A square peg in a round hole?
An exploration of constraints to the adoption of constructivist-based practice by beginning mathematics teachers

Simon Henley

This paper presents a pre-service teacher's exploration of the tensions that became visible in the intersection of his teacher education programme and the associated school/classroom 'teaching' experiences, and considers a framework that offers both personal and pre-service potential resolutions for these tensions.

Introduction

As a pre-service mathematics teacher, I am soon to begin my secondary school teaching practice. Yet after a year of pre-service teacher education, I do not feel confident about facing the reality of mathematics teaching in New Zealand classrooms.

My fear is that the hopes that I have for my practice, and the beliefs I have come to hold regarding how I would like to teach will be worn down by the myriad realities and pressures I am likely to experience as a beginning teacher. In many ways I suspect that the teaching tools with which I have been equipped by my pre-service training, based largely on constructivist principles, may ill-prepare me for the real world of secondary school mathematics teaching. Indeed, at times I feel like I have been armed with a square peg and am about to be faced with a round hole; and I wonder how long I will keep trying to make them fit.

The intent of this paper is thus to illuminate obstacles that may impact on my future practice by exploring the various tensions and pressures that come to bear on beginning secondary school mathematics teachers, and how their beliefs and teaching practices may be affected. The literature on cultural and institutional forces opposing the use of constructivist-based practice, in particular by beginning teachers, will be examined and a framework for understanding such constraints in the context of beginning teacher development will be introduced. I will conclude by looking at the

implications of these pressures for my beginning teacher practice, for my sense of personal and professional agency, and for pre-service teacher education.

Rationale

Ensor (2000) poses a key question: why do teachers frequently not seem to implement in their classrooms the practices acquired on teacher education courses?

The transition to the workforce from pre-service teaching seems fraught with difficulties. Research indicates that beginning teachers are generally not prepared for the workload encountered in the school, nor the complexities of the interpersonal relationships they must navigate (Moss, Fearnley-Sander & Moore, 2002). At the classroom level, beginning teachers often struggle with classroom management, with meeting the individual needs of students, and with the management of curriculum and resources.

The literature discusses how many beginning teachers, at some stage after experience in schools, will commonly reject significant parts of their pre-service academic training (Moss, Fearnley-Sander & Moore, 2002). In fact, under the pressures of time and the curriculum, beginning teachers frequently appear to teach with little regard to theoretical principles guiding their action (Kane, 1994).

I have encountered this dilemma first-hand in my own experiences on practicum. My associate teachers have spoken of the multiple pressures and constraints that they experience which influence their teaching methods, including curriculum and assessment requirements, school and departmental policies, limited time, and high workload. Many acknowledge that the most effective mathematical teaching is sacrificed in the interest of managing these tensions and demands. This suggests to me that within New Zealand secondary schools there are significant potential barriers to quality mathematics teaching practice. I would like to understand these constraints more clearly, in order to better inform my own teaching approach as a beginning teacher.

Constructivism: A square peg

The value of a mathematics teaching approach based on constructivist principles of learning, where students are supported in constructing their own mathematical understanding, is widely documented in the literature (Begg, 1999b; Noddings, 1990; Skemp, 1976). It is not surprising then that it has been a cornerstone of my pre-service mathematics teacher education. As Klein (1998) suggests, one doesn't have to go far to find policy and curriculum documents in mathematics teacher education extolling the virtues of investigatory or inquiry methods of teaching mathematics. This is in keeping with a view of mathematical knowledge as an active personal construction, where learning refers to "the creation or building up of relationships in the mind of the individual" (Klein, 1998, p. 295).

It is thus equally unsurprising that my own pedagogical approach to mathematics teaching is also based on student-centred and constructivist principles. As a direct result of my pre-service teacher education I have come to strongly believe that effective mathematic teaching practice is based on providing students with rich and open tasks to explore for themselves. I agree that the role of the effective teacher in this model is that of a facilitator who elicits student ideas, and supports and extends their thinking (Fraivillig, Murphy, & Fuson, 1999). To a large degree, I have adopted the values and beliefs of my pre-service educators.

