that I discuss in this paper. Thereafter I commence the paper with a discussion of why the work of Lave and Wenger (1991) and Wenger (1998) provided a useful frame for the INSET and the challenges that the use of their perspective brought to the study.

1.1. *The mathematical context of teachers' learning*

Around the world there tends to be far more concern about mathematics teacher knowledge and mathematical confidence (or math phobia/anxiety) than for other subjects. Thus, while many of the experiences of the teachers in this study are likely to resonate with the learning experiences of teachers of other subjects, there are many aspects of the teachers' learning experiences that are integrally connected to the particular nature of the subject 'Mathematics'. Furthermore, educational reforms, which began since South Africa's first democratic elections in 1994, have introduced a new learner-centred, outcomes-based curriculum for schools placing further pressure on the confidences and competences of the teachers in the study (Graven, 2002a). This curriculum shifts from a view of mathematics as a body of infallible objective truth to a view of mathematics as a 'human activity' (NDE, 1997). The new emphasis on mathematical learning as relational, flexible, transferable and integrated with everyday life, increases the mathematical competence demands on teachers (Adler et al., 2000). These shifts have major implications for the new roles that mathematics teachers are expected to adopt. In addition, the poor mathematical histories of the teachers in the study (discussed in subsection 4.1 below) place teachers in a particularly vulnerable position with respect to these curriculum reforms.

Elsewhere (see Graven, 2002a) I have outlined and elaborated four different orientations towards mathematics that can be identified within the new mathematics curriculum and have related these to four corresponding roles for teachers. These are to – prepare learners for critical democratic citizenship (i.e., the teacher becomes a critical analyzer of the way mathematics is used socially, politically and economically); develop local curriculum and apply mathematics in everyday life; be an exemplary 'mathematician' and induct learners into ways of investigating mathematics; and serve as conveyer of mathematical conventions and practices important for further mathematics studies. Managing these roles and finding an

appropriate balance between the roles is demanding especially in relation to teachers' mathematical histories where only the 4th role is likely to be familiar to most South African teachers of mathematics (see Taylor and Vinjevold, 1999). Wenger (1998) raises an important issue for teacher education in this respect. Although national education departments can design roles, they cannot design the identities of teachers. These changing roles challenge teachers' mathematical competence and could easily undermine teacher confidence (even for teachers with strong mathematical histories).

The data in this paper indicate that confidence in being able to learn mathematics is a resource that enables and supports teachers with little mathematical training to learn the mathematical competences necessary for their profession. Thus, the development of mathematical confidence (be it related to illusory or real mathematical competence) enables and supports mathematical learning necessary for ongoing professional development within mathematics education. Since the INSET program in this study focused on the development of teachers' mathematical knowledge for teaching (discussed in subsection 4.1 below) the teachers' increasing mathematical competence and confidence continually informed each other in a dialectical relationship. This paper illustrates that confidence in relation to the many aspects of being a professional mathematics educator (which includes but is in no way limited to mathematical knowledge for teaching) is a central component of learning that enables and supports teachers in learning to become and be professional mathematics educators.

2. WHY I USED LAVE AND WENGER (1991) AND WENGER (1998) AS A FRAMEWORK

Two primary assumptions informed the design of both the INSET and the research: (a) teacher learning would be enhanced by stimulating participation within a community of practice where members of the community of practice would provide support for teacher learning; (b) implementation of the new curriculum would involve changes in teacher roles and teachers' 'ways of being' (identities).

In interviews with teachers about their learning within the INSET context, it became evident that teachers themselves saw their learning as a process of developing new identities. This quote from a participating teacher captures this: "You know before I always used to introduce myself as the music teacher, now I introduce myself as the maths teacher" (Beatrice, July 1999).

Since INSET was long-term where teachers engaged regularly with the same group of people about mathematics education and new curriculum developments, it was *de facto* a community of practice. The work of Lave

and Wenger (1991) and Wenger (1998) embraced (and elaborated) these assumptions and resonated with my experiences of teacher learning, the design of the INSET and the research aims of this study. Indeed their work proved to be highly useful for understanding, analysing, explaining and enabling learning in a way that gave primacy to the local, subjective and socially constructed context within which I was working, except in two central respects that are the focus of this paper. However, before focusing on these two aspects I briefly engage with those aspects of their work that are central to the discussion that follows.

2.1. *What do Lave and Wenger (1991) and Wenger (1998) say about learning?*

According to Lave and Wenger (1991), learning is not located in the acquisition of structure or in the heads of individuals but in the process of co-participation and the increased access of learners to participation. Lave and Wenger (1991) prioritise the importance of *participation in the practices of a community* and *identity* as primary features of learning:

> (learning) implies becoming a full participant, a member, a kind of person.... (p. 53)
> learning and a sense of identity are inseparable: They are aspects of the same phenomenon. (p.115)

Since participation in the practices of a community is essential for the development of identity (and therefore of learning) they refine the notion of community for the purposes of learning and define a 'community of practice' as 'a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice' (p. 98).

The notion of access is central in relation to a community of practice since 'to become a full member of a community of practice requires access to a wide range of ongoing activity, old-timers, and other members of the community; and to information, resources, and opportunities for participation' (p. 101). In this respect Lave and Wenger's perspective on learning has implications for ways of enabling learning. That is, learning is maximised if one maximises learners' access to participation in, and the resources of, a community of practice in which the development of identities in relation to that community are supported. Wenger's (1998) book *Communities of Practice: Learning, Meaning, and Identity* extends his work with Lave and provides a theory of learning in which the primary unit of analysis is neither the individual nor social institutions but 'communities of practice'. The theory explores systematically the intersection of the learning components: community, practice, meaning and identity

and these provide a conceptual framework for analysing learning as social participation.

In the Introduction to his book Wenger explains the aims and achievements of his earlier work with Lave, but notes that the central concepts of identity and community of practice (to which I was most drawn), while central to their work, 'were not given the spotlight and were left largely unanalysed' (p. 12). Wenger (1998) explains that communities of practice are everywhere and because they are so informal and pervasive they are rarely focused on. He relates communities of practice to the learning components of meaning, practice, community and identity as follows:

> On the one hand, a community of practice is a living context that can give newcomers access to competence and also invite a personal experience of engagement by which to incorporate that competence into an identity of participation. On the other hand, a well functioning community of practice is a good context to explore radically new insights without becoming fools or stuck in some dead end. A history of mutual engagement around a joint enterprise is an ideal context for this kind of leading-edge learning, which requires a strong bond of communal competence along with a deep respect for the particularity of experience. When these conditions are in place, communities of practice are a privileged locus for the *creation* of knowledge. (Wenger, 1998, p. 214)

Wenger (1998, p. 9) adds that reflection on learning is important because 'we wish to cause learning, to take charge of it, direct it, accelerate it... Therefore our perspectives on learning matter... It is our conception of learning that needs urgent attention when we choose to meddle with it on the scale which we do today'. Wenger's work resonated with many of my common sense assumptions of learning, and I too was compelled to reflect more systematically on these assumptions since, as an INSET practitioner, I was directly involved in 'meddling' and 'taking charge of' the learning of teachers. Wenger (1998:5) summarises his framework for a social theory of learning consisting of four components that are 'deeply interconnected and mutually defining' in the following diagram:

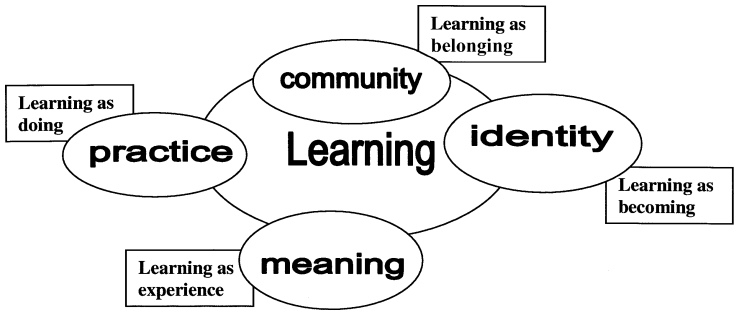

Figure 1. Components of a social theory of learning: An initial inventory.

