Appendices

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APPENDIX A

VARIATIONS IN TEACHER EDUCATION PRACTICES ACROSS DIFFERENT CONTEXTS

1. Introduction

In what follows I briefly discuss examples from across developed and developing contexts to show that variations in the nature of regulations and policies are related to how key foci identified in Chapter 2 Section 2.4 (that is: institutional location; agents and agencies involved in producing the regulations; what is seen as relevant for the school, economy and polity; understanding of research; and understanding of the relationship between institutional and work-based learning), play out within particular contexts. These variations produce different possibilities for teacher education. In particular, I will show that while it appears that all regulation policies claim in some way or another to be based on 'research', some policies are highly *prescriptive* and lead to decreased autonomy for teacher educators to make decisions over their work, whereas others are more *generative* and lead to the possibility of teacher educators having a significant influence and relative autonomy to make decisions over and lead developments in teacher education.

The move to regulate teacher education through policy has generally gone hand in hand with its movement into higher education. In many developed nations, the movement has lead to what is termed the 'universitisation' of teacher education (Arreman, 2005; Flores & Shiroma, 2003; Vonk, 1995; Zhou & Reed, 2005), where comprehensive universities have increasingly become involved in initial teacher education programmes for all levels of schooling. Within many of these contexts, the focus has been on developing a research-base and a strong academic focus for initial teacher education, with varying degrees of attention paid to the professional and work-based aspects across different contexts. In other cases, mostly in developing countries, single purpose institutions in higher education (sometimes new institutions and in other cases converted/ incorporated colleges of education or normal schools), take the responsibility for teacher education, and here more often the focus is on the professional (or pedagogic) aspects of teacher education (Flores & Shiroma, 2003; Zhou & Reed, 2005). The nature and focus of the research and the connection to practice within the teacher education programmes produced in these contexts varies from institution to institution and country to country (Arreman, 2005; Hoban, 2005).

The literature suggests that the regulations are in some cases designed and implemented by the government (and their agencies) in order to impose a specific (prescribed and audited) order, as was the case in the UK (see for example Furlong, Barton, Miles, & Whitty, 2000; Gilroy, 2002; Tulasiewicz, 1996). This was a pattern across many of the commonwealth countries. It was also attempted in Brazil (see Flores & Shiroma, 2003) and other Latin American counties (see Avalos, 2000). In other cases it appears that the move to regulate teacher education, while also led by governments wanting to set up systems of accountability, are negotiated in conjunction with other agents (for example academics/ and or teachers through the involvement of universities/ professional associations/ unions etc) (Tulasiewicz, 1996). In some of these cases the regulations are used to encourage teacher education to become more research-based and to develop a professional body of knowledge for teaching and school improvement, as is reported to be the case in Sweden, Canada (see Arreman, 2005) and other Western European countries (see Vonk, 1995). In other countries professional bodies have taken the lead in developing such standards and assuring quality in teacher education and governments have not had direct involvement. This has been the case, for example, in parts of the USA (see Bullough, Clark, & Patterson, 2003) and Australia (see Bates, 2002; Sullivan, 2002).

In the following subsection I will discuss examples from developed contexts where the three movements are most advanced. This will be followed by a discussion of examples from developing contexts. These cases will be used to highlight the international trends, commonalities and differences in teacher education policies and practices. Later, in chapter 3, the ways these movements have played out in the South African context will be explored.

2. Regulation and accountability in developed contexts

Arreman (2005) argues that the nature of regulation in developed contexts is characterised by different political patterns which are productive of different perceptions of teachers' professionalism *and* teacher educators' professionalism. In some cases regulation has resulted in government led prescription leading to decreased autonomy of teacher education academics in HEIs (for example, through prescriptions over curriculum decision making). In such cases, teacher educators in HEIs are seen as being out of touch with the realities of the profession and in need of control to bring them in line with what is required by the system: less irrelevant theory and more relevant practice oriented experience. This is illustrated by the situation in England and Wales, where the move has been presented as an attempt to raise the professionalism of teacher educators by government-led measures derived from so called evidence-based (brute data) research, which has lead to university based teacher educators having less control over what they teach and over teacher education more generally (see Arreman, 2005; Furlong et al., 2000; Gilroy, 2002; Tulasiewicz, 1996). In other cases, there is the recognition by the state that teacher educators require support for providing and developing relevant teacher education. For example, in Finland, Sweden and Portugal the move has been to develop teacher education as a research-based field and to encourage teacher educators to become engaged not only in research but also in decision making over the directions that teacher education takes in general (see Arreman, 2005; Flores & Shiroma, 2003; Vonk, 1995). In these examples a common theme is the use of *research* as a basis for making decisions over the provision of teacher education and the criteria for its regulation. However, what is clear is that there are differences in the type of research that is used for making decisions, and there are also differences in what such research is used for, who does it and how it is funded.

