

Issues of Teaching & Learning in South Africa: A disjunction between curriculum policy and implementation

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Abstract

This article examines how issues of teaching and learning have been implemented in South African classrooms. We apply a framework of curriculum implementation (Rogan & Grayson, 2003) to studies of classroom teaching and learning reported in the literature. In doing so, we use the framework to categorise and comment on the research studies and determine the applicability of the framework to science and mathematics classrooms. Our review findings show that the framework's constructs of 'profile of implementation' and 'capacity to innovate' can be applied, with some adaptation, to both mathematics and science classroom studies. Fewer studies have involved the third construct 'outside support'. We conclude that there is an inevitable dislocation between policy and curriculum implementation, and that the framework provides a useful notion of 'feasible implementation' by suggesting how (in a series of small steps) individual schools can put into practice new curriculum policy.

Keywords: curriculum, policy, implementation, teaching, learning.

Introduction

The South African educational system has undergone a major transformation since 1994. The new curriculum (Curriculum 2005 and later the NCS), representing a radical paradigm shift, has been greeted with resistance by some and enthusiasm by others. Research on both the intended and implemented curriculum has followed. In this article we choose to focus on school curricular issues as a key driver of much of the research into teaching and learning over the past 8 years.

The story of the South African schooling system since 1994 has been the story of Curriculum 2005 (C2005) (Department of Education, 1997) and its revision in the form of the Revised National Curriculum Statement (RNCS) in Grades 1-10 (Department of Education, 2002); and the introduction of the National Curriculum Statement (NCS) in grades 10-12 (Department of Education, 2003b). Several editions of the African Journal of Research in Mathematics, Science and Technology Education have included studies involving the curriculum, with particular attention being paid to its implementation (e.g. Scholtz, Watson, & Amosun, 2004;

Stoffels, 2005). We do not therefore intend to describe details of either the curriculum or the *process* of introduction, revision and subsequent implementation. Instead, we examine key mathematics and science education research articles since 2000 which have researched the results of implementation. Drawing on the concept of disjunction between the promulgation of curriculum and its implementation we use a theoretical framework developed by two South African academics (Rogan & Grayson, 2003) to analyse the research into teaching and learning in the schooling sector over the past eight years.

Curriculum 2005 was designed as an answer to apartheid schooling based on principles of Christian National Education. In the new government's view the previous curriculum involved an authoritarian style of teaching which supported the tenets of apartheid. After the democratic election of 1994, the new curriculum developed was an outcomes-based programme involving principles of learner-centredness and continuous assessment. C2005 was implemented in all government schools during the late nineties, with the intention that it would be fully executed up to grade 9 by the year 2005. In-service teacher training was provided using a cascade model (basically a one-week 'train the trainer' system) but problems with implementation led to a review process. The outcome was the Revised National Curriculum Statement (RNCS) (Department of Education, 2002), a version which still held to the principles of the original curriculum, but had a simplified structure and terminology.

Theoretical Framework

Curriculum planning and curriculum implementation draw on different sets of assumptions and models and use different discourses to respond to and examine different contexts. A regulatory discourse is used for curriculum planning and a pedagogic discourse for curriculum implementation (Parker & Adler, 2005). The context for curriculum planning can be regarded as stable and documented, as evidenced in the constitutional and political goals, while that for curriculum implementation is dynamic and ever-changing. To establish a dialogue between curriculum planning and curriculum implementation will inevitably be problematic in that the challenges they address are different, and hence a 'gap' will exist between intended curriculum and implemented curriculum (Sethole, 2004). This 'gap' has been defined in different ways by different authorities with Jansen (2001) for example, referring to it as policy 'disjuncture' from reality, Rogan as a "mismatch between expectation and reality" (Rogan, 2004, p. 176), and Drake (2006) as a 'dislocation' between intended policy and implemented policy. These are common terms used to describe the differences between the manner in which policy is articulated in the policy documents and the instructional practices which are implemented. They are often quite unlike the practices proposed by education reform documents hence the 'gap', 'disjuncture', 'mismatch' or 'dislocation'. In this paper we prefer to use Sethole's term of 'gap' as the simplest descriptor of the intended-implemented curriculum disparity.

A relevant framework for curriculum implementation

While there is a wealth of books and articles examining the implementation of curricula (e.g. Barab & Luehmann, 2003; Fullan & Hargreaves, 1992) there are relatively few looking at how this has been done in developing countries such as South Africa. Those that do, either do not provide a model for analysis (e.g. Cross, Mungadi, & Rouhani, 2002) or present a model which Rogan and Grayson (2003) suggest is linear and endorsing a deficit approach (e.g. Verspoor, 1989). Rogan and Grayson's theory of curriculum implementation provides a new framework

based on the South African context which builds on the strengths of the school environment. This theory is based on three constructs for analysing school implementation: profile of implementation, capacity to support innovation and support from outside agencies (Rogan and Grayson, 2003). Each construct is composed of subconstructs. The relationships between these constructs (in circles) and their subconstructs (in boxes) can be seen in the framework in Fig. 1.