He points out that one could 'switch any of the four peripheral components with learning, place it in the centre as the primary focus, and the figure would still make sense' (p. 5). It was the ability of these four components to capture the complexity of learning through the interconnectedness and mutual definition of the components, and its provision of a structuring framework for analysing teacher learning within a community of practice, that proved particularly useful as a structuring device for describing and explaining teacher learning in the INSET. They corresponded with the primary recurring phenomena emerging from the data, except two central areas of challenge remained. These were related to the absence of discussion of the role of teaching and the role of confidence in learning.

3. A CHALLENGE IN APPLYING WENGER'S THEORY TO *TEACHER* LEARNING

A key challenge in applying Wenger's four-component model of learning as a frame for the analysis of teacher learning is related to the specificity of the profession of teaching. The focus on communities of practice led Lave and Wenger (1991) to challenge traditional forms of teaching. 'Rather than a teacher/learner dyad, this points to a richly diverse field of essential actors and, with it, other forms of relationships of participation' (p. 56). In breaking down the teacher/learner dyad they shifted from a focus on teaching to a focus on learning and emphasised that teaching is not a precondition for learning. Indeed, their work did not deal with the notion of teaching at all. Rather than providing a set of guiding principles for teaching, they provided recommendations for maximising learning. In this sense Lave and Wenger (1991) have reconstituted learning but without reconstituting teaching. Their disregard for teaching in relation to learning, although understandable in apprenticeship contexts where teaching is more incidental than deliberate, is problematic.

Wenger (1998) further undermines the value of teaching to the point that he asks: 'How can we minimise teaching so as to maximise learning?' (p. 267). Wenger's avoidance of the concept of teaching *per se* is also likely to stem from the apprenticeship context from which his work developed. In this context there are no 'teachers', only 'masters'. However, Wenger does not use the term 'master' in his 1998 work and fails to provide a thorough discussion of the central role of such a person in a community of practice or more specifically in a learning community. The result is that much work needs to be done in order to translate Wenger's (1998) perspective on learning (based in the context of learning on the job) to learning in more formal education contexts where teachers (or facilitators, co-ordinators etc.) have a central role in ensuring that successful learning

occurs and are, furthermore, held accountable for such learning. That is, the success of a teacher's vocation depends on successful learning. Thus, I argue that since the corollary of 'teaching is not a precondition for learning' is not 'teaching does not result in learning' it is important to ask: Where is teaching in learning? (See Graven and Lerman, 2003).

A view of learning that undermines the role of teaching is problematic and is, I believe, especially problematic in the current context of rapid curriculum change in South Africa. Many teachers have interpreted the new curriculum and its emphasis on learner-centredness, co-operative learning and group work to mean that they do not really need to teach. This is particularly problematic in mathematics classrooms where such interpretations mean that teachers no longer share with learners algorithms and procedures passed down over centuries since they interpret the new curriculum to imply that they should abandon their familiar role of serving as a conveyer of mathematical practices. For some teachers this results in withdrawal from the mathematical learning processes as they allow learners to 'discover' mathematics themselves through activities limited to real life problem solving in groups. In so doing the centrality of their role as teacher, facilitator and/or co-ordinator in guiding learning is undermined. Without a detailed re-conceptualisation of the practice of teaching, teachers and others are left to misinterpret the importance of their role in enabling learning which further demoralises the status of their profession.

Just as Wenger (1998) does not articulate the notion of master he fails to engage with the notion of 'mastery'. Mastery of the profession of mathematics teaching is clearly much broader than mastering the practice of teaching learners mathematics, or in Wenger's terms, successfully organising a community of practice in which mathematics learning takes place. Mastery, in relation to becoming a professional mathematics teacher, involves becoming *confident* in relation to – one's professional knowledge (especially mathematics knowledge for teaching) and experiences, one's participation in professional activities, one's membership in a range of professionally related communities and one's identity as a professional mathematics teacher. This brings me to the second focus of this paper.

4. THE STUDY AND THE EMERGENCE OF CONFIDENCE

4.1. *The empirical field of the study*

The empirical field of the study was an in-service mathematics teacher education project called the Program for Leader Educators in Senior-phase Mathematics Education (PLESME). PLESME was developed in order to work with practicing mathematics teachers in so called 'previously

disadvantaged' areas to support their interpretation, critique and implementation of current South African mathematics curriculum innovations. Elsewhere (Graven, in press) I have described the evolution of the program's various design features in terms of the confrontation of several dilemmas ranging from practical and ethical decisions involving who, what, where and when, to issues relating to the content and nature of the INSET. This confrontation of dilemmas resulted in the articulation that the underlying assumptions of PLESME were that teacher learning would be best enabled by long-term, small-scale, classroom-focused, community of practice-based INSET in which reflective practice, networking and focusing on developing deeper mathematical and mathematical pedagogical knowledge were central.

Initially PLESME was structured to include: weekly workshops; individual and group reflection sessions; classroom visits accompanied by the use of video to facilitate reflection and discussion; individual and collaborative practical activities to be done in school; and some written activities that accompanied practical activities (for example, lesson reflections). However, with time, other practices and activities emerged as important PLESME features. For example, the practice of teachers sharing frustrations (primarily related to the implementation of curriculum innovations) and sharing teaching resources, commenting on each others videos of lessons and the inclusion of activities in which teachers were networked into the broader professional community of mathematics educators.

In this respect PLESME included organised fieldtrips to various teacher centres, district offices and the offices of mathematics INSET organisations, mathematics education associations and curriculum development organisations. PLESME teachers worked collaboratively to provide input into various mathematics curriculum documents and curriculum review documents. In addition, PLESME teachers attended mathematics education conferences (in particular the annual national conferences of the Association of Mathematics Education for South Africa (AMESA)). At these conferences the teachers presented papers relating to mathematics teaching ideas and/or challenges confronted in implementing mathematics curriculum ideas. This participation in broader professional networks was seen as a means of sustainability of teacher learning and participation within the field of mathematics education beyond PLESME. In the revised PLESME document, a year into the project, it was emphasised that PLESME would

- coordinate dynamic motivated educators to run workshops;
- constantly encourage reflection on practice and find ways of working with new ideas – 'recipes' for teaching would not be prescribed;
- obtain its direction from the participating teachers;

- take cognisance of the wide range of experiences and knowledge which teachers bring to the program and draw on this as a resource;
- assist teachers to network with a wide range of mathematics education related communities;
- view learning as a two-way process between presenters and teachers; and
- support teachers in sharing their knowledge, experiences and enthusiasm with other teachers in and beyond their communities.