a) Government imposed and prescribed practice-oriented standards: The example of teacher education in England and Wales

The example of England and Wales, is one where there was a "rapid and under-resourced change" in teacher education precipitated by government "imposition of what appears to be a new order, defined by regulations, in which the balance of time and responsibility has shifted to schools and teachers" (Lambert & Totterdell, 1995, p. 13). Control over what was to count as quality teacher education, which in this context had traditionally been in the domain of universities was taken over by the state without negotiations or consultations with the profession or with teacher educators (Tulasiewicz, 1996). Commentators have criticised the increased state intervention and the control over the teacher education curriculum (see Edwards, Gilroy, & Hartley, 2002; Furlong et al., 2000; Gilroy, 2002) showing how over the last two decades of the twentieth century the system moved from one of diversity and autonomy to one of homogeneity and central control with a narrow conception of teacher professionalism.

By 2000 requirements for initial teacher education in England and Wales were highly specific, prescribed and audited. They were developed by an agency set up by the government for this purpose (the Teacher Training Authority – TTA) and inspected and audited through a second purpose built agency (Office for Standards in Education – OFSTED) (see Edwards et al., 2002; Furlong et al., 2000; Gilroy, 2002; Tulasiewicz, 1996). The TTA produced a list of competences that preset students *must* attain as well as guidelines for managing and financing all teacher education courses. This was done without consulting or working with academics who had been involved in teacher education, many of whom were aware of the problems, were not in principle against the idea of regulating and quality assuring teacher education and may have had a useful contribution to make (Newby, 2003; Tulasiewicz, 1996).

Within this context compliance with standards and inspection is ensured through the imposition of significant *financial penalties* for non-compliance (Beck, 2002; Furlong et al., 2000). This move has severely compromised the relative autonomy of universities to develop and teach courses that they believe appropriate in terms of intellectual standards and social needs. It has also transferred significant resources from universities to schools[1], and has resulted in many universities being put under enormous pressure as student funding decreases and work loads increase. At the same time it repositioned schools as sites of professional education which put additional pressure on practicing teachers, not only to teach their learners, but also to help train new teachers.

It appears that the major motivation for these moves was the failure of schooling as recognised within statistics that showed poor school performance, high drop-out rates and poor literacy skills and innumeracy amongst disaffected youth. There was also strong public opinion that held "teachers alone responsible when their classes (did) not reflect current values or for the outcome of such conflicting practices as meeting parental demands, providing equal opportunities, ensuring strong pupil motivation, and achieving good results which are not exclusively within the grasp of teachers or their trainers to deliver" (Tulasiewicz, 1996, p. 28). Tulasiewicz suggests that these criticisms were not fully researched or assessed, however they were used to rapidly change the teacher training system. Arreman (2005) argues that the government used this 'empirical research' in the form of 'brute data' showing the achievement of learners in schools to be less than adequate, to conclude that professionalisation of teaching requires less (irrelevant) theory and more (relevant) practice. This so-called 'evidence-based' policy development enabled them to force practice-based standards on teacher education.

[1] Tulasiewicz (1996) makes the point that from 1993 to 1998 there was an increase from 150 schools accredited for teacher education to "thousands".

Paradoxically, the consequence of the regulations is that the content of teacher education courses has become more prescribed, while the connection between these university-based requirements and what happens in schools when the teachers are learning in practice, has become less linked (Furlong et al., 2000). Hoban (2005) also makes the point that it has resulted in preset teachers spending two thirds of their time in schools and far less time in universities. Tulasiewicz (1996) argues that in these moves there was an assumption by the authorities that professionalizing teaching meant connecting the preparation of teachers intimately with their later work and has had the consequence of undermining the development of a knowledge-base for teaching (unlike other professions where preparation begins in the academic domain and then moves into the world of work).