My experiences on teacher pre-service practicums, however have frequently been in sharp contrast to these values and beliefs. In my observation of mathematics teachers during practicum, I have witnessed the widespread use of behaviourist and teacher-centred teaching practices in the classroom. Furthermore, in my own teaching experiences on practicum I have on many occasions found myself adopting similar approaches. This is frequently at odds with my own pedagogical beliefs.

It would seem then that there is some tension or resistance to constructivist-based teaching practice in the reality of New Zealand classrooms. Despite the acknowledged and largely undisputed theoretical research base in support of this pedagogical approach, it appears that for some reason it may not fit easily into teacher practice within real classrooms. What then are the factors within New Zealand secondary

schools that oppose the adoption of constructivist-based teaching practices by beginning mathematics teachers?

The culture of the mathematics classroom: A round hole

Zevenbergen (1995) argues that there is an identifiable culture within the mathematics classroom, which is generally different to that of other curriculum areas. The primary focus of a mathematics lesson may be the learning of mathematical concepts – yet within classroom interactions many other messages are being conveyed about the nature of mathematics.

Traditionally, mathematics is seen by students and teachers as a set of basic facts which have to be memorised (Klein, 1998). It is seen to focus on computational skills, using transmission models of learning where the teacher controls knowledge, and where students imitate teacher demonstration of mathematical convention. It is frequently seen to follow a Skinnerian approach to teaching, where the teacher explains, then students practice a task under teacher direction (Zevenbergen, 1995). This is reinforced by a common experience by students of mathematical problems having a binary (right or wrong) answer (Klein, 1998). There is thus a clear power relationship enculturated within mathematics education, in which traditional discourses strongly entrench the teacher as "knower" imparting knowledge, and the student as the "learner" receiving the knowledge.

To be constructed as effective learners of mathematics within this traditional model of the mathematic classroom, students must learn this hidden agenda to mathematics, and must learn to comply with it (Zevenbergen, 1995). This traditional mathematics culture seems at complete odds, however, with constructivist-based teaching principles. It would seem to be infertile ground in which to sow the seeds of constructivist-based teaching; and indeed, so far constructivist-influenced changes in teaching methods have not impacted on classrooms as readily as many would have hoped. According to Klein (1998) what students learn and how they learn it remains largely unaltered. Indeed, she maintains that any creative and investigative impulses by teachers are largely negated when confronted by established notions of mathematical knowledge and how it should be taught. It seems entirely apt to think of this "cultural clash" as resembling trying to fit a square peg in a round hole.

Occupational socialisation of the beginning teacher: Making the peg fit

On entering both a school and classroom for the first (or indeed any) time there are many and varied tasks to carry out and many and varied ways in which to do so. Only some of these will smoothly meet the expectations of the staff in a particular local social/cultural environment and the potential mismatch is greater with beginning teachers with a fresh theoretical background. Walshaw and Savell (2001) propose that the overwhelming complexity of the role of the teacher causes an inevitable conflict between theory and practice; and between what should happen in teaching practice and what does actually happen.

Learning to become a teacher is thus wider than pre-service theoretical teacher education. In fact, it can be viewed as a complex process of socialisation. There have been many studies that take a functionalist orientation towards the occupational socialisation of beginning teachers (for example, Goodman, 1988). In these studies, beginning teachers are viewed as a product of their environment, their practice moulded by external forces. These forces may include both biographical messages (from the beginning teacher's past experiences) and institutional messages (from both pre-service institutions and from schools). Beginning teachers thus develop in relation to a variety of significant others – pre-service educators, associate teachers, school management, students, and people from past and present (Walshaw & Savell, 2001).

However, there is much evidence of conflict between these forces. Pre-service teacher education institutions seem to generally offer strong messages of constructivist-based teaching approaches. The traditional culture of the mathematics classroom, however appears to remain strongly entrenched in the beginner teacher's past and present school experience, and this appears to frequently oppose these pre-service constructivist beliefs. This works to undermine constructivist-based teaching practices in several ways.