A primary aim in the conceptualisation of PLESME was to reject traditional 'fix it' approaches which judge teachers without paying attention to what they are actually doing (Breen, 1999) in favour of an approach which viewed learning as a life long process which teachers must themselves direct and which is an ongoing part of their professionalism. The purpose of PLESME was therefore to stimulate this life long learning and to enable forms of participation in which learning would thrive during and beyond PLESME. When teachers expressed their learning in terms of their engagement in PLESME, they highlighted the importance of the ethos of PLESME in relation to the *nature* of their participation. Interviews and questionnaires indicated an emphasis by teachers on their 'ownership' of PLESME:

> The fact that PLESME was stretched over a longer period than your usual INSET workshops gave us a *sense of ownership* of the program. This was further complemented by the fact that *we formed part and parcel of deciding how, what and how fast we develop*. The latter was made possible by our coordinator that *consulted us* about the nature of certain aspects of the programme *instead of dictating* our very action. More importantly I believe this *gesture was sincere and was necessary to ensure the success of this programme*. The PLESME programme was *not judgemental* but developmental and also *did not dictate* how we should develop but rather exposed us to a number of aspects of our profession that we needed to formulate an opinion about. (Karl Questionnaire, July 2000; emphasis added)

Other teachers similarly emphasised the importance of not being dictated to and added the importance of 'a lot of personal interaction', 'ample opportunity for discussion', 'ample opportunity to criticise, evaluate and disagree' and being treated like professionals. Many of these comments were made in contrast to the teachers' experiences of departmentally organised in-service workshops:

> There was a *lot of interaction* amongst the team whereas with the *Department no interaction only instruction* given to us without understanding what to do. (Puleng Questionnaire, July 2000; emphasis added)

> What I pick up is how different the GDE (Gauteng Department of Education) district treats us. Here *we are seen as a professional*. . . . (Sam Interview, June 1999; emphasis added)

These comments reveal teacher experiences of INSET as dictatorial and judgemental. Indeed this has been the dominant practice in teacher development under apartheid and change in this period of transition is slow. The ethos that emerged from the PLESME base assumption that teachers' professionalism and experiences should be a major resource for PLESME (as opposed to a starting assumption of 'teacher deficit') enabled workshops to be guided by teachers' needs and enabled the 'new' (mathematical content, pedagogy, policy etc.) to be constantly interpreted in terms of the realities of teachers' classroom experiences. Almost all workshops were dominated by teacher talk which was encouraged and enhanced through group activities and also through whole group discussion. Teachers' regularly brought their classroom experiences into discussions as resources which enabled the concretisation of more general discussions. This grounding of the 'new' in the realities of teaching was complemented by the ongoing implementation of workshop ideas in teachers' classrooms. Video recordings of lessons aided the reflection of this process and by the second year almost all teachers requested the input of their school colleagues on these lessons.

Furthermore, strong bonds of communal support formed between the teachers as they informally shared resources and discussed and debated their day to day problems relating to their lessons and to general school and departmental pressures. As time went on the importance of the PLESME teachers in each others' learning became more and more central and the emphasis on the workshop presenters as the stimulus for learning receded (see Graven, 2002b). By the second year some workshops, and parts of many workshops, were run by PLESME teachers.

PLESME worked with teachers from schools in Soweto and Eldorado Park (both urban townships outside Johannesburg) over a 2-year period. An important point to note about the teachers in the study is the large absence of mathematical background in their teaching preparation. Currently in South Africa 50% of teachers of mathematics have less than a Grade 12 mathematics qualification (Kahn, 2001). The mathematics qualifications of the PLESME teachers reflected these national statistics (only three of the ten teachers had passed Grade 12 mathematics on the higher grade[1]). Thus while the participating teachers of PLESME came into the program as *teachers of mathematics* the majority of teachers had not studied or intended to become *mathematics teachers*. In interviews and informal discussions with PLESME teachers it became evident to me that the distinction between one's identification as a *teacher of mathematics* or a *mathematics teacher* was a substantive issue which demanded focused attention especially in relation to the framework of PLESME and its related research.

The PLESME teachers shared many stories of how they became *teachers of mathematics* by 'default'. For example, Moses explained that it was not considered politically acceptable as a black student to study mathematics when he was at school and college. Rather, one had to study history and other subjects considered important for the struggle against apartheid (Journal, August 2000). Moses had therefore studied to become a history teacher but became a teacher of mathematics due to the shortage of mathematics teachers. Another teacher, Barry, despite having taught mathematics and headed a mathematics department for many years, explained that he was *not* a mathematics teacher since he did not 'even' study mathematics at high school. He called himself an art teacher since this is what he had studied (Journal, October 1999). Similarly, as the quote by Beatrice in Section 2 of this paper indicates, Beatrice used to introduce herself as 'the music teacher' despite teaching predominantly mathematics classes.

These examples illustrate an effect of South Africa's apartheid history. Although all PLESME teachers were *teachers of mathematics*, most were not *mathematics teachers* by training or by choice. They had not studied to become mathematics teachers, and they did not necessarily identify themselves as mathematics teachers. The challenge for PLESME was therefore to help teachers to 'become' *mathematics teachers* in terms of mathematical competence and confident identification with mathematics teaching as their profession.

PLESME responded to this situation by focusing workshops on mathematical activities aimed at enabling teachers to explore familiar mathematics topics in more depth; explore new mathematics topics introduced by the curriculum; explore mathematics problems and topics in relation to South Africa's social, political and economic context, and to explore what it means to teach all of these in a learner-centred way. (All of which were guided by new curriculum policy even while the discourse within workshops and in classroom reflection sessions maintained a level of critique of curriculum demands). Such explorations were modelled in ways that teachers might themselves have used to introduce the work to their classes. Teachers worked on activities in pairs and/or groups, reported back to the whole group on their findings, engaged in discussion and critique on the applicability of the work to their classroom lessons, and engaged with the group on their experiences of trying out workshop ideas in their lessons. Workshops thus developed mathematics content knowledge for teaching (Shulman, 1986) and always contextualised discussions of 'new' pedagogies within mathematical contexts. It is interesting to note that Shulman is currently revising his earlier work on mathematical content knowledge for teachers to include the importance of communities of teachers as learners (Boaler, 2003).

4.2. *The methodology of the study*

In PLESME I wore two hats. Firstly I was the co-ordinator of PLESME. I raised funds for it, designed it, set up a steering committee and negotiated with schools, districts and teachers as to the nature of the project. This was my full time vocation and I was accountable to my organisation, the university, steering committee, donors, teachers and schools on the value and 'success' of the project. At the same time, I was also a researcher in the process of conducting research on the nature of mathematics teacher learning.

I was expecting some tension to emerge between my role as an 'INSET co-ordinator' *and* my role as 'researcher'. I was expecting this primarily because I had struggled to distinguish these roles clearly in the research proposal. I discovered, however, that no such tension emerged in practice and the tension remained a primarily theoretical tension. Instead I discovered a powerful praxis in the duality of being both INSET worker and researcher. This duality as a methodological issue needs careful consideration and is discussed in detail elsewhere (see Graven, 2002b; Graven, in press). Suffice it to say here that the 'theoretical tension' was turned into a research advantage by continually addressing and reflecting on the duality explicitly and openly in the broader study.

The duality enhanced and enabled a form of action-reflection practice that I had been unable to achieve with success in previous INSET projects. For example, reflecting on interviews, lessons and other data helped me to develop research ideas and refine my research objectives. It led to asking specific questions in interviews and questionnaires that related specifically to my research interest in understanding the nature of teacher learning. Such reflection on data also led to the re-planning of PLESME activities and the design of additional activities that enhanced teacher participation and teacher learning. For example, interviews became a combination of discussions as a necessary part of praxis and discussions that were geared towards gathering data necessary to assist me in answering my research questions. Similarly, my ongoing reflection in the form of journal entries (relating both to PLESME and my work as a researcher) and the readings I was engaged with helped me reflect on how to improve PLESME.

This study adopted a longitudinal, qualitative ethnographic approach. The need for long term studies that take into account the wide range of contextual factors which affect teachers is especially important in the South African context where rapid complex social, political and economic changes are occurring since our first democratic elections in 1994. The choice of qualitative research coheres with various philosophical, epistemological and ontological assumptions inherent in this research, in the INSET and in the chosen theoretical framework.