One of the consequences of this introduction of competency-based teacher training has, as Beck (2002) argues, involved the suppression of the discursive base of education reforms and therefore denies novice teachers access to alternative discourses, especially education disciplines (for example, philosophy and sociology of education) which might have equipped them to become critically *aware* of the forces that were really structuring their professional re-formation. So while the changes are reported to professionalize teaching, the consequence is for it to become de-professionalized. Significantly in England and Wales this exclusion of certain discourses (and agents) from teacher training was achieved not by explicit censorship but by filling the course time available with what are defined as *essential* and *practice* related contents, which are audited to ensure compliance.

The emergence of very strong school-based component in teacher education in England and Wales, in which the practical dimension became primary for the professional development of teachers and contact with the university environment, and their control over the curriculum diminished, is a particular consequence of the way in which the various international movements in teacher education have played out within this context. While teacher education is still located in higher education (universities award the qualifications), universities have less autonomy and little control over their curricula and strong government regulations define competencies and standards against which the training of prospective teachers is to be carried out and evaluated, and on which teacher education providers are funded and audited. This was made possible by excluding teacher educators and the profession from involvement in decision making with respect to the regulations and by the administrative and economic power of the state to put in place the kind of systems which enabled them to control teacher education in this way.

The literature shows that strong government intervention resulting in school-based practice models of teacher education, loss of a theoretical knowledge base for teaching and severe loss of autonomy for university based teacher educators is not a necessary characteristic of all efforts at promoting accountability in teacher education around the globe, as will be shown in the next subsections.

b) Government funded research-based standards leading to the establishment of a theory of teaching: examples from Europe

Vonk (1995) shows that there is a general trend in Western European countries towards professionalism in teaching, which can be seen in efforts to establish a body of professional knowledge and expertise aimed at bringing "Teacher Education curricula to the academic level" (*Ibid*. p. 272). This fits in with Arreman's (2005) account of teacher education in Sweden and other western European countries as developing teaching into a research-based profession, and with Flores and Shiroma's (Flores & Shiroma, 2003) account of recent government led moves in Portugal, Spain and France to replace the traditional divides between primary and secondary teacher education by ensuring that all teacher education becomes university-based and "extending the formal training of the former, and by emphasising the pedagogical component of the latter" (*Ibid*. p. 7). The trend in these European cases is towards teacher education involving a longer academic and professional training and a greater involvement of universities in developing regulatory policies and producing relevant curricula for the initial education of teachers. This is confirmed by Tulasiewicz (1996) who also stresses the relative autonomy that teacher educators have in European countries (in contrast with the UK) regarding their decision making over the inclusion of theory in the preset curriculum, and supportive funding for researching and developing a theory of teaching (generally referred to as didactics in the European context). In these cases, the move into higher education is linked to its location in universities and the enhancement of the status of the profession through ensuring a knowledge-base for the profession that is rooted in research.

This is well illustrated by the example of Sweden. Arreman (2005) explores the position of teacher education in the higher education system in Sweden and the struggles over discourses of teacher education within that context. He argues that while there has been an international focus on regulating teacher education for developing teacher professionalism, the way it manifests itself is connected into the way power works within a specific context. He shows this by drawing on theoretical constructs, including the ideas of Foucault (1980), Bernstein (1977) and Bourdieu to illustrate how, in contrast to what occurred in the UK, teacher education developed as a research-based discipline in Sweden. He argues that through "struggles over knowledge and power, teacher education was able to claim the right to establish new and different research paradigms, for its own benefit" (Arreman, 2005, p. 230). This lead to the establishment of a notion of teacher professionalism in Sweden as based on an assumption that teacher educators and teachers require research as a means of providing theoretical underpinnings for improved professionalism and practice.

In the 1960s Sweden established specialised colleges for teacher education and although there was commitment to " 'practical pedagogy', as a specific research mode of the discipline of educational studies … teacher educators [were] primarily concerned with methods teaching and practice [and] had little possibility of engaging in research or post graduate studies" (Arreman, 2005 p. 227). In 1977 teacher education was formally incorporated into the university sector by the state in a move to professionalise teaching and teacher education and encourage the development of a research focused knowledge-base. However, paradoxically despite its new location teacher education did not develop into a research focused sector of the university – it remained set apart from other university disciplines, at the same time as "policy discourses emphasised the view of teachers and teacher educators as 'professionals' with a vocational knowledge base underpinned by research" (Ibid. p. 227). The discrepancy between policy discourse and practice became increasingly visible and in 2001 the government made a decision to intervene with major reform initiatives in teacher education which lead to the establishment of research structures for teacher education within the universities.