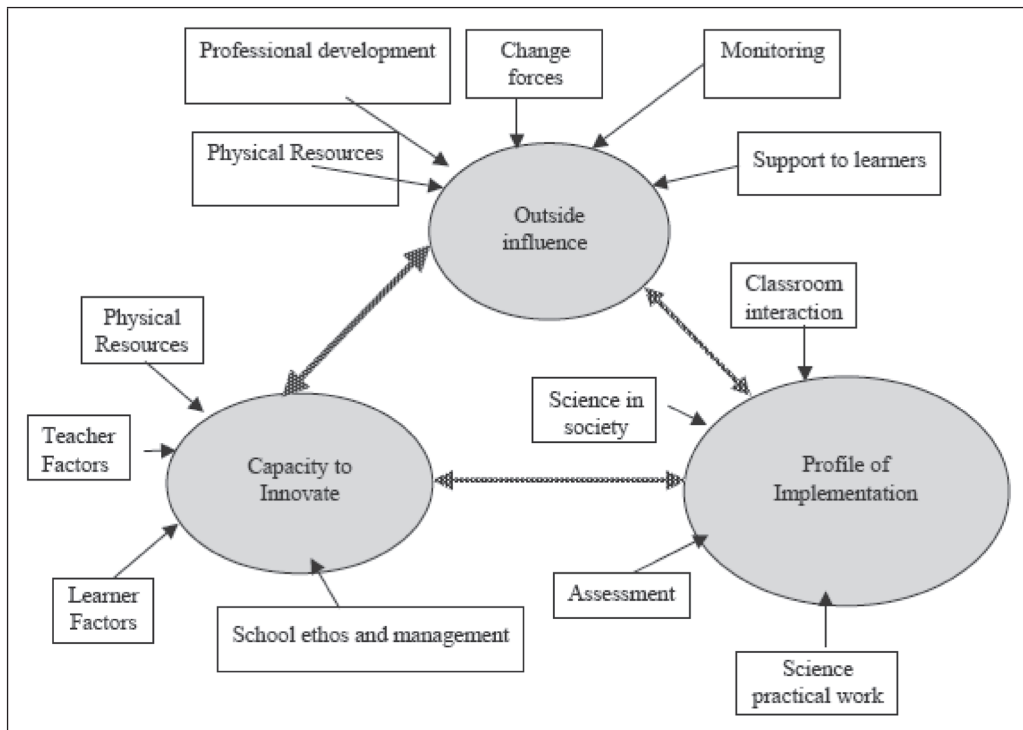


Figure 1: Rogan and Grayson’s framework for analysis of curriculum implementation (Rogan 2007b)

The profile of implementation allows one to identify the extent to which the new curriculum is practiced in the classroom; levels of implementation are described within each sub-construct (Rogan & Grayson, 2003). The levels describe teachers’ increasing repertoire of practice in which “higher” levels include lower levels of practice. Factors identified by Rogan and Grayson that might affect the capacity of a school to innovate and thus implement C2005 practices and the influence of outside support are also represented as subconstructs in Fig. 1. Levels in the profile of capacity to innovate and in the profile of outside support represent a progression towards a greater capacity to implement C2005.

Rogan and Grayson’s theoretical framework for implementation is premised on the need for starting by recognising current reality and then moving on to build on the strength of various components of the educational system such as teachers, learners and the school environment. What this framework emphasises is the recognition that there should be a next level to aspire to in line with values or expected outcomes of the curriculum. The framework recognises that the diversity in quality of the schooling system in South Africa cannot be catered for by a

blanket policy implementation strategy. It further maintains a positive outlook by focusing on the building and consolidation of strengths rather than focusing on remedying of weaknesses. Rogan and Grayson (2003) adapted Vygotsky's (1978) idea of Zone of Proximal Development (ZPD) to the field of curriculum and school systems development. They refer to their analogous concept of curriculum and school system development as the *Zone of Feasible Innovation* (ZFI), a hypothetical construct which suggests that innovation should not exceed current practice by too large a gap between existing practice and the demands of the innovation. *Successful innovation they suggest would be possible if the teacher takes a series of small steps from their current practice towards the goal of C2005 practices.* The profiles provide schools at different levels of development with a framework by which they can analyse their present position and devise suitable and varied strategies that will enable them to move through their zone of feasible innovation to higher levels of implementation.

In the remainder of this article we use Rogan and Grayson's theory as a lens through which we view the various gaps between the intentions of C2005 (or RNCS/NCS) and the actual practices observed by researchers of mathematics and science classrooms. In this analysis we attempt to identify how research in mathematics and science has or has not been addressing the gap between policy and practice and determine the applicability of the theory to a variety of situations in both mathematics and science. We have organised the studies according to Rogan and Grayson's (2003) three constructs, namely profile of implementation, capacity to support innovation and support from outside agencies. Although the framework was designed with science education in mind, we have found that the majority of studies of implementation of the mathematics curriculum can be incorporated into it. Where relevant, we have discussed below how the framework can be broadened and related to mathematics education.