At the basis of my choice of qualitative methods are the assumptions that—reality is constructed by individuals interacting in their social worlds; meaning is embedded in individuals' experiences and is mediated by the researcher's perceptions (Merriam, 1998); knowledge is both personal and social (Lave and Wenger, 1991; Wenger, 1998). This should not imply that I believe that as a researcher I am free to interpret at will. Rather, I believe that although the social world is mediated by the researchers' experiences, these experiences are still subject to issues of rigor, trustworthiness and validity.

Methods of data collection similarly cohered with the theoretical framework of social practice theory and the work of Lave and Wenger (1991) and Wenger (1998). In their terms, data collection would need to include teachers talking about (and within) their practices. The data therefore included what teachers said and what they did. This data was gathered in interviews, questionnaires, classroom observations, video recordings of teacher lessons and field notes. Data gathered in interviews and questionnaires were then triangulated with data gathered in fieldnotes and classroom observations (see Graven, 2003). To access such data involved close interaction between the teachers and myself, and required good relations of trust and mutual respect. This was supported by the duality of roles discussed above.

For ethical reasons[2] and also because of the small number of teachers in PLESME, all PLESME teachers constituted the empirical setting (Brown and Dowling, 1998). Another advantage to keeping all participating PLESME teachers in the general sample related to the theoretical framework of the study. In relation to Lave and Wenger's (1991) and Wenger's (1998) theory of learning in communities of practice, it is necessary to see the individual teacher in relation to PLESME and also to see PLESME in relation to the individual teachers who constitute it. Collecting data on all teachers enabled the unit of analysis for the study to be *both* the teacher and the PLESME community of practice, viewed in dynamic relation to each other. That is the unit of analysis was both the *teacher in PLESME* and *PLESME in the teacher,* or as Slonimsky[3]so succinctly put it – '*the teacher*-in-*PLESME*-in-*the teacher'*.

Thus, despite the enormous amount of time involved in collecting qualitative data on fourteen teachers over a 2-year period, I proceeded to collect data on all participating PLESME teachers. In the write up of the broader research study (and for this paper) I focus on 10 teachers. These teachers were chosen because full data sets over the 2-year period were available for them. I did not have full data sets for the other four teachers since they had either started late or did not teach mathematics at the senior phase (grades 7–9)[4] for the period of the study.

Thus, the sample can be described as a small, purposive, opportunity sample in the sense that the PLESME teachers were not randomly selected but were volunteers from schools suggested by their respective districts. The teachers are not typical of the general population of mathematics teachers. They are from urban township schools and are clearly dedicated teachers as evidenced by their willingness to contribute a large amount of their time and energy in order to participate fully in PLESME. The teachers showed great commitment to learning more about mathematics education and to improving their practice.

Note that while the findings I discuss in this paper were supported by classroom observations it is beyond the scope of this paper to include data from these sources. See Graven (2003) for an analysis of teacher learning where interviews, questionnaires and classroom observations are triangulated in the story of one of the participating teachers). The two primary sources of data that I use in this paper are interviews and questionnaires. I therefore discuss these briefly. There were, over the 2-year period, three sets of interviews that all related broadly to teachers' understanding and practice of the new curriculum and teachers' understanding of their process of learning as related to PLESME. A fourth interview was conducted at the end of the 2-year period after data analysis revealed that teachers' prolific use of the term 'confidence' required further exploration. Interviews were semi-structured in the sense that they were conversations stimulated by a set of questions and probes. All interviews were conducted with teachers individually in an unoccupied classroom or office and were recorded for transcription.

A first questionnaire involved basic information gathering relating to teacher qualifications, teaching experience, previous workshops attended and views of mathematics and mathematics teaching. Subsequent questionnaires asked similar questions to those in interviews. Questionnaires were used in addition to interviews and were useful in the sense that they provided another context for teachers to reflect on their practice. Questionnaires enabled teachers time to organise and revise their thoughts and provided access to 'written discourses' that can differ from 'verbal discourses' because the activity of filling in a questionnaire positions teachers differently to interviews. Written discourses can often take on a more formal tone as teachers perceive written work to require thought before responding whereas interviews may illicit more informal, 'thinking as one speaks' responses. (For this reason the grammar and language in the data from teacher interviews in this paper is often incorrect and jumbled.)

In the broader study a language of description was developed to analyse, describe and explain teacher learning in relation to Wenger's four

components with the addition of a fifth component that emerged from the data, that of 'confidence'. In each part of the broader study I elaborate on both the way in which each component explains a *mechanism for learning* and I explore *the nature* of that learning. I also draw out connections between the components so as to illustrate the complexity of learning to become a 'professionalised' mathematics teacher (see Graven 2002b). In the next section of this paper I focus only on the fifth component – that of confidence.

4.3. *An exploration of some data from which to theorise about the role of 'confidence'*

The use of the term 'confidence' had arisen sporadically throughout the data from the second interview in June 1999 (6 months after the commencement of the INSET) until the final questionnaire in July 2000. The frequency of the use of this term by teachers to describe and explain their learning, increased as time went by. This prompted further exploration and data gathering on the meaning of 'confidence'. In this paper I first discuss the emergence of confidence, as a central phenomenon in teachers' learning, from the data collected during PLESME. I then discuss the data on confidence from the interview that took place in November 2000. It is important to note that my focus on 'confidence' occurred during the post-PLESME phase of the broader study. This highlights that 'confidence' was not part of the research agenda, it was not a term I used in interviews, and it was not a term used in the discourse of PLESME workshops. Instead 'confidence' was a term introduced by teachers (independently of each other) as a means of describing and explaining their learning.

Although there was evidence that teacher learning extended to the realm of general education and general school issues (i.e., not all learning was directly related to *mathematics* education), the lack of the explicit use of the term 'mathematics' in teacher utterances should not imply that the utterances are devoid of mathematical context. Since the community of PLESME was explicitly organized around participation in activities related to mathematics education, it is reasonable to expect that the term 'mathematics' might be implicit in responses of teachers to interviews or questionnaires. For example, in the quote below, it is likely that Delia's use of the term 'outcomes' refers to mathematics outcomes rather than generic curriculum outcomes since these were a primary focus of attention in PLESME.

In the second interviews, 6 months into PLESME, three of the ten teachers mentioned 'confidence' in their responses. Confidence in these

interviews of June 1999 related to four categories:

1. Mathematics classroom practice. For example: 'I am more confident in my class' (Sam); 'it (PLESME) gives me confidence to stand in front of the children' (Moses).
2. Gaining increased understanding of the new mathematics curriculum and curriculum in general. For example: 'The last time you interviewed me I didn't understand the outcomes, now I've got a good basis to work from, that makes me feel quite confident' (Delia); 'Because we are more confident. . . the more confident the teacher is the more confident the student' (Moses).
3. Being involved with 'more informed' people. For example: 'Its very important to rub shoulders with people who are more informed than you and well educated so you can gain the expertise they have and be confident as a teacher. . . if pupils do not understand I derive ways and means for them to understand. It makes me more confident and I have more people to refer to if I have problems' (Moses).
4. Others having more confidence in them as mathematics teachers. For example 'Puleng and I are discovering that they (management) have more confidence in us, they are more satisfied and the results speak for themselves' (Moses).