The account of Swedish teacher education is illuminating – first it shows the movement from the establishment of specialised colleges to the incorporated into universities that was based in the need to professionalise teaching, which was understood as being connected to the development of *knowledge* for practice, which would be in keeping with a general understanding of what being a profession is all about. Then it illustrates a problem that education in general and teacher education in particular has faced within the university environment: education was not regarded as a discipline in its own right and therefore not worthy of space and resources within the university as a whole. Arreman's study suggests that the "lack of power and status of teacher education was related to its exclusion from academic discourse, or following Bourdieu, its lack of cultural capital" (2005, p. 230). What is most interesting is that the struggles over establishing itself as a legitimate area of knowledge production were not very successful over the decades and it was only in the 1990s, with the development of state policies that provided the backing it needed, that it was able to do so. A research focus was created through the kind of government regulation which enabled teacher education academics within institutions to develop their identities as researchers and teacher educators. A significant aspect of this was the involvement of the profession and universities in the development of the policies. The understanding of the role of research within this context was significantly different from what had occurred in the UK. A further very significant aspect was the provision of supportive funding.

This focus in teacher education is not only something that is recognised in European countries. Arreman explains that this movement took place much earlier in some other developed countries, specifically pointing to the example of Canada. The moves from normal schools and teachers' colleges into universities began in Canada in the 1950s with a demand for a research profile from teacher education academics already clearly visible in the second half of the 1960s (Arreman, 2005).

While in the cases discussed above, it was government who drove the initial move to standard setting and regulating teacher education, in whatever form it took, in the USA and Australia the move has rather been driven by professional organisations, also with differing results.

c) Standards movement led by professional bodies and/or unions: examples from the USA and Australia

In line with what has been discussed earlier, there have also been moves towards greater regulation in the USA that have been driven by the perception that education has failed – "(s)ince 1983, and the publication of *A Nation at Risk* (National Commission on Excellence in Education) which declared publicly funded education in the US a failure, […], Americans are demanding new levels of teacher accountability and supporting development and implementation of set and measurable standards of performance that enable comparisons across programs, schools and states" (Bullough et al., 2003, p. 36). The standards movement, propelled by *A Nation at Risk*, led to three standards movements in teacher education – standards in core knowledge, standards for student achievement, and standards for teacher accreditation. While inputs still matter within this context, Hoban (2005) suggests that *demonstrated performances* have become a central concern in the US, and these are to be measured against a set of standards developed by the National Council for the Accreditation of Teacher Education (NCATE), which positions itself as speaking for the profession.

What is interesting in relation to these movements in the USA is the enormously varied and market driven system of teacher education operating across and within different states. Bullough et al. (2003) explain that there are thirteen hundred higher education institutions involved in the preparation of teachers. These include specialised colleges and universities. Of these only about half are accredited through the NCATE, which was established in 1954 and is composed of representatives from professional (teacher) bodies. They suggest that before the late 1990s, the main aim of teacher education accreditation in the States through NCATE was to ensure that institutions had a "clear focus and sufficient resources to provide a quality program and that each intending teacher had been exposed to the subject mater and pedagogic content and had a range of experiences of a specific duration in schools" (Ibid., p. 38). The institutions providing teacher education had autonomy over the design of their programmes and the selection of contents in their curricula and there was no compulsion to become accredited through NCATE, which was entirely voluntary. More recently however, there have been moves by the various states to require accreditation against a set of agreed standards as a guarantee of quality, and NCATE has produced standards for this purpose.

However, in the USA, there are many institutions that do not support the standards movement, and since it is not mandated by state governments or by prospective employers of the teachers produced through these institutions, becoming accredited against the 'agreed' standards is still voluntary. Hoban (2005) discusses an opposing movement, the strength of which is reflected in the 700 unaccredited schools of teacher education. This movement aims to deregulate teacher education by opening the market for any institution to train teachers, and to leave it to schools of teacher education to determine their programmes and to market forces to determine their quality and success as teacher education institutions. It is assumed that students will 'vote with their feet' to sustain those of high quality, and schools (whose governance is devolved to the local level) will employ teachers from institutions that prove their worth.