Studies involving the Profile of Implementation

Several studies from 2000 to 2007 fall within this construct (Hattingh, Aldous, & Rogan, 2007; Rogan, 2000, 2004, 2007a, 2007b; Rogan & Aldous, 2005; Rogan & Grayson, 2003) Since developing their theory, Rogan and collaborators have mainly interrogated this construct, with occasional reference to the other two constructs.

The Rogan studies draw on school development, educational change and science education literature to build a framework of curriculum implementation with special reference to developing countries and the learning area of Natural Science. The first article of the series (Rogan, 2000) begins by drawing from research to suggest a premise that schools as systems fall along a developmental continuum of implementation of an innovation. In this article, the notion of the Zone of Feasible Innovation (ZFI) is first put forward by Rogan. Rogan argues that the implementation process should be an ongoing process in which teachers determine where they start and how fast they go in the change process. He suggested that a long term research and development agenda based on the continuum should be established and current efforts at innovation researched. Rogan advocated the creation of 'test-beds', in which NGOs, departments of education and research institutions collaborate, and where C2005 can be implemented and researched. The Rogan and Grayson (2003) article expands on this notion by providing the framework (their tables 2 to 4) by which institutions can identify their current position (or perhaps recognise that they have not yet reached level 1) and within each construct can identify what the next small step is towards the ultimate goal of C2005 practices. The Rogan (2004) and Rogan and Aldous (2005) articles shed light on issues of teacher change factors as well as

improvement of classroom learning environments. Case studies in some Mpumalanga schools indicated that within each subconstruct (Fig. 1), most lessons fell below or into level one, whilst a few demonstrated features of level 2 in certain subconstructs. Content knowledge was still the focus of classroom discourse but one change was evident i.e. the emphasis on group work (whether useful or not) and learner involvement in lessons. Time management and planning emerged as an endemic problem as well as issues of depth and scope in addressing topics. In terms of the new assessment standards in the natural sciences, the level of achievement of the grade 9 learners observed in these case studies is only at about grade 4 level. A large gap between expectation and reality was very evident, i.e. it extended beyond the ZFI.

A further study examining one particular school (Rogan, 2007b) reveals that changes are often superficial and sometimes reveal a misinterpretation of C2005; teachers are very willing to implement the new curriculum but do not know how to do so; they have attempted to make sense of C2005 in terms of past experiences and thus continue to practice in the same way or make superficial or changes e.g. arranging learners in groups. Confirming other studies such as those of Modisenyane, Rollnick & Huddle (2004), the Rogan studies reveal that school ethos and the way in which a school is managed have the greatest impact on implementation. The articles argue that whole school development is more important than professional development in particular learning areas since different approaches to curriculum change in a school can be counter-productive. They further propose that professional development should be institutionalized and approached in a systemic and systematic way or otherwise it becomes a futile exercise.

Although the Rogan and Grayson framework was developed for Science, there are certainly clear areas of commonality with issues that have occurred in the implementation of the new mathematics curriculum. In what follows we will look at each of the subconstructs within the profile of implementation (Fig. 1) and discuss its applicability to the implementation of the mathematics curriculum.

The issue of classroom interaction has received attention within the body of South African mathematics education research in recent years. For example, Brodie (2000) analyses reform-pedagogies and the shift to learner-centredness in the mathematics classroom, Maoto and Wallace (2006) use action research to explore what a teacher does in an effort to teach mathematics for understanding and Sethole (2001) and Ensor et al. (2002) investigate the use of the textbook in the mathematics classroom in relation to the teacher's pedagogic practices. Although many of the level descriptors for classroom interaction have clear resonances within the mathematics education research literature, there are some that appear more science-specific. One of the level 4 descriptors, that the teacher "assists learners to weigh up the merits of different theories that attempt to explain the same phenomena" has no direct parallels within the mathematics curriculum. However the directive within the mathematics FET curriculum to explore alternative definition of quadrilaterals has elements of this notion and could be extended to exploring and comparing the alternate axiomatic systems that could be constructed. At level 3 Rogan & Grayson talk about the teacher introducing "the learners to the evolving nature of scientific knowledge" (2003 p. 1184), which has some parallels with an aspect of the definition of mathematics given in the FET curriculum statement: "Mathematics is developed and contested over time through both language and symbols by social interaction and is thus open to change." (Department of Education, 2003a, p. 9). It would be interesting to open up whether and how these descriptors would fit into a similar table for the profile of implementation for mathematics. A discussion of what notions of classroom interaction the mathematics curriculum privileges and research that examines current classroom practices against this, would be revealing.