In the final questionnaire in July 2000 the frequency and distribution of the term 'confidence' had greatly increased. In this questionnaire, seven of the ten teachers used the term explicitly in various responses. As in the interview of July 1999, the use of the term confidence in the questionnaire related to these four categories:

1. Classroom practice. For example: 'I have more confidence in presenting the subject and asking questions' (Ivan); 'I am now in a position to make my own mathematics programme with confidence' (Moses); 'the programme of class visits in the school boosted our confidence in class' (Puleng); 'Building self-confidence as a teacher' (Karl).
2. Gaining increased understanding of the new curriculum. For example: 'I have more confidence in talking about OBE (Outcomes-based education)' (Elaine).
3. Being involved with other people. For example: 'If someone questions me I can answer them and give them an argument based on my pool of people I work with' (Sam).
4. Others having more confidence in them as teachers. For example 'The colleagues have more confidence in me because I share with them the new information' (Ivan).

However, in this questionnaire, two new categories emerged in relation to teachers' increasing confidence. These related to

5. Increased and broader participation in activities relating to education. For example 'My newfound confidence as a teacher has led me to become more involved in the organization of the school' (Karl).
6. Identification with mathematics teaching into the future and/or pursuing further studies in mathematics. For example, 'I am 10 times better and more confident than what I was 2 years ago. I enjoy my maths teaching so much I will probably do it for a long time to come. Future Plans. I want to study and get my degree in Maths Education' (Sam).

These categories clearly indicate that teachers' increasing confidence was closely interwoven with changes in *meaning* (new knowledge, understandings and experiences of the new mathematics (and general) curriculum, see quotes in Category 2 above), *practice* (new practices in the mathematics classroom and in schools more generally, see quotes in Categories 1 and 5, respectively), *identity* (new ways of being 'identified' by others, identifying with the profession and imagining future trajectories within it, see Categories 4 and 6, respectively) and *community* (new ways of belonging to the broader mathematics education community and participation in overlapping communities such as the school community, see Categories 3 and 5, respectively).

Ivan explained his increased confidence in a way that highlights the interrelatedness between Wenger's four components of meaning, practice, community and identity.

> I have more confidence in presenting the subject and in asking questions that are exciting to pupils. The children love my subject because it is not monotonous, they always look forward to my next period. When children tell you that they enjoy your subject and their results are improving and you also get a positive feedback from parents it is very encouraging. The colleagues have more confidence in me because I share with them the new information, they refer other children. . . Teachers from other schools invite me to ask for solutions, sometimes even over the phone. (Ivan Questionnaire, July 2000)

In this quote we see that Ivan's newfound confidence is complexly connected to each of Wenger's four components. The new meanings and understandings that Ivan has gained about mathematics teaching relate to his changed practices (such as asking questions that are exciting and sharing 'information' with colleagues), these relate to a change in the way he is identified by others in the school community (children, colleagues) and in the community of mathematics teachers of schools in the area which closely relate to his identity and 'belonging' within his classroom, school and

neighbouring school communities. The quote also shows us that through Ivan's increased confidence he is participating more in mathematical activities that extend beyond his own mathematics classroom and therefore his opportunities for furthering his mathematics knowledge for teaching are increased. For example, Ivan is helping children who are 'referred' to him and is engaging with teachers from other schools in finding solutions to mathematical problems.

Karl, on the other hand, emphasised his increased confidence in terms of increased participation in a range of activities that extended beyond activities specific to communities of *mathematics* educators.

> My new found confidence as a teacher has led me to become more involved in the organisation of the school. New committees that I now also serve on. . . The above can be directly linked to PLESME having had a confidence building effect on my teaching profession. I also tend to give more input into our subject meetings. (Karl Questionnaire, July 2000)

This indicates the extension of Karl's confidence beyond the sphere of mathematics education into overlapping spheres. Although the utterances above provided some insight into the interrelatedness of confidence with other components of learning, the extent to which 'increasing confidence' recurred as a central phenomenon throughout the data led me to explore the concept further. The data above show that the frequency of 'confidence' as an explanation for, and description of, teacher learning greatly increased over time. This is important to note, as it is likely that the delay in the emergence of confidence, as a *central recurring* phenomenon, has resulted in many shorter-term research studies of learning overlooking its significance.

Lave and Wenger (1991) and Wenger (1998) also appear to have overlooked 'confidence' in their emerging perspectives on learning. Perhaps this is due to the 'psychological baggage' that a term such as 'confidence' carries. Perhaps it is a result of the difference in the nature of the contexts in which they are working. Or perhaps it is that the studies that informed their perspective on learning were not sufficiently longitudinal for confidence to emerge as a central phenomenon in learning in a community of practice. Whatever the reason, since 'confidence' was unexplored in relation to the theoretical framework in which I was working it begged further *grounded* exploration in relation to this study.

4.4. *Further exploration of the notion of confidence*

In November 2000 I interviewed each of the PLESME teachers on what they meant by their earlier statements of confidence. I was hoping that by working in a grounded way I could construct a fuller meaning for 'confidence'

from a social practice perspective, and explore its relation, in more depth, to Wenger's (1998) components of learning. From the transcriptions of the interviews I coded responses into various categories and sub categories. In a small number of cases, utterances were placed in more than one category.

The emergent categories were similar to those that emerged in earlier interviews and questionnaires with some additions and shifting of emphasis within categories. The categories included: classroom practice, access to knowledge resources, access to community resources, confidence of others in teachers, increased participation, affective factors and understanding one's own limitations. These categories related closely to Wenger's four components of learning, namely, meaning, practice, identity and community. I discuss the relationship between the categories and these components following Table I further below. The table gives an indication of the distribution of teacher utterances (see *f* in the table) in each category as well as the learning component/s of Wenger (1998) which each category relates most closely to (see italics above each category in the table).

Clearly the categories are interrelated. The following quote reveals the interrelationships between categories 1, 2, 3, 5 and 6. That is, it shows the relationship between classroom practice, access to ideas, access to support, increased and new forms of participation, and affective factors:

> Okay, before it was more or less a one-man show... There is no feedback at all, you haven't shared any ideas with other teachers... Being in a group that you could rely on you got quite a few ideas and this now stimulated my interest in developing worksheets, new teaching styles, being creative in the classroom... And then sharing with the colleagues in the group if it didn't work, why it didn't work and what could possibly work so that also gave me a lot of confidence in the classroom... And I think the support that we get knowing people, like we know you, we know the GICD (Gauteng Institute for Curriculum Development), we know Paul Laridon (prominent South African Professor of Mathematics Education, curriculum developer and textbook author), you know we've got personal contact with them. I think that also helps us in a way because we know we can pick up the phone. (Delia Interview, November 2000)

As in the quote above, Category 3 of the table shows an emphasis by teachers on access to people as a supportive resource in developing confidence. This category receives the greatest number of utterances (21 in total). This concurred with the teachers' emphasis on this aspect in relation to listing the major benefits of their participation in PLESME (see Graven, 2002b). Within this category belonging to the PLESME community features most prominently (12 utterances). Thus increased participation and a sense of belonging (membership) within the PLESME community of practice and overlapping communities was noted as a primary contributor in the process and production of increased confidence.

The first six categories closely relate to learning as changing forms of experience (meaning), doing (practice), becoming (identity) and belonging (community).

Category 1 indicates teachers' use of confidence in relation to changing *practice,* (learning as doing as is captured by Rosina's comment 'I know what I am going to do') and reveals a close relationship with *meaning* (learning as changing understanding and experience). For example, Rosina comments that she is now more open to her learners and says that 'the children are not afraid. . . they talk freely' indicating a changing 'way of being' in the practice of mathematics teaching. Similarly Moses' comment is indicative of his confidence being linked to his changed understanding and experience of mathematics learning and his ability to create a more positive learning environment in which his learners are themselves confident: 'knowing it (learning) is a two way process that on its own makes me more confident. It makes them confident learners. We interact in a very healthy way'.