While there is enormous diversity in teacher education provision and regulation in the USA, this is not the case in most countries. Bates (2002) suggests that unlike in America where there is huge variation in types of institutions and variations in quality of output according to the institution, this is not the case in Australia where there is a much narrower range of undergraduate and graduate education. However, in relation to the teacher education curriculum wide variations exist according to the providing institution, and institutions have the autonomy to make decisions over their curricula. For example, while there is a general requirement for a practice component in any teacher education programme across states, there is no consistency in terms of what is required.

Bates (2002) explains that Australian single purpose teacher education colleges were closed and teacher education was fully incorporated into the university system during the 1990s. The capacity of universities to develop and fund teacher education programmes and the direction that programmes have taken is not uniform across the system. This is connected to a significant reduction of resources allocated to teacher education since the incorporations and to the importance of research production as a major source of funding in this environment. In addition, over the past two decades or so there has been a general decline in resource allocation for higher education as a whole and this has lead to major pressure on universities, and even further squeezing of allocations to teacher education. In many universities this lead to the closure of campuses originally devoted exclusively to teacher education and to the amalgamation of faculties of education into super faculties. The low status of teacher education as an area of research in the university sector and to the lack of funding associated with teacher education is a major problem for faculties or schools of education. Universities are more likely to put their resources into the high status programmes and areas where research funding is readily available. This analysis of the Australian situation reminds us of the situation in Sweden before government intervention to actively fund teacher education research and development.

The literature does suggest that since the incorporation of the colleges of education there has been considerable upgrading and reform of teacher education programmes in some institutions. However, these changes were not driven by government policies, but rather by academics involved in the production of teachers. There are no specific criteria for teacher education qualifications that must be adhered to (see for example, Bates, 2002; Hoban, 2005; Sullivan, 2002). However, there is increasing pressure to produce professional standards for teacher education particularly by professional bodies which are being established to develop, implement assure and accredit such standards. Much of this work is derived from examples of standards produced in the USA by NCATE.

Hoben (2005) suggests the call for standards and the establishment of a regime of verification by some state departments of education is becoming more widespread. For example in New South Wales a report by the state department of education and training, *Quality Matters. Revitalising teacher education policy: Critical choices* (Ramsey (2000) as discussed by Hoban, 2005), recommended the establishment of an "Institute of Teachers" to identify professional standards and career pathways for teachers which would include responsibility for endorsing and deregistering programmes of teacher education. A major motivation for this was a government funded research finding that most teacher education programmes undervalued the importance of school-based experience, and on the basis of this the report doubted the value of much of what was done in teacher education. The report recommended that teacher education focused less on the academic and more on the practical, suggesting that:

> It is possible to reorganise the knowledge bases of undergraduate teacher education subjects so that they are more integrated with school and classroom culture, and therefore more relevant, more meaningful, better appreciated by student teachers, with less duplication across subject areas. (Ramsey (2000) quoted in Hoban, 2005, p. 5)

It appears, however, that while such reports are produced, they are not necessarily implemented and that in Australia the direction of teacher education is still in a situation of flux. Over 20 different reviews and reports on teacher education have been produced over the past two decades (see Bates, 2002; Hoban, 2005; Sullivan, 2002). Hundreds of recommendations for reform have been suggested in these reports, however none of the reports have had any sustained impact and almost none of the recommendations have been implemented. The situation is such that a power struggle for the control of teacher education standards and quality assurance is underway, with state departments appearing to support professional bodies, and universities and academics coming under increasing pressure with lack of funding for both teacher education and research creating difficulties for them to assert their positions. The widespread calls by professional bodies for professional standards in teacher education and the establishment of a regime of verification would, if successful have an impact on teacher education curricula. There are two major focuses of these calls – first the call for higher levels of disciplinary expertise and secondly the call for higher levels of professional (pedagogical) expertise.