Firstly, the adolescent experience of most beginner mathematics teachers will have included learning the traditional culture of the mathematics classroom. Despite all the talk of mathematical empowerment, of students and teachers together searching for mathematical patterns and connections and communicating these with confidence to enhance and develop mathematical ideas, many teachers continue to teach largely as

they were taught (Klein, 1998). Even though they may not admit it, many hold on tenaciously to this view of mathematical knowledge as facts, skills, rules and procedures to be transmitted, and to the absolute authority of teacher and text; and will tend to revert to this, particularly in times of stress.

Secondly, the complex and constantly shifting situation of the teaching experience places the beginning teacher in a vulnerable and dependent position. As a neophyte, a beginning teacher both seeks and is receptive to advice, support and guidance. Indeed, first year teachers frequently remain locked into an apprenticeship of observation and consequently rely on modelling their practice on the overt behaviour of more knowledgeable others (Kane, 1994). The "others" in schools offer persuasive ways of doing things, and to that extent the creation of beginning teacher identity is derived in a large part from the identity and discursive practices of these others (Walshaw & Savell, 2001). As most of these colleagues too have been enculturated within the traditional mathematics teaching culture, their support will frequently be towards the traditional transmission model of teaching, and away from constructivist-based approaches. This socialisation thus invariably eats away at the constructivist ideals of the neophyte teacher.

Additional factors opposing constructivist-based practice

There are additional factors that work further to override the intended teaching aims of beginning teachers, and serve to further entrench and continue the traditional culture of the mathematical classroom. Haynes (1996) suggests that other such external pressures include high workload, limited time, teaching to a content-oriented curriculum; and assessment. Kane (1994) suggests a further factor: the potential failure of pre-service teacher education to equip beginning teachers with sufficient practical tools to deal with the realities of the mathematics classroom. These factors mirror the pressures that I have observed and experienced while on practicum, and I will explore each in more detail.

Time, stress and workload: Teaching for survival

During their first year of teaching, beginning teachers will be subject to overwhelming and at times conflicting influences upon their classroom practice. Beginning teachers report of the increased presence of constraints which act to

undermine the application of the theoretical and pedagogical knowledge obtained from pre-service education (Kane, 1994). The high workload and time pressures experienced by beginning teachers result in an overwhelming tendency to adopt "quick fix" survival strategies based on trial and error within a narrow experience, and which for the most part have no sound pedagogical basis. In this stressful environment, beginning teachers will thus frequently resort to "doing what comes naturally"; teaching as they were taught, modelling the teaching behaviour of colleagues, or acting as seems appropriate within the classroom with little reference to theoretical principles guiding their action.

Curriculum and assessment

According to Begg (1999a) constructivist approaches to learning frequently fail to provide clear and consistent models for curriculum and assessment. Begg suggests that "teachers are subjected to mixed messages when they talk about constructivist learning but are presented with curricula and assessment in a behaviourist format" (p. 68).

These "mixed messages" are clearly identifiable within the current New Zealand mathematics curriculum (Ministry of Education, 1992). On one hand, the curriculum argues for a problem-solving approach that is clearly constructivist in nature. While on the other hand, the curriculum is prescribed through achievement objectives, with an implication that these are well-defined and measurable. Underlying this structure of small, measurable objectives there appears to be a reductionist view of knowledge, and a behaviourist view of learning. This sits rather uncomfortably with the constructivist views presented in the curriculum statements about learning processes and the problem-solving approach (Education Review Office, 2001).

Adding to the confusion, beginning teachers have difficulty inventing suitable constructivist-aligned problems that provide an appropriate context for the mathematics they want their students to learn. According to the Education Review Office (2001) it is possible that teachers would be able to better use the curriculum's constructivist approach if they were provided with many practical problems that they could use to teach the ideas prescribed in the content strands of the curriculum.

Further, there has been found to be a close link between assessment and instruction (Barnes, Clarke & Stephens, 1995). Mandated external assessment sends strong messages to schools that the style of assessment and the types of activities assessed play a powerful role in determining which aspects of the mathematics curriculum are valued by teachers. In circumstances where extended and reflective activities involving communication, problem solving or investigation do not play a role in the external assessment, schools invariably place a low priority on such activities.

This combination of inadequate problem-solving resources, a prescribed curriculum, and external assessment again acts to undermine constructivist-based teaching practices.