Category 2 highlights the relationship between confidence and access to knowledge as a resource, which relates to changing *meaning* and *practice*. The knowledge that teachers most valued, as evidenced by their utterances in these interviews, related to mathematical understandings, mathematical-pedagogical understanding and new (mathematics) curriculum information. In the quotes we also see that practice is always affected by this changing meaning. For example, Elaine explained that with her new experience of OBE she is able to motivate others and argue with others about OBE. These various aspects of mathematics knowledge for teaching formed the primary focus of most PLESME workshops. In light of this it is perhaps surprising that this category has a lower frequency of utterances than Categories 1, 3 and 5. However, the complex connectedness of *mathematical* meaning (and possible implicitness in the utterances in other categories) makes it risky to deduce that it is therefore a less important category of teacher confidence. Indeed, this increased access to knowledge resources relates directly to teacher identity and the nature of teachers' participation within various communities. For example, Ivan's quote in Category 2 reveals that he appreciates mathematics more as a subject and is now able to study further which shows a stronger identity as a mathematics teacher with a trajectory of further learning within the field. (Note that five of the ten PLESME teachers furthered their studies in *mathematics* education subsequent to PLESME.) Elaine's quote explains how her access to knowledge resources relating to the new curriculum enables her to 'argue', 'motivate' and 'train' other teachers thus indicating her willingness to take on new roles within her communities. The adoption of these new roles will influence Elaine's changing identity and identification by members of those communities.

Categories 3 (which primarily relates confidence to *community)*, 4 (primarily relates confidence to *identity*) and 5 (primarily relates confidence to *practice*) are closely intertwined in that confidence, in its derivation from support available from belonging to a broader community of professionals, is related to teachers' changing status/identity in various communities. This changing status relates to teachers' changing practices and the changing forms of (increasing) participation in those practices within those communities. Thus in Table I Category 4 is primarily related to identity and secondarily to community and similarly Category 5 is primarily related to practice and secondarily to community.

Categories 1–5 are similar to the categories that emerged in relation to teacher comments on confidence in earlier interviews and questionnaires (discussed above). The *distribution* of utterances in the categories is, however, different in November 2000. In the July 2000 questionnaire most teacher utterances were clustered in relation to classroom practice (Category 1). In the November 2000 interviews 'community as a resource' became far more prominent, having the highest frequency of utterances (Category 3). That is many teachers related their increased confidence to the resource of people. I argue that with time initial peripheral participation within various communities (PLESME and other overlapping professional communities) transformed to more central participation resulting in these communities becoming a far more powerful learning resource than they were at the start of the INSET. This argument is further supported by the much higher frequency of utterances in Category 5 in the November 2000 interviews as well as by the changing nature of teacher participation in PLESME workshops as discussed in subsection 4.1 above.

Category 5, relating to increasing and new forms of participation, revealed a new aspect of teachers' confidence that was not revealed in earlier data. It revealed a newfound confidence in teachers to argue, to challenge, and to justify and be proud of one's actions. The following quote illustrates this (see also the last two quotes in Category 5):

> Like when you have your syllabus your HOD (Head of Department) will tell me I have to cover everything and then just to please him I must cover everything but now I'm to a point where I can say listen there's no need for me to cover everything. I've got the confidence and I say listen this is my time what I have. . . And the other confidence is, how can I say, its not where I would sit in my class, I don't know if you've picked this up, teachers don't want you to go into their classrooms, but to me it doesn't matter who is in my classroom you can come in when I'm doing, I'm confident in what I'm doing you can do whatever you want in my classroom I can justify what I am doing and why. In the past I would say no I don't want you in my classroom, just go away please. If you come into my class I would just stop my teaching but now whoever comes it doesn't matter what is your ranking, inspector who else. . . ' (Sam Interview, November 2000)

TABLE I
The distribution of teacher utterances on 'confidence' from Interviews, November 2000

Category (and range)	*f*	Exemplar utterances
Practice and meaning		
1. Classroom practice	14	A lot, a lot a lot (of change in confidence), because when I stand in front of the children I know what I am going to do . . . The children are not afraid to do anything in the class, they're asking questions they want to find more from what they have learnt . . . Yah they talk freely, they even come to me after lessons. . . and I am now open to them. I am no more as harsh as I was before (laughing) (Rosina).
Improved mathematical competence	(5)	
Improved methodology and ideas	(6)	
Approaches to teaching/learning: more input from learners, learner confidence and better class ethos	(3)	
		Whenever I step in the classroom – knowing it is a two-way process that on its own makes me more confident. It makes them confident learners. We interact in a very healthy way (Moses).
Meaning and practice		
2. Access to knowledge resources in relation to:	12	By confidence I mean the command of subject, Ok the strategies in presenting the subject, the approach. . . You know personally when you are confident about the subject it is easier to impart it than when you are not sure. . . You yourself appreciate the subject and dig deeper or do further studies' (Ivan).
Mathematics	(4)	
Methods, Ideas, strategies (for teaching mathematics)	(5)	
New (mathematics) curriculum information	(3)	
		Confidence to me means that you do your work without struggling, you have resources, not only human resources but you also have learning materials, you have interesting ideas. . . (Cedric).
		Before we started this course if someone asked me what is OBE I would just rely on what I had read in the newspaper. So I couldn't talk to someone and say what I think OBE is because there was no confidence and after this course if somebody asks me I can still have an argument, can motivate. . . But you see the confidence also to train the other teachers in the department because I can explain what I want from them, or what is a lesson based on OBE (Elaine).

(*Continued on next page*)

TABLE I
(*Continued*)

Category (and range)	*f*	Exemplar utterances
Community		
3. Communities as a resource	21.	And then sharing with the colleagues in the group, if it didn't work, why it didn't work and what could possibly work so that also gave me a lot of confidence in the classroom... And I think the support that we get knowing people, like we know you we know the GICD, we know Paul Laridon, you know we've got personal contact with them I think that also helps us in a way because we know we can pick up the phone (Delia).
PLESME community	(12)	
AMESA conference community	(4)	
Other teachers/principal	(2)	
Other organizations/individuals in organizations	(3)	
		Ya I say now we have given us the chance to attend conferences to impart our knowledge to people who have got more knowledge than us that on its own gives more confidence... gradually to be in your mist makes me more confident than ever (Moses).
Identity and community		
4. Others have more confidence in teachers. Teachers accorded more status and recognition by:	9	Others have more confidence in me, they (other teachers) are asking me to set papers and evaluate theirs, so it means they have confidence in me. Also interacting with other teachers, how Mr X (his principal) came to support me and wanted me for his school, its how it comes about and interacting with other teachers, like knowing guys like Cedric and Karl (Ivan).
Learners	(3)	
Teachers/ Principal	(2)	
Broader community	(3)	
District	(1)	
		I must say you get your status as well in your community, its one of the good things, even with your children, your children see you as for example the other classes I don't teach, the children say Mr Tune will you teach us next year for maths please... So that's the other confidence the children see how I work and how I approach certain things and they start to grow in confidence... (Sam).
		Even my, what do you call it, DC (district advisor), comes to ask me nowadays what do I know what do I think about this whole thing (Elaine).