Bates (2002) suggests there is widespread agreement in Australia that university knowledge is irrelevant to work in schools and that this has encouraged a call for movement towards the apprentice model of teacher education, similar to England's move towards school-based teacher education. Bates suggests that teacher educators, now part of universities, are detached and ignorant of what life is like in schools with too little recent relevant experience and under pressure to focus on research, which he sees as irrelevant to the work of educating teachers. He suggests that the activity that leads to this research is not what is required for the training of teachers. However at the same time he acknowledges that many of these same academics, through their research programmes and interests in schools, have been active in bringing about changes in curriculum, professional practice, school organisation and accountability in schools. Bates' position seems a little contradictory, he appears to be advocating a less academic curriculum for teachers and more of a focus on professional aspects, while at the same time acknowledging that research does have a place in terms of providing a knowledge base for change within schooling itself.

Bates does not give any compelling evidence or argument for the suggestion that what university based teacher educators do is irrelevant to future teachers' lives. This evokes a feature that appears to be common amongst many government-based and profession lead reform initiatives, as Edwards et al. (2002, pp. 3-4) suggest

> Their agenda are offered in a discourse marked by transcendental certainties that find expression in a series of anti-teacher-educator slogans that do little but capture an ideology in a sound-bite. Such slogans associate teacher education variously with the dangerous left, with out-of-touch academics and profligate wastage of public funds.

The contrast between Sweden and Australia with regards to the place of teacher education in the university and the preparation of teachers is interesting and illustrates the ideological nature of moves in teacher education. While Bates does not theorise the move into higher education, his description of the status of teacher education in the university points to the same kind of situation that existed in Sweden in the 1980s. In advocating a move to school-based practice as the way to professionalise teaching and teacher education (by being more relevant to the work of schools) he puts forward a position that is ideologically different from what was advocated in Sweden. In Sweden the research-base was needed to develop a discipline that was connected to the work of teachers and teaching and therefore could enhance teacher professionalism, and at the same time take up a legitimate place within the university itself. Teachers existing expertise and experiential knowledge was not seen as the basis for this professionalism. In Bates' Australia, a position is advocated that suggests a view of research as an 'ivory tower' business, and experience within schools as a better basis for developing the profession. The fact that this has not as yet been instituted in Australia also points to the possibility that there is a power struggle underway around the claiming of the teacher education terrain that Bates is not reporting. The calls for the moves he describes are coming from the professional bodies, whose interests are in the schools, and not from the university based academics who he so severely criticises.

In the above discussion on teacher education and regulation in developed countries a number of things have been illustrated. While in most industrialised countries the move to higher education has resulted in university-based teacher education becoming the norm, the extent to which university based teacher educators have been able to claim the space for decision making over teacher education curricula and in particular the balance between and focus of formal (institutional–based) learning and work-based learning within programmes has varied considerably. Their ability to develop and maintain a research culture and a knowledge base for teaching has also varied across contexts. The focus of teacher education in these contexts and the relationship between various forms of learning is connected to the power that various agents and agencies have in influencing the regulatory context, and this is specifically related to economic issues of controls over funding for teacher education and research. When research is carried out by government agencies (such as in the UK) and then used to justify what appears to be popular demand for teacher education to be more relevant through work-based training a different notion of professionalism is produced from where research is used to develop a disciplinary basis for teacher education (as in Sweden). In contexts where the state has not taken direct control (as in USA and Australia) and professional bodies are the major instigators, while there are clear movements towards standardisation that would favour the practical over the academic, the situation is far more in flux and contestations for the control of what is to count as quality in teacher education are less defined.

3. Developing Countries and the regulation of teacher education

The discussion above relates mainly to industrialised countries nevertheless the trends in developing countries are not dissimilar. While in the context of developing countries the move towards standards and quality assurance in teacher education has occurred much later than in developed countries, it is also becoming increasingly common. However the context of teacher education reform in these countries is significantly different, particularly with respect to administration systems and resources.

Avalos (2000) shows how developing countries around the world have been caught up in the international educational reform movement during the 1990s. She suggests that the most common way this is done is to begin with general reforms in the education system as a whole before considering the education of teachers. Thus educational reforms are decided upon, new curricula for schools are produced, textbooks are written and then teachers are informed of contents and taken through inset programmes so that they can implement the changes in their classrooms. This is a familiar scenario for teachers in South Africa with the introduction of the new outcomes based (OBE) school curriculum in 1996. Avalos cites the situation in Papua New Guinea as one of the few examples where the opposite process took place to illustrate a different possibility. Here the reform began with teacher education, secondary teachers were funded to complete university degrees, primary teacher programmes were lengthened and teacher educators at the colleges were “stimulated to review their curriculum” (Ibid., p. 460).