Inadequacies of pre-service teacher education

According to Kane (1994), there is an explicit distinction between the knowledge gained from pre-service teacher education – propositional knowledge, and that of effective classroom practice – procedural knowledge. She suggests that pre-service education is frequently insufficient for developing an understanding of the rigorous nature of the authentic practice encountered in the first year of "real" teaching.

It makes sense to acknowledge that the way in which constructivist-based practice is taught in pre-service education is a factor in its limited uptake in mathematics classrooms. Pre-service education is often viewed by beginning teachers either as a source of technical hints or as a theoretical backdrop, neither of which fully prepares the beginning teacher for the practical context of the real mathematics classroom. The current pre-service teacher education system frequently allows propositional knowledge to be encountered without clearly establishing where and how it fits within actual classroom practice. A consequence of this is an ever increasing gulf between propositional and procedural knowledge. If pre-service teachers experience difficulties implementing the theory-based strategies advocated at the university, they are likely to return to or adopt the strategies that they have seen successfully used by those they regard as more able than themselves (Kane, 1994).

Towards a framework for understanding beginner teacher development

Based on the literature, a clear picture seems to be emerging of genuine constraints that oppose constructivist-based teaching practices in mathematics classrooms. This is especially true for beginning teachers, whose identities are still being formed through institutional socialization. One question that arises then is: how can these constraints be best understood in order to inform pre-service teacher education?

It seems that a theoretical framework for teacher education would prove useful here. One such framework has been suggested by Goos (2002), who proposes extending and applying neo-Vygotskian theories of learning to teacher education. Goos argues that beginning teacher development can be informed by considering it in terms of Valsiner's (1987, cited in Goos, 2002) framework of three developmental zones:

1. *Zone of Proximal Development* (ZPD). This encompasses the novice teacher's emerging skills that have not yet been fully developed.
2. *Zone of Free Movement* (ZFM). This encompasses the environmental constraints that limit freedom of thought and action in the beginning teacher.
3. *Zone of Promoted Action* (ZPA). This encompasses the efforts of teacher educators and/or teaching colleagues to promote particular teaching skills or approaches.

The ZFM can be seen as incorporating the various external socialisation pressures and constraints discussed in this paper, which impact on the beginning teacher. Importantly, however, Goos suggests that the ZFM also includes the beginning teacher's own internal pressures (2002). This is a phenomenological view that acknowledges the importance of a person's internal perceptions and interpretations, which may constrain their development as much as external factors (Bronfenbrenner, cited in McMillan, 1991).

The critical point made by Goos (2002) is that *promoted actions must be within the neophyte teacher's reach if development of their identity as a teacher is to occur*. In other words, actions promoted by pre-service teacher educators (ZPA) must acknowledge both the beginning teachers' levels of skill (ZPD) and the constraints they experience (ZFM). It could be that pre-service teacher educators may not be fully acknowledging the genuine constraints that neophyte teachers will experience in

school, and are failing to situate their teacher education within this context. A beginning teacher may thus discover that much of their pre-service constructivist knowledge does not fit within these constraints, and this may be discarded in favour of observed approaches that do match. This seems to explain in part the failure of many beginning teachers to subsequently practice in a constructivist way.

Implications for beginning teacher practice

In this paper, I have argued that constructivist-based approaches to mathematics teaching, as frequently taught by pre-service teacher training institutions, do not match the reality of many New Zealand classrooms. I have explored the socialisation forces that act to oppose and constrain the attempts of beginning teachers to adopt such practice, and suggested a framework for teacher development within which these forces can be understood. What then are the implications, both for pre-service education and for my personal practice? How can the square peg be made to fit the round hole?

I believe that one possibility lies in considering how to bridge the gulf between learning and doing as a beginning teacher. I feel that I am missing some practical tools and experiences that will be needed for me to make this transition from the propositional knowledge of my training course to the procedural knowledge of my developing classroom practice (Kane, 1994). I suspect I will need to rely on my experiences in the classroom in order to develop these tools, and to trust in my own ability to adopt tools that are aligned with my constructivist values.