(*Continued on next page*)

TABLE I
(*Continued*)

Category (and range)	*f*	Exemplar utterances
Practice and Community		I can share my ideas with other teachers from other schools, I can join in with the OBE thing and express my opinions . . . Yah, even when I am talking to parents now, its not where, how can I say, I can actually come up with examples and explain to them. . . (Sam)
5. Increased (and new forms of) participation in broader education activities involving:	15	
Other teachers	(4)	
Conferences	(3)	
Department	(4)	
Parents and community	(4)	
		The other thing which I've learnt is to go to conferences even with AMESA and those conferences we thought those were only for people with degrees and so on that's not for us and when I started with the conferences and so on I feel more comfortable talking in front of people and sharing ideas, its not where I'm this little teacher in this little classroom trying to do a little thing (Sam).
		I'm more free to talk to the DCs (district advisors) than before because if I can argue a thing with them so that we can be able to come to an agreement, we never did that we were afraid of these people. When they come to us we see them as people who are coming to do something bad to us (Rosina)
		For me it's the power that this project gave me. How to expose myself without feeling ashamed or guilty of what I know or what I don't know. Actually having that courage to go further than that take it further and give input. Give the ideas that I have and not be afraid that the ideas that I have may be incorrect or wrong or I don't know enough to risk that confrontation if it may be (Karl).
Overlaying all four components		And when you see the response and you see the result then you are always motivated and your confidence is growing and your workplace becomes a nicer place (Cedric).
6. Affective factors/ ethos	8	
Motivation	(3)	
Work with ease	(2)	
Encouragement from style and ethos of PLESME	(3)	

(*Continued on next page*)

TABLE I
(*Continued*)

Category (and range)	*f*	Exemplar utterances
		A lot of encouragement. I'll never forget the first day you came to film me and I did the graph, you know when I made that mistake. . . and at the end that was actually one of the strong points that you mentioned, I didn't expect that when you said the kids actually saw your thinking process. . . There you also gave me a lot of confidence. . . you made us feel that we were intelligent, that's how you made us feel good (Beatrice).
		That is what that self confidence, where it originates from I think basically we have been exposed to one another and we found out that people are not out there to get you. It's a situation where we want to assist each other I think that was the environment the PLESME group had (Karl).
Relates to the component of confidence in its own right		
7. Understanding one's own limitations:	10	I was confident enough to invite Barry to do this part of the lesson and the kids will enjoy it. I have confidence in myself for inviting him. We are usually afraid to do this because it means admitting weakness. Confidence allows me not to have to know everything (Ivan).
Allow mistakes and reflection	(4)	
See space for growth and improvement	(6)	
		I can expose myself to what I know, I mean to other people and I am willing to say Okay fine, show me wrong, prove me wrong. What is your idea then? What I say is I am open let's learn. That is what that self-confidence is (Karl).
		And also knowing that if it doesn't work for this lesson I can change my method and try something else, its not a matter of do it or die kind of thing (Delia).

Note: Quotes also indicate participation in terms of challenging others or arguing one's point.

Sam's confidence in relation to his access to knowledge resources, his confidence in belonging to various professional communities, his confidence in his mathematics teaching practice and his related 'status' in his school community (see also Sam's quote in Category 4) is linked to his

expressed increase in his agency within his classroom. Sam explains that he is now willing to challenge his head of department and to justify his reasons for this challenge. He further expresses his ownership of his classroom, and his confidence in this ownership, by stressing that he does not mind who observes or 'inspects' his class. Furthermore, Sam's ownership and agency within the profession of mathematics education extended beyond his classroom to directing his growth, leadership and changing identity within mathematics teaching. At the start of PLESME Sam was primarily a business economics teacher who taught one mathematics class. Today Sam is the head of a mathematics department, he has completed his Honours degree in Mathematics Education, and is considering studying for a Masters degree in mathematics education.

Category 6 links confidence to affective factors that result from teachers' access to a wide range of resources involving participation in various *practices* and having access to a particular kind of support incorporated within the ethos of the PLESME *community*. This 'ethos' is often undervalued in explaining teacher learning and in the design of INSET and is discussed in subsection 4.1 above. It is an important area that requires further articulation in relation to analysing mathematics teacher learning within a social practice perspective.

Furthermore, in November 2000 an important additional category emerged in relation to confidence. This category (see Category 7) related confidence to understanding one's own limitations and viewing one's learning as a life-long process within the profession of mathematics teaching. Category 7 is especially interesting in that it provides us with insight into the notion of confidence, in relation to learning, in its own right. That is, it relates confidence to learning to become a *confident* 'masterful' professional mathematics teacher.

It is possible that Category 7 emerged only in the final interview because of the longer time needed for teachers to develop their confidence to the point that they could accept that, to be a competent mathematics teacher, one did not have to know all there is to know about mathematics education. The quotes in Category 7 reveal a shift in teachers' understanding of their own learning and the nature of learning in general. This shift resonates with a Socratic philosophy of learning—that it is better to know that you don't know, than to think you know—and that there is power in understanding one's own limitations. For example, Ivan explained:

> Like for instance I was confident enough to invite Barry (teacher in PLESME) to do this part of a lesson and the kids will enjoy it. I have confidence in myself for inviting him. We are usually afraid to do this because it means admitting weakness. Confidence allows me not to have to know everything (Ivan Interview, November 2000).

Ivan's quote reveals that confidence enables him to accept that he does not have to know everything in order to be a competent professional mathematics teacher. This enables Ivan to work confidently from what he does know, to access necessary resources for that which he must still learn, and to position himself as a life long learner (as opposed to a learner with a deficit that demands immediate fixing). In a dialectical cycle Ivan's confidence enables him to be a learner in a way that produces more confidence.

Similarly, many PLESME teachers changed their understanding of what it meant to be a competent professional mathematics teacher and began to see learning as an integral part of being a professional, irrespective of one's level of formal education. This can be especially difficult for teachers since they are usually constituted as 'all knowing'. Teachers as learners in an INSET context differ from other learners in schools or apprenticeship contexts. The evidence in Category 7 suggests that teachers challenged the 'all knowing' construction of 'a professional teacher'. This new construction supported teachers in strengthening their identities as mathematics teachers despite the limitations of their pre-service studies. I emphasise the limitations in their *pre-service* studies since these limitations were, to an extent, addressed through their 2-year participation in PLESME. Teachers expressed confidence in the acceptance that indeed one cannot know everything but one can become a life-long learner within the profession of mathematics teaching. This new approach to learning was both a result of confidence and provided teachers with increased confidence. Furthermore, confidence became a resource for further learning. This relates to the discussion earlier, that confidence (including mathematical confidence) is an important learning component irrespective of the level of competence that one brings to the learning process because it contributes to one's becoming a life-long learner within the profession of mathematics education. Indeed, five of the ten teachers chose to further their studies in mathematics education subsequent to PLESME.

In sum, the interviews of November 2000, as summarised in Table I, provide evidence to support a conception of confidence as both a product and process of learning that involves dialectical movement towards mastery of the practice of being, and becoming, a professional mathematics teacher. This assertion requires further exploration and elaboration.

4.5. *Theorising confidence as both a product and process of learning*

The emergence of Categories 1–7, and the nature of the examples in the categories, illustrate that increased confidence was both a *product* (resulted from teacher learning) and a *process* (an explanation for teacher learning) of teacher learning. Evidence provided in the table illustrates that teachers had

indeed become confident in their level of mastery in the practice of being professional mathematics teachers. I use the phrase 'level of', as a qualifier of mastery, to indicate that my use of the term 'mastery' is primarily as an ongoing process, involving both being and becoming, that at any point in time can be experienced, by teachers, as a product of learning. In this way teachers can experience a particular level of mastery in relation to a particular aspect of their practice and their learning.

Mastery involved: confidence in what teachers had learnt and the meanings they formed in relation to changing developments in their profession; confidence in their ability to participate in the various practices (and communities) of the profession of mathematics teaching; confidence in their ability to access resources to supplement their learning; confidence in their identities as professional competent mathematics educators; confident acceptance that there was still much to learn and a willingness and confidence to be a life-long learner in the profession of being (and becoming) a mathematics teacher.