Avalos (2000) suggests that while teacher education is a concern of the state since it has responsibility over the education of youth in general, the power of the state to regulate teacher education programmes varies greatly in developing countries depending on the local contexts within a country, particularly on the administrative organisation of the state and the nature of the teacher education institutions themselves. The move towards regulation of quality in teacher education is occurring more rapidly in those contexts where the state has the resources to take a more active part, such as in South Africa and Brazil. In primary education the state generally has more control over the provision of teacher education and curriculum than for secondary education. This is because in most developing countries primary teacher education still takes place in normal schools and special colleges, many not part of tertiary institutions, and is fully funded by the state. However, the institutions themselves often exhibit inertia and change is difficult to manage.

Flores and Shiroma (2003) provide an account of teacher education in Brazil, where changes in educational policy in 1996 dictated that all teacher education should be re-located to higher education. However the state did not choose to incorporate it into the existing universities as had been the case in most developed contexts, but rather into new purpose built institutions. Brazil has a population of 170 million and 2 million teachers. While traditionally secondary school teachers were trained in public universities, 78% of primary teachers did not have formal qualifications. The intention of the 1996 state reforms in teacher education was to move teacher education onto a professional footing and declare that it should all be done in higher education institutions. However, at the same time the state wanted to remove teacher education from the public universities altogether as they did not believe the universities were producing the kind of teachers they required; traditional initial teacher education programmes were labelled as inadequate for current social demands. They did this by setting up specific higher education institutions for teacher educaiton outside of the existing university system. Since these institutions did not exist they had to be built and state resources for teacher education went into building and developing these institutions. At the same time the government reduced funding to public universities that had traditionally trained secondary teachers, thus forcing them out of teacher education. In Brazil the move of teacher education into the higher education system meant that secondary teacher education was moved out of the public university sphere into specialised colleges of education, while primary teacher education was put on a more formal footing and brought into the new state controlled colleges.

The effect of these moves in Brazil was supposed to elevate the status of the profession by moving all teacher education into higher education, however, the scale of the operation and the assumed need to develop a whole new sector served to undermine the one part of the teacher education system that had traditionally operated to produce qualified teachers for secondary education. New regulations and curricula for relevant teacher education in Brazil have been produced by the state for implementation in these institutions, undermining the possibility of developing a research culture in teacher education and focussing on practical and experiential aspects of teaching. These moves have served to reduce the knowledge base of teaching, leading to a focus on what is seen as professionally *useful* in the classroom, and therefore devalue professionalism, turning teacher work into a technical function.

Since the 1980s there has also been major reform in teacher education in China (Zhou & Reed, 2005). The focus was two-fold: strengthening existing teacher education institutions; formalising qualifications and making changes in the basic curriculum for teachers towards problem solving and critical thinking[2]. In the 1980s there was an attempt to recover the teacher education system from the decimation that occurred in the previous decades and the focus was on strengthening the institutions which were responsible for teacher education. At this time there were four types of institutions involved in teacher education in China: two–year normal schools for training pre-school and elementary school teachers, professional teacher colleges for training junior high school teachers, normal universities for secondary school and vocational teachers, and major normal universities for higher education institutions. Thus, in China there has traditionally been a clear distinction between training for teachers at different levels in the system, which is a characteristic of many developing countries. The second focus which occurred during the 1990s was on improving the quality of teacher education. Teaching was formally identified as a profession and a formal teacher certification system was put in place.

Zhou and Reed explain that more recently there has been recognition that teacher education needs to be restructured more systematically. In particular there is an increasing trend towards moving all teacher education into the Higher Education system. In 1999, the system was reviewed and a two tier system for preparing school teachers instituted – the professional teachers colleges would take over the role of preparing pre-school, elementary and junior high teachers (with the normal schools/ education schools merging with the professional colleges or becoming secondary schools); and the number of higher education institutions involved in teacher education would increase, with all universities encouraged (through funding incentives) to produce teachers for all levels in the system. In addition there have been numerous new policies developed by government to deal with the regulation of teacher education, including the setting of standards, accreditation of standards, and quality for teacher education. The professional colleges are gradually being absorbed into the higher education system, but remain single purpose institutions.