The subconstruct “science in society” has clear overlaps with the notions of contextualised or relevant mathematics. Although the call for relevance is clear from the mathematics curriculum, as discussed in Venkat, Bowie & Graven (2009) there are a number of different agendas at play underlying this call. For this reason providing level descriptors for a “contextualised mathematics” subconstruct would not be straightforward and we certainly could not assume that mirroring the descriptors in science descriptors with a mathematical flavour would be easily accepted. This being said, however, there has been considerable research from within the mathematics education community in South Africa on some of the challenges involved in implementing a curriculum that has a greater focus on contextualised mathematics. For example, Taylor (2000) argues on the basis of empirical evidence from the implementation of C2005 that the complexity of integrating mathematics with relevant content leads, in many cases, to a severe lack of focus on mathematical content in the classroom. Sethole (2004) and Adler, Pournara & Graven (2000) similarly highlight the way mathematics is foregrounded or “disappears” when teachers attempt to bring together mathematics and contexts. Interestingly, both these two aforementioned articles bring to the fore some of the issues that would arise in attempting to construct level descriptors for “contextualised mathematics”. These issues range from questioning transfer of mathematics learnt in the classroom to contexts outside the classroom to questioning the need for authenticity of contexts.

There was very little published in the mathematics research papers reviewed for the position paper (Venkat, Adler, Rollnick, Setati & Vhurumuku, 2009) that addressed the issue of assessment. However assessment has received considerable attention in the policy documents that have been released by the South African Department of Education over the last few years. (see for example, the Subject Assessment Guidelines for FET mathematics, 2005, p. 93-100 of the Revised National Curriculum Statement, 2002 and the exemplar examination papers for the FET phase released by the department in 2006, 2007 and 2008). Thus although one could draw up a set of level descriptors for assessment in mathematics from the policy documents, there is little research evidence to talk back to this subconstruct in the profile of implementation.

Despite the fact that the subconstruct “science practical work” has the least obvious parallels within the mathematics curricula, there are proposals from research in mathematics education that suggest a possible mathematics subconstruct that has some resonance with the notion of practical work in science. The notion of activity-based and discovery learning attracted considerable attention within mathematics education in recent years (see, for example, Barnes 2004, 2005). However Ensor et al.’s (2002) investigation of teachers’ use of a mathematics textbook suggests that despite considerable rhetoric favouring this style, it is not always easily translated into practice. They found that the inductive style of the textbook being used was in conflict with the deductive style preferred by the teachers. In addition, attention to the potential use of technology as tool within the mathematics classroom has suggested the possibility of more experimental approaches to mathematical discovery in the classroom. Researchers like Govender and de Villiers (2004) and Hockman (2005) have pointed out the value in investigative work using dynamic geometry software and Hardman (2005), Yushau, Mji and Wessels (2005) suggest that the use of technology has beneficial effects on creativity in the mathematics classroom.

It would thus be interesting to consider whether, in adapting the Rogan and Grayson framework for use within mathematics education, we could create a subconstruct that encompasses notions of activity-based work and to explore what issues research raises about these ideas. In the next section, we show that a wide variety of studies across mathematics and science provide further evidence for the theory in the construct of the capacity to innovate.

Studies involving the capacity to support innovation

Most of the studies we identified during the review period could be classified in this category, with an emphasis on how teacher factors, learner factors and resources constrain (and in some cases enhance) the capacity to innovate.

Teacher Factors

Teacher factors play a crucial role in teachers' ability to innovate in their classrooms. In our review we have identified four ways in which teacher factors play out in relation to innovation and the new curriculum, namely teachers' uncertainties regarding the curriculum, their ability to work with the philosophy of the curriculum, how they approach new topics and outcomes, and finally teacher identity.

Uncertainties

Investigating teachers' perceptions of the new curriculum, Aldous (2004) found that teacher support in terms of in-service-training (INSET) in Mpumalanga province so far has concentrated on the content of C2005 (concepts and ideals) and not on pedagogy. Misconceptions exist about the C2005 (e.g. C2005 is just a new name for the old, objectives are the same as outcomes, content is not important, group work to be done all the time), however fewer teachers showed misconceptions in 2002 than in 2001. More seriously there was a strengthening of the negative perceptions around the curriculum since 2001 and a decrease in positive perceptions. In terms of levels, the more than 200 teachers in the study could be regarded 'on average' as being at level 2 for 'teacher factors', and the INSET being conducted would probably hope to move the average towards level 3.

Van Etten & Smit (2005) illustrate the difficulties involved in choosing and developing learning materials in mathematics that comply with the curriculum and links with the level of knowledge of learners and teachers, particularly because C2005 leaves unclear the balance between formal mathematics and approaches based on using mathematics in context. Similarly, Sethole (2001) found that teachers were uncertain of what their focus should be when incorporating the everyday into the mathematics classroom. These studies suggest that the curriculum is difficult to interpret, and that teacher factors such as qualification and experience play a role in teachers' ability to innovate.