In this respect, like Wenger's (1998) other four components of learning, confidence is both a product of, and a process inherent in, teachers' learning to become professional mathematics teachers. Thus, in the same way as *identity* involves *learning as becoming*, as well *being* a person with a particular identity at a particular point in time, confidence involves *learning as mastery,* as well as *being* a mathematics teacher with a particular level of mastery at a particular point in time. In this way confidence, and mastery, are producing and produced by learning.

There is a range of data in Table I that supports the assertion that confidence is both a product and process of learning. For example the quotes in Category 1 show that increased confidence is largely a *product* resulting from improved knowledge about teaching and changing classroom practices. Similarly the quotes in Categories 2 and 3 show confidence to be a *product* resulting from access to resources such as 'professional' knowledge and the support of a broader community of people. However, the quotes in Categories 4 and 5 indicate that increasing confidence is both a result (product) of, and part of the *process* of teachers' changing identities/status. And confidence is a product of, and part of the process of, teachers' changing forms of participation in various practices and in relation to various communities. Similarly the quotes in Categories 6 and 7 illustrate that confidence is a 'growing' *process* that both results in, and is produced by, affective factors (e.g., motivation) and acceptance of one's limitations and openness to further learning.

Due to the absence of the notion of confidence in Wenger's (1998) work, I argue that his framework of learning does not deal comprehensively with all primary aspects of learning (in all contexts). I consider confidence as an

overarching fifth component requiring discussion and analysis in its own right. As is shown above, confidence was closely intertwined with all four of Wenger's learning components in the same way as these components are intertwined with each other. However, in my view confidence, as it emerged from the data, has its own specific features that could not be subsumed within the other components. Teachers had mastered their profession to the extent that they were able to reconcile 'mastery' with understanding the limitations of what is possible at a particular point in one's profession and the notion of lifelong learning (see Category 7). Ivan's statement that confidence allows him not to have to know everything captured this. This aspect of teachers' confidence did not relate directly to any of Wenger's four components. In discussion of this data, Wenger himself was open to the idea that 'confidence' may not be 'subsumable' within the other four learning components (personal communication, March 2002).

Thus, mastery involves the insight to know when you do not know, the confidence to admit to this, and the ability to access the necessary information (or experience) and support from the broader professional community of mathematics educators (or other overlapping communities).

I argue that this alignment is crucial especially within the profession of teaching where experience, reflection and engagement with others are key sources of lifelong learning. Furthermore, the profession of teaching will always be subject to adaptations relating to new research findings and changes in education policy and curricula. In this respect being a professional mathematics teacher involves the ability to be adaptable to changing circumstances, new knowledge resources and to being a continuous learner. Thus mastery of the profession of mathematics teaching involves a dynamic process of becoming a confident mathematics teacher in relation to the components of meaning, practice, identity and community. Furthermore, mastery of the profession of *mathematics teaching* involves mastery of particular epistemic demands relating to *mathematics* knowledge for teaching.

5. In conclusion

In this paper I have drawn on interviews and questionnaires of 10 teachers participating in the 2-year mathematics PLESME INSET project to explore the phenomenon of confidence, in relation to teacher learning, both empirically and theoretically. The rich and textured teacher explanations of confidence illustrate: the centrality of confidence in relation to their learning; the breadth of the concept; the interrelatedness between confidence and Wenger's (1998) four learning components; and the way in which confidence enables, as both a product and process, mastery of becoming and being a professional mathematics teacher.

Confidence as a product and a process of learning enabled the teachers in the study to move from being *teachers of mathematics* towards being and becoming competent and confident *mathematics teachers*. The paper provides the example of a participating teacher who expressly denied being a 'mathematics teacher', despite having taught mathematics for over 30 years and heading his mathematics department. Similarly many other teachers felt themselves to be mathematically insufficiently qualified to consider (or to introduce) themselves as mathematics teachers as opposed to, for example, a music teacher who happened to be teaching mathematics. Indeed, most of the teachers at the start of the INSET were not qualified to teach mathematics *per se* and struggled with the epistemic demands required to teach *mathematics*. Thus, the distinction between *teachers of mathematics* and *mathematics teachers* and the movement from the former to the latter was particularly pronounced in the study due to the poor mathematical histories of the participating teachers *prior* to the INSET.

The conceptualisation of confidence as movement from the periphery of various (mathematics) education related communities towards more central participation, identification and belonging within these communities, provides a contribution to explorations of confidence within the field of mathematics education. This conceptualisation provides an alternative, located within a social practice framework, to more prolific conceptualisations of confidence as internalised knowledge or belief located within cognitive frameworks.

I have argued that the increasing use of Lave and Wenger (1991) and Wenger's (1998) work in the field of mathematics and mathematics teacher education necessitates careful critique and re-contextualisation of this work into mathematics education and teacher education. While I have illuminated the usefulness of Wenger's (1998) four learning components for exploring mathematics teacher learning, I have suggested ways in which his work can be extended. I have highlighted Wenger's avoidance of the notion of teaching *per se* and have stressed the need for considering the importance of the role of teaching within learning, especially in the case where the learners are in fact teachers. Through illustrating the centrality of confidence in relation to the mathematics teachers' learning I have highlighted that Wenger's avoidance of the notion of confidence in his work is problematic. I have argued that since many teachers explained their confidence in relation to acknowledging their own limitations and becoming life-long learners within the profession of mathematics education, confidence should be considered a fifth component of learning rather than a component which is subsumable within meaning, practice, identity and/or community.

Since confidence is not dealt with by Wenger or in the range of related social practice literature that has informed this study, its elaboration here,

grounded as it is in the data of mathematics teacher learning within an in-service community of practice, provides an advancement of this perspective. I have argued that it is likely that the longitudinal nature of this study enabled confidence to emerge more strongly in teacher explanations of the product and the process of their learning than would have been the case had the INSET ended after a short period of time. Furthermore, the 'delayed' emergence of confidence as a central phenomenon of teachers' learning has implications for the design of INSET. If we accept, as is argued in this paper, that confidence is a central phenomenon which enables and supports teachers' mastery of the profession of mathematics teaching then it is important that INSET work with teachers is sufficiently longitudinal for confidence to become and be a central part of the product and process of teacher learning.

I have elaborated and illustrated the notion of confidence as it emerged in the data of the mathematics teachers' learning in this study. Clearly, more work needs to be done in order to theorise the notion and role of confidence, more generally, in relation to applying social practice theories to the field of mathematics education. Such theorisation should be based on a broad range of research in a variety of mathematics education and teacher education learning contexts.

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NOTES

1. In South Africa learners can choose to study subjects on either higher grade or standard grade level. Higher-grade mathematics is usually required for entry into 'Science studies' at universities.
2. Clearly teachers valued their time during interviews as an opportunity to express how they were feeling about PLESME, about education, about mathematics teaching in general and about their work in their classroom. Teachers wanted to share what they had been doing in their classes and share their positive experiences and frustrations of 'trying out' new ideas. Furthermore, selecting teachers would inevitably involve excluding others. Such a process could affect relationships in PLESME and create division between those involved in the research and those who were not. For these reasons, I felt it problematic to exclude any PLESME teacher from 'research related' activities.
3. Slonimsky used this phrase in a reading group session in 1999 in which we discussed some of the data emerging from PLESME. Steve Lerman, a guest of our reading group, recently discussed this concept in relation to Slonimsky's idea of mind in society in mind (an extension of Vygotsky's Mind in Society), see Lerman (2000). Put in such

a way the dialectical relationship between 'mind' and 'society' is foregrounded rather than focusing on one at the expense of the other.

4. PLESME focused on Senior Phase mathematics teachers since that was the phase of the new curriculum that was to be implemented at the time. However some teachers who did not teach in this phase or did not teach mathematics specifically requested to participate in PLESME as they intended to teach mathematics in this phase in the future.

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