I suspect, however, that a source of useful tools lies in the realm of behaviourism. There has been little focus on behaviourist-informed practice in my pre-service education, which has focused instead on constructivist approaches. However, some authors do argue that behaviourism and constructivism are thoroughly compatible (Irwin & Irwin, 2000) with the difference being one of emphasis. I hypothesise that if the approach taken by pre-service educators is modified to include more specific practical behavioural techniques, this may indeed help to bridge the gap between theory and practice; and would help better prepare beginning teachers for the realties of teaching by better situating their pre-service learning within their ZFM. Exploring

whether and how to do this is beyond the scope of this paper, but I believe it is an important issue to consider for future research into pre-service teacher education.

A final key factor missing from this discussion seems to be the issue of agency. I agree with Klein (1998) that beginning teachers like myself find it very difficult to position ourselves to "teach against the grain" of the traditional mathematics culture. Developing a sense of agency would enable me to more confidently retain my constructivist-based principles, and help me reshape the "round hole" of mathematics classroom culture rather than allowing my practice to be subsumed by this culture.

I do not yet know how I may do this – the fears I expressed in the introduction to this paper still remain. However, one tool that I have available, and which has been encouraged in my pre-service education, is reflective practice. Several authors support the idea that reflective inquiry is an important tool in developing a sense of agency as a teacher (Goodman, 1988; Kane, 1994). I feel that ongoing reflection on my perspectives, beliefs, experiences and practice will prove particularly important in developing a sense of myself as an active force in teaching, one that may be able to resist the pressures of the traditional mathematics culture. Ultimately, perhaps reflection is the tool which will enable me to adapt my practice in line with my constructivist beliefs, and in the process help me to transform my mathematics classroom into a constructive and effective learning environment.

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My fear is that the hopes that I have for my practice, and the beliefs I have come to hold regarding how I would like to teach will be worn down by the myriad realities and pressures I am likely to experience as a beginning teacher. In many ways I suspect that the teaching tools with which I have been equipped by my pre-service training, based largely on constructivist principles, may ill-prepare me for the real world of secondary school mathematics teaching. Indeed, at times I feel like I have been armed with a square peg and am about to be faced with a round hole; and I wonder how long I will keep trying to make them fit.

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Firstly, the adolescent experience of most beginner mathematics teachers will have included learning the traditional culture of the mathematics classroom. Despite all the talk of mathematical empowerment, of students and teachers together searching for mathematical patterns and connections and communicating these with confidence to enhance and develop mathematical ideas, many teachers continue to teach largely as they were taught (Klein, 1998). Even though they may not admit it, many hold on tenaciously to this view of mathematical knowledge as facts, skills, rules and procedures to be transmitted, and to the absolute authority of teacher and text; and will tend to revert to this, particularly in times of stress.

Secondly, the complex and constantly shifting situation of the teaching experience places the beginning teacher in a vulnerable and dependent position. As a neophyte, a beginning teacher both seeks and is receptive to advice, support and guidance. Indeed, first year teachers frequently remain locked into an apprenticeship of observation and consequently rely on modelling their practice on the overt behaviour of more knowledgeable others (Kane, 1994). The "others" in schools offer persuasive ways of doing things, and to that extent the creation of beginning teacher identity is derived in a large part from the identity and discursive practices of these others (Walshaw & Savell, 2001). As most of these colleagues too have been enculturated

within the traditional mathematics teaching culture, their support will frequently be towards the traditional transmission model of teaching, and away from constructivist-based approaches. This socialisation thus invariably eats away at the constructivist ideals of the neophyte teacher.

Additional factors opposing constructivist-based practice

There are additional factors that work further to override the intended teaching aims of beginning teachers, and serve to further entrench and continue the traditional culture of the mathematical classroom. Haynes (1996) suggests that other such external pressures include high workload, limited time, teaching to a content-oriented curriculum; and assessment. Kane (1994) suggests a further factor: the potential failure of pre-service teacher education to equip beginning teachers with sufficient practical tools to deal with the realities of the mathematics classroom. These factors mirror the pressures that I have observed and experienced while on practicum, and I will explore each in more detail.