Curriculum philosophy

The uncertainties described above may be exacerbated by the nature of the curriculum. Green & Naidoo (2006) employed a multi-dimensional analytical framework to interrogate the contents of the grade 10 Interim Physical Science curriculum document (IS) (1995) and the NCS for Physical Science (2004) with the aim of investigating changes in knowledge valued in these two policies. The article suggests that on the whole the NCS reconceptualises valid science knowledge while IS portrays absolutist view of science. What they argue is that the NCS appears to be a hybrid product that intersects different ideological traditions, different discourses, a range of competences and complexities and that particular socio-historical contexts (and probably global forces) have shaped the curriculum that has emerged. With all this background, they argue that science for its intrinsic worth appears to be overshadowed by the need to study science for

its social constructionist and utilitarian worth. A similar conclusion was reached by Ramsuran (2005) in her examination of Curriculum 2005 (1997) and the RNCS (2002) from a scientific literacy viewpoint. She found that C2005 and the RNCS are similar to overseas documents (Australia, UK, USA) with a goal of scientific literacy advocated through prescribed outcomes and standards. She maintained that there was very little attempt to localise the definition in response to African cultures and rural experience. Although these are critiques of the curriculum itself and not its implementation, the nature of the curriculum can affect the way teachers are able to put it into practice. For example, teachers at level 1 or 2 on Rogan and Grayson's scale may not have either the training or background to interpret this type of open and ambiguous curriculum in a sophisticated manner. As we stated above, a re-evaluation of teacher factor levels in terms of teacher knowledge would assist in identifying an appropriate ZFI for progression.

New topics and outcomes

In mathematics, the new curriculum has introduced a new learning outcome in the form of data handling, representation and statistics. This is a critical outcome of mathematics learning and is in line with broader thinking about enhancing mathematical power. According to Goldin (2002), "the study of representation in mathematical learning allows us – at least potentially – to describe in some detail students' mathematical development in interaction with school environments and to create teaching methods capable of developing mathematical power" (p. 39). However, Wessels, Wessels & Nieuwoudt (2006) found that teachers' knowledge of subject matter and the development of statistical thinking, especially in the formative years in primary school, is not yet up to standard. This finding has enormous consequences for implementing the mathematics curriculum with respect to this learning outcome. More recently, there has emerged a field of research into teachers' knowledge under the umbrella of 'mathematical knowledge for teaching' (MfT). Studies are beginning to take place that tell the story of the mathematical work of teaching, and the specialized knowledge that is required for this activity across a range of mathematical areas (see for example, Kazima & Adler (2006) with respect to the area of probability). Clearly, teachers' qualifications and knowledge of mathematics and science are key factors in their ability to progress towards Rogan and Grayson's levels 3 and 4 in the capacity to innovate. Again, individual studies probably need to more clearly delineate the levels within this construct, as the current ones described originally by Rogan and Grayson such as 'teacher has minimum qualification for the position' (level 2) and 'teacher makes an extra effort to improve teaching' (level 3) are relatively coarse-grained and ill-defined. Incorporation of concepts of MfT and Pedagogical Content Knowledge (PCK) into the teacher factor levels would enable a clearer identification of progression towards the higher levels of this construct.

In their study, Gaigher, Rogan & Braun (2006) investigated the effect of a structured problem-solving strategy on problem-solving skills and conceptual understanding in physics. They assessed the effectiveness of the problem-solving strategy using new instruments, namely a solutions map and a conceptual index. The results indicated that the problem solving strategy produced significant gains in learner performance in physics. This strategy could increase teachers' capacity to innovate by providing them with an appropriate tool to promote problem-solving skills, one of the expected outcomes of the NCS. The low cost of the intervention makes it suitable for disadvantaged classrooms and the intervention could be used in in-service teacher development programmes.

Teacher Identity

Another aspect of teachers which is likely to influence innovation is their identity. There seems to be a disjuncture between the demands that policy makes on teachers and the personal identities of these teachers. In line with this, Parker (2006) has argued that for successful implementation of the new curriculum to happen, it requires internal changes in teachers' orientation to knowledge and meaning, and therefore identity. Teachers' personal biographies can be important in understanding what they do and why. Jita (2004) examined the biography of one teacher, and found that changing practice requires a significant shift in the teacher's identity and that a teacher's personal resources e.g. their experiences in the past contribute to their ability to shift in practice. He suggests that a science teacher under township conditions needs a strong will, a vision of change, plenty of resources to carry out the change (cultural, professional and educational) and the desire to change. For such individuals, action research may be an appropriate way in which a teacher can reflect in order to change his practices. A study by Modisenyane, Rollnick & Huddle (2004) explored the use of action research in this way. Like Rogan & Aldous (2005), Modisenyane et al. argue that a school-based approach to teacher support is more effective because it is in the context of teaching, and that only limited changes can be made by individuals working alone.

Stoffels' (2005) findings raise questions on the role of identity in curriculum change. He observes that even highly experienced science teachers still ascribe high authority to learner support materials and follow textbooks and the national curriculum document as it is. Stoffels argues that this is not necessarily a reflection of the reluctance or inability of teachers to make pedagogical decisions but that the pedagogical shifts required of them are too high and they feel unprepared. Teachers harbour the perception that authors have valid knowledge and expertise which teachers feel they should make use of, hence, the teachers' inability to actively and innovatively add additional themes and activities.

It is apparent therefore, that the nature of the curriculum and the contexts in which teaching and learning take place demand shaping and reshaping of teacher roles, functions and responsibilities. Also, the desired teacher agency in curriculum matters implicit in the RNCS is not yet being realised. A further disparity in teachers' capacity to innovate might result from the gap between what researchers of learning and teaching study and report on, and actual classroom practice. Many classroom teachers of mathematics have limited access to the research materials which inform policy. A great number of these materials communicate in an academic register and contain jargon that is incomprehensible to practising teachers. As part of teacher support systems in professional development programmes there needs to be an avenue where this information not only reaches the classroom, but is accessible in both its findings and language in order to translate research findings into usable sources of information for teachers. In the South African context the academic experiences of researchers and teachers of mathematics are more often than not two separate experiences that separate theory and practice (Paras, 2001).

Learner Factors

Various learner 'factors' are crucial in any attempt by teachers to innovate in their classrooms, and it is worth examining Rogan and Grayson's (2003) specific categories here (see Table 1) as we discuss the papers relevant to this section.

Table 1: Learner factors from the profile of the capacity to support innovation (Rogan & Grayson 2003)

Level	Learner factors
1	Learners have some proficiency in language of instruction, but several grades below grade level.
2	Learners are reasonably proficient in language of instruction. Learners attend school on a regular basis. Learners are well nourished. Learners are given adequate time away from home responsibilities to do school work.
3	Learners are proficient in language of instruction. Learners have access to quiet, safe place to study. Learners come from a supportive home environment. Learners can afford textbooks and extra lessons. Parents show interest in their children's progress.
4	Learners are fluent in the language of instruction. Learners take responsibility for their own learning. Learners are willing to try new kinds of learning.

Vithal & Gopal (2005) reported on an international study (the Learners' Perspective Study) that had a central focus on capturing learners' voices and experiences of curriculum reform. The study sought to develop a view of the mathematics from the learners' vantage point. They concluded that the principles and practices of the new curriculum reforms (e.g. learner-centredness, group work, integration) are being taken up by learners and are brought into their awareness and understanding of what the reforms mean and offer them. They suggest that learners' experience of the new reforms is linked to what their teachers say or do about these reforms in the mathematics classroom.

Aligned with new curriculum reforms has been a progression to re-examine modes of pedagogy, with a strong focus on learner-centred teaching. How then do teachers design and implement curricula that are in line with this approach? Stears, Malcolm & Kowlas (2003) explored what constituted the everyday knowledge of learners from townships and informal settlements in the Cape Flats, how this knowledge might be introduced and used in the science classrooms and how teachers and learners made shifts between formal science and everyday knowledge. They found that learners related strongly to content that dealt with their lives in townships and informal settlement (e.g. fire, cooking, repairing damaged equipment) and this resulted in deeper engagement with each other and the teacher. They point out however that as one tries to respond to local interests, cultures and needs, content and outcomes may differ resulting in diversity in curriculum and learning that can run counter to common outcomes. They suggest that deeper discussions need to be held to try to negotiate and resolve these tensions.

Stears & Malcolm (2005) found that if learners and teachers are co-designers of curricula, this is more effective than curricula designed by teachers or outside agents. If learners bring their everyday knowledge and concerns into the classroom and these are used to develop themes that are relevant to their lives then learners take ownership of the content, participate more freely, develop confidence and contribute to the design of the module. Learner participation in planning the curriculum can lead to the design of more relevant curricula and learners place a high value on such participation. It is interesting to try and place these learners into levels in the capacity to

innovate profile (Table 1). They would appear to be at least at level 2 ('attend school on a regular basis; well nourished'), but are unlikely to have reached level 3 ('come from a supportive home environment'; parents show interest in their progress'). However, the study itself was moving the students' ZFI towards level 4 ('learners take responsibility for own learning; will to try new kinds of learning'). It may be that a more fine-grained approach to the subconstruct levels described in the Rogan and Grayson framework is needed for individual classroom situations, and it is not clear whether there is a true progression in learner factors between levels 1 and 4. It may be that learners are able and willing to try new kinds of learning even if they don't come from a supportive home environment. It is also worth noting that in the studies we looked at, the issues of learners' nourishment, time on home responsibilities and parental involvement were not explicitly addressed, so the framework has yet to be tested in this domain.

Implementing learner-centred practices appears to be far from straightforward (Brodie, 2000). The perception that curriculum reform encourages less teacher intervention is widespread, and that when teachers do intervene, they find it hard to do so particularly in situations involving group discussions. Further, it has been observed that teachers (even from well resourced contexts) find it hard to intervene to get learners to challenge their conceptions (Brodie, 2000). Similarly, skills such as listening and responding sensitively to learners are not easy to accomplish by the majority of teachers (Breen, 2004). Research does not seem to have extended to issues of the dynamics of learner identity and its role in learning the science classroom in South Africa (Stoffels, 2005). The Rogan and Grayson (2003) framework may need to be further adapted to account for identity under the subconstruct of learner factors.