Time, stress and workload: Teaching for survival

During their first year of teaching, beginning teachers will be subject to overwhelming and at times conflicting influences upon their classroom practice. Beginning teachers report of the increased presence of constraints which act to undermine the application of the theoretical and pedagogical knowledge obtained from pre-service education (Kane, 1994). The high workload and time pressures experienced by beginning teachers result in an overwhelming tendency to adopt "quick fix" survival strategies based on trial and error within a narrow experience, and which for the most part have no sound pedagogical basis. In this stressful environment, beginning teachers will thus frequently resort to "doing what comes naturally"; teaching as they were taught, modelling the teaching behaviour of colleagues, or acting as seems appropriate within the classroom with little reference to theoretical principles guiding their action.

Curriculum and assessment

According to Begg (1999a) constructivist approaches to learning frequently fail to provide clear and consistent models for curriculum and assessment. Begg suggests that

"teachers are subjected to mixed messages when they talk about constructivist learning but are presented with curricula and assessment in a behaviourist format" (p. 68).

These "mixed messages" are clearly identifiable within the current New Zealand mathematics curriculum (Ministry of Education, 1992). On one hand, the curriculum argues for a problem-solving approach that is clearly constructivist in nature. While on the other hand, the curriculum is prescribed through achievement objectives, with an implication that these are well-defined and measurable. Underlying this structure of small, measurable objectives there appears to be a reductionist view of knowledge, and a behaviourist view of learning. This sits rather uncomfortably with the constructivist views presented in the curriculum statements about learning processes and the problem-solving approach (Education Review Office, 2001).

Adding to the confusion, beginning teachers have difficulty inventing suitable constructivist-aligned problems that provide an appropriate context for the mathematics they want their students to learn. According to the Education Review Office (2001) it is possible that teachers would be able to better use the curriculum's constructivist approach if they were provided with many practical problems that they could use to teach the ideas prescribed in the content strands of the curriculum.

Further, there has been found to be a close link between assessment and instruction (Barnes, Clarke & Stephens, 1995). Mandated external assessment sends strong messages to schools that the style of assessment and the types of activities assessed play a powerful role in determining which aspects of the mathematics curriculum are valued by teachers. In circumstances where extended and reflective activities involving communication, problem solving or investigation do not play a role in the external assessment, schools invariably place a low priority on such activities.

This combination of inadequate problem-solving resources, a prescribed curriculum, and external assessment again acts to undermine constructivist-based teaching practices.

Inadequacies of pre-service teacher education

According to Kane (1994), there is an explicit distinction between the knowledge gained from pre-service teacher education – propositional knowledge, and that of effective classroom practice – procedural knowledge. She suggests that pre-service education is frequently insufficient for developing an understanding of the rigorous nature of the authentic practice encountered in the first year of "real" teaching.

It makes sense to acknowledge that the way in which constructivist-based practice is taught in pre-service education is a factor in its limited uptake in mathematics classrooms. Pre-service education is often viewed by beginning teachers either as a source of technical hints or as a theoretical backdrop, neither of which fully prepares the beginning teacher for the practical context of the real mathematics classroom. The current pre-service teacher education system frequently allows propositional knowledge to be encountered without clearly establishing where and how it fits within actual classroom practice. A consequence of this is an ever increasing gulf between propositional and procedural knowledge. If pre-service teachers experience difficulties implementing the theory-based strategies advocated at the university, they are likely to return to or adopt the strategies that they have seen successfully used by those they regard as more able than themselves (Kane, 1994).

Towards a framework for understanding beginner teacher development

Based on the literature, a clear picture seems to be emerging of genuine constraints that oppose constructivist-based teaching practices in mathematics classrooms. This is especially true for beginning teachers, whose identities are still being formed through institutional socialization. One question that arises then is: how can these constraints be best understood in order to inform pre-service teacher education?

It seems that a theoretical framework for teacher education would prove useful here. One such framework has been suggested by Goos (2002), who proposes extending and applying neo-Vygotskian theories of learning to teacher education. Goos argues that beginning teacher development can be informed by considering it in terms of Valsiner's (1987, cited in Goos, 2002) framework of three developmental zones:

4. *Zone of Proximal Development* (ZPD). This encompasses the novice teacher's emerging skills that have not yet been fully developed.