Finally, each of Rogan and Grayson's levels refers to the learners' proficiency in the language of instruction. This was a clear cluster of research studies identified in the Marang position paper (Venkat, Adler, Rollnick, Setati & Vhurumuku, 2009), and is discussed separately in this issue (Setati, Chitera & Essien, 2009).

Resources

Another group of indicators within this construct fall into the physical resources category. The presence or absence of resources, and teachers' ability to harness them, are likely to be crucial in any attempts at innovation. Onwu & Stoffels (2005) and Stoffels (2005) found that the lessons of science teachers in large under resourced classrooms in Limpopo province were typically traditional, teacher-centred using the question and answer mode, text-book-based and whole class oriented. Physical constraints (e.g. shortage of science equipment and support material, large numbers and restriction of movement in the classroom) and teachers' lack of confidence in managing activity-based lessons severely limited their ability to change to new approaches. They point out that these teachers have never seen new practices in action and they suggest that there is a need to focus efforts on helping teachers to bridge the gap between what is intended in the new curriculum and classroom implementation in the realities of the teachers' school context.

Through a case study approach, Sethole (2001) investigated the use that is made of textbooks, class work books and scribblers in a township mathematics classroom. Dickson & Adler (2001) explored how textbooks are used and perceived in grade 7 and 9 mathematics classrooms. The findings from these studies point to varying degrees to which textbooks and other resources materials are used in the classroom. In particular, there were language difficulties that made grade 9 mathematics textbooks inaccessible to learners. This demonstrates that resource availability does not necessarily translate to use. Despite the widely-held belief that C2005 might lead to

textbooks being devalued, in the classes studied the teachers still used textbooks extensively (Dickson & Adler, 2001). The research does, however, point to a great disparity between experiences in urban schools and those of rural schools on various levels. Kotze & Strauss (2006) report that nationally only 41% of Grade 6 learners were in possession of mathematics textbooks. This problem was mainly experienced in rural schooling communities. In suburban schools teachers supplemented the textbooks with other materials, but in less well-resourced school this did not happen. Despite the fact that textbooks were valued as teaching resources and used extensively in Grade 7 and Grade 9 mathematics classrooms, Dickson & Adler (2001) point to the language which teachers feel is inaccessible to the Grade 9 learners. These issues have a negative effect on the performance of learners in mathematics, and as a consequence the access to mathematics becomes limited. This has some pedagogical consequences for teachers too when the Language of Learning and Teaching (LoLT) in South African schools (and textbooks) is mainly English, since this is not necessarily their first language. Two studies examined textbooks that favour an inductive pedagogic modality (Davis, 2001; Ensor et al., 2002). Ensor and colleagues argue that 'the inductive style prioritised by the textbook *Maths for All* is in tension with the preferred deductive style of most of the teachers, resulting in the fragmenting of its semantic structures' (p1). They make a strong case for assisting teachers in the design of learning material to supplement textbooks as well in the use of textbooks in order to facilitate an inductive approach to teaching mathematics. Davis (2001) analyses a series of tasks in a Grade 4 South African mathematics textbook, and highlights the difficulties and contradictions inherent in texts purporting to use an inductive approach.

Clearly, many aspects of the capacity to innovate have been the focus of studies by researchers since 2000. In our opinion, this is a healthy development, as this construct of Rogan and Grayson's framework is a key area for the development of C2005. The extent to which its implementation will succeed is likely to stand or fall on the ability of teachers to innovate in their classrooms. While resources, teacher and learner factors have all been the subject of investigation by researchers, school ethos and management does not appear in the discussion above. The reason for this is likely to be that examination of a school's ethos and the way it is run are whole school issues. In our choice of articles focusing on science and mathematics, issues of whole school development, while often mentioned, are not prioritised. This leads us to Rogan and Grayson's third construct: the extent to which support from outside agencies affects curriculum implementation.

Studies of the profile of support from outside agencies

We could identify few studies in the literature that fall within this construct from the Rogan and Grayson framework. This is likely to be because most mathematics and science education researchers are interested in finding out what is happening at the level of the classroom rather than at higher levels in the system. The only studies we identified examined the subconstruct of professional development, and one such study (part of the Rogan project) was conducted in rural schools between 2000 and 2005 with interventions at both curriculum implementer and teacher levels. The aim was to create support for a greater fidelity in the implementation of curriculum change and raise learner performance. Participating teachers were assisted with development of learner support materials (Hattingh, Rogan, Aldous, Howie, & Venter, 2005). The study was conducted in two phases; three years of capacity building involving school-based and cluster-based professional development (INSET) followed by three years of delivery in the classroom. From this study it was concluded that even with intervention a gap still existed

in learner performance and this seemed to be due to (among other factors) socio-economic factors. Hattingh and her colleagues observe that there is a need to address the gap between socio-economic groups sensitively with curriculum design; that this gap may result in increased science achievement differential in schools.

Another study examined how teachers' pedagogical practices change in response to curriculum innovation and why they change in the way they do (Scholtz et al., 2004). Indications are that where interventions are made to assist teachers, the new pedagogical strategy is adapted to their working situation (context) while some old pedagogies are selectively retained because they survive in their classroom conditions. Teachers are not irrational opponents of change but rationally weigh alternatives according to perceived realities and so it is critical to match development programmes to teachers' perceived needs and working situations.