5. *Zone of Free Movement* (ZFM). This encompasses the environmental constraints that limit freedom of thought and action in the beginning teacher.
6. *Zone of Promoted Action* (ZPA). This encompasses the efforts of teacher educators and/or teaching colleagues to promote particular teaching skills or approaches.

The ZFM can be seen as incorporating the various external socialisation pressures and constraints discussed in this paper, which impact on the beginning teacher. Importantly, however, Goos suggests that the ZFM also includes the beginning teacher's own internal pressures (2002). This is a phenomenological view that acknowledges the importance of a person's internal perceptions and interpretations, which may constrain their development as much as external factors (Bronfenbrenner, cited in McMillan, 1991).

The critical point made by Goos (2002) is that *promoted actions must be within the neophyte teacher's reach if development of their identity as a teacher is to occur*. In other words, actions promoted by pre-service teacher educators (ZPA) must acknowledge both the beginning teachers' levels of skill (ZPD) and the constraints they experience (ZFM). It could be that pre-service teacher educators may not be fully acknowledging the genuine constraints that neophyte teachers will experience in school, and are failing to situate their teacher education within this context. A beginning teacher may thus discover that much of their pre-service constructivist knowledge does not fit within these constraints, and this may be discarded in favour of observed approaches that do match. This seems to explain in part the failure of many beginning teachers to subsequently practice in a constructivist way.

Implications for beginning teacher practice

In this paper, I have argued that constructivist-based approaches to mathematics teaching, as frequently taught by pre-service teacher training institutions, do not match the reality of many New Zealand classrooms. I have explored the socialisation forces that act to oppose and constrain the attempts of beginning teachers to adopt such practice, and suggested a framework for teacher development within which these forces can be understood. What then are the implications, both for pre-service

education and for my personal practice? How can the square peg be made to fit the round hole?

I believe that one possibility lies in considering how to bridge the gulf between learning and doing as a beginning teacher. I feel that I am missing some practical tools and experiences that will be needed for me to make this transition from the propositional knowledge of my training course to the procedural knowledge of my developing classroom practice (Kane, 1994). I suspect I will need to rely on my experiences in the classroom in order to develop these tools, and to trust in my own ability to adopt tools that are aligned with my constructivist values.

I suspect, however, that a source of useful tools lies in the realm of behaviourism. There has been little focus on behaviourist-informed practice in my pre-service education, which has focused instead on constructivist approaches. However, some authors do argue that behaviourism and constructivism are thoroughly compatible (Irwin & Irwin, 2000) with the difference being one of emphasis. I hypothesise that if the approach taken by pre-service educators is modified to include more specific practical behavioural techniques, this may indeed help to bridge the gap between theory and practice; and would help better prepare beginning teachers for the realties of teaching by better situating their pre-service learning within their ZFM. Exploring whether and how to do this is beyond the scope of this paper, but I believe it is an important issue to consider for future research into pre-service teacher education.

A final key factor missing from this discussion seems to be the issue of agency. I agree with Klein (1998) that beginning teachers like myself find it very difficult to position ourselves to "teach against the grain" of the traditional mathematics culture. Developing a sense of agency would enable me to more confidently retain my constructivist-based principles, and help me reshape the "round hole" of mathematics classroom culture rather than allowing my practice to be subsumed by this culture.

I do not yet know how I may do this – the fears I expressed in the introduction to this paper still remain. However, one tool that I have available, and which has been encouraged in my pre-service education, is reflective practice. Several authors support the idea that reflective inquiry is an important tool in developing a sense of

agency as a teacher (Goodman, 1988; Kane, 1994). I feel that ongoing reflection on my perspectives, beliefs, experiences and practice will prove particularly important in developing a sense of myself as an active force in teaching, one that may be able to resist the pressures of the traditional mathematics culture. Ultimately, perhaps reflection is the tool which will enable me to adapt my practice in line with my constructivist beliefs, and in the process help me to transform my mathematics classroom into a constructive and effective learning environment.

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