Conclusions and Implications

The research into teaching and learning we have described has a few things to say about the curriculum being implemented in South African schools. In our opinion, such commentary is likely to apply not only to C2005 (and RNCS), but also to the NCS newly introduced to the Further Education and Training level in grades 10 to 12. First, the openness and the ambiguity of the NCS document lends it to multiple interpretations. Even in a stable education system with well-trained teachers this could be a difficult aspect of curriculum implementation. In the current climate of uncertainty and change, such ambiguity means that teachers find it difficult to interpret what is required of them by the curriculum documents.

Implicit in our analysis is that the dislocation between curriculum policy and practice is inevitable. We would contend that this is because curriculum policy and curriculum practice need to be seen as different fields. Contrary to views that consider curriculum as contextualised social practice (e.g. Cornbleth, 1990), prevailing practices of curriculum consider policy making and policy implementation separately. The Rogan & Grayson (2003) framework provides a useful way of examining how researchers have interrogated the implementation of C2005 in mathematics and science classes. We have shown that there are commonalities between the two learning areas, particularly in teacher and learner factors in the capacity to innovate in the classroom, as well as the use of resources. However, there are also differences in research focus between mathematics and science curriculum implementation. With respect to mathematics, there is a clear focus on understanding mathematical concepts i.e. considering the concepts that are taught and learnt as objects of study and interrogation from a range of perspectives e.g. Vygotskian (Berger, 2004) and semiotic (Davis, 2003). The nature of the concepts that are covered in these interrogations range from those covered at primary school level (e.g. fractions) to those in the upper end and pre-university school levels (e.g. calculus). The study of these concepts is undertaken not for its own sake but there are intrinsic reasons for doing this, for example designing teaching materials might be influenced by identifying learners' misconceptions involving decimal fractions (Murray, 2000). Such curriculum materials are useful to support teachers, some of whom are said to have "weak subject knowledge" (Reeves & Muller, 2005). Science on the other hand has tended not to focus on issues of concepts, but instead on how teachers understand and attempt to implement C2005 (e.g. Aldous 2004; Stoffels, 2005).

Common to both mathematics and science education has been the need to integrate mathematics and science with everyday knowledge. Adler, Pournara & Graven (2000) examined forms of integration espoused by the new curriculum and how these translate into practice. They questioned

the meaning of integration in the curriculum, and its implications for learning and teaching of mathematics in schools. They argue that there are forms of integration that are promoted in the new curriculum which may not be possible from both a practical and theoretical point of view. Two of the stories the authors reflect on suggest that integrating mathematics with the everyday or with other disciplines is very difficult for teachers to accomplish. In the sciences, on the other hand, research on integration and the use of everyday knowledge in teaching and learning has progressed from questions of its feasibility to the investigation of implementation strategies. Stears, Malcolm & Kowlas (2003) have reported on the successful use of everyday knowledge to achieve shifts between formal science and the learners' world, while Stears & Malcolm (2005) observed increased learner participation where curricula incorporating everyday knowledge are co-designed by teachers and learners.

Two issues on curriculum alignment were: policy and practice alignment and policy and cultural values alignment. The argument was that there will be little or no effect on performance in terms of the intended curriculum if what happens in the classrooms is poorly aligned with the intended policy. Therefore this alignment issue needs to be considered when designing instruments assessing learner achievements. The second argument is that if the intended and practiced curricula are to support each other, then measuring instruments and educational philosophies have to be sensitive to the prevailing value systems in schools (Hattingh et al., 2005)

How best can we then bring about innovation in schools? Rogan and his associates have proposed approaches to introducing innovations in schools in a feasible manner. Rogan & Grayson's (2003) framework provides schools with a map by which they can plan for change. Their notion of a Zone of Feasible Innovation provides some guidance on how much change should be attempted. While they describe their framework as tentative, we have found that two of its constructs (profile of implementation and capacity to innovate) are useful ways in which to view much of the research into mathematics and science curriculum implementation over the past 8 years. There is a gap in research around the third construct, 'support from outside agencies', which we found has not attracted much research in both mathematics and science. Further, Rogan & Grayson's levels need to be seen as examples, and future studies should attempt to define their own levels more exactly than the rather broad categories listed in the original framework. The ZFI is a helpful construct that can assist both professional development programmes and individual teachers to shift their practices in the 'series of small steps' rather than in a 'big bang' approach. In order to plan this series of small steps, Rogan (2007a) proposes that within a school community, teachers should construct a continuum in which they use their current classroom practice and the capacity of the school as their beginning point, create a coherent sequence e.g. of classroom strategies within that continuum, decide on the boundaries of their ZFI, i.e. what change is feasible and meaningful, and then teachers should begin to move through their ZFI. Rogan points out the value of learning materials and communities of practice in providing support and in scaffolding this change through the ZFI. Policy makers need to consider these proposals and consider working within this framework.

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