The opening up of teacher education to comprehensive universities has lead to the establishment of a number of new schools of education at major universities and the development of a wide ranging set of models for teacher education. This represents the move to an open system for

[2] This was a characteristic of more recent changes in many other developing countries, including in Latin America (Avalos, 2000).

teacher education in China, however, with the majority of teachers still being trained in single purpose teacher training institutions, the “universitisation of teacher education in China is the future long-term aim” (Zhou & Reed, 2005 p. 211).

This account of the trends in China reiterates the international move of teacher education into Higher Education and highlights the fact that moving into Higher Education does not necessarily involve moving teacher education into the university sector. So while the move to higher education is an international trend, and in the past few decades most developed countries have moved all teacher education into universities, this is not necessarily what the move has meant in developing contexts.

APPENDIX B

ORIENTATIONS TO KNOWLEDGE - EXAMPLES OF CODING

Examples of the way in which the assessment statements in the NCSM were coded into the various categories revealing orientations to knowledge, as discussed in Chapter 4.

<u>Examples of AS's coded as (1) "mathematics for critical democratic citizenship":</u> LO 1, AS 4, Grade 12 - Critically analyse investment and loan options and make informed decisions as to the best option(s) (including pyramid and micro-lenders' schemes; or, LO 4, AS 3(a), Grade 12: Identify potential sources of bias, errors in measurement, and potential uses and misuses of statistics and charts and their effects (a critical analysis of misleading graphs and claims made by persons or groups trying to influence the public is implied here).

<u>Examples of AS's coded as (2) "mathematics as relevant and applicable to aspects of everyday life and local contexts":</u> L O1, AS 4, Grade 10 - Use simple and compound growth formulae ($A = P(1+ni)$ and $A = P(1+i)^n$) to solve problems, including interest, hire purchase, inflation, population growth and other real-life problems.

<u>Examples of AS's coded as (3) "mathematics for inducting learners into what it means to be a mathematician, to think mathematically and view the world through a mathematical lens":</u> LO 3, AS 2, Grade 10 (a) - Through investigations, produce conjectures and generalisations related to triangles, quadrilaterals and other polygons, and attempt to validate, justify, explain or prove them, using any logical method (Euclidean, co-ordinate and/or transformation). (b) Disprove false conjectures by producing counter-examples. (c) Investigate alternative definitions of various polygons (including the isosceles, equilateral and right-angled triangle, the kite, parallelogram, rectangle, rhombus and square).

<u>Examples of AS's coded as (4) "mathematics as conventions, skills and algorithms to master in order to gain access to further studies":</u> LO 2, AS 5, Grade 11 - Solve: (a) quadratic equations (by factorisation, by completing the square, and by using the quadratic formula) and quadratic inequalities in one variable and interpret the solution graphically; (b) equations in two unknowns, one of which is linear and one of which is quadratic, algebraically or graphically.

Examples of AS's coded as (5) "mathematics as a human activity produced historically in cultural and social contexts": LO 3, AS 7, Grade 11: Demonstrate an appreciation of the contributions to the history of the development and use of geometry and trigonometry by various cultures through an alternative form of assessment (e.g., an investigative project).

An example of an assessment standard showing a combination of orientations: LO 2, AS 6 , Grade 10 and Grade 11: Use mathematical models to investigate problems that arise in real-life contexts (2): a) making conjectures, demonstrating and explaining their validity; (3); b) expressing and justifying mathematical generalisations of situations (3); c) using various representations to interpolate and extrapolate (4); d) describing a situation by interpreting graphs, or drawing graphs from a description of a situation, with special focus on trends and pertinent features (4). (Examples should include issues related to health, social, economic, cultural, political and environmental issues. (1)).

APPENDIX C

SURVEY DOCUMENTS AND DATA

Appendix C.1: Permission to collect formal documentation from DoE/CHE

Letter sent to the Registrars of the various institutions requesting permission to obtain their University's formal documentation from the CHE/ DoE

UNIVERSITY OF
KWAZULU-NATAL

PIETERMARITZBURG CAMPUS
School of Education, Training and Development
Private Bag X01,
Scottsville, 3209, KwaZulu-Natal
South Africa
Telephone +27 (0) 33 2605368
Facsimile +27 (0) 33 260 5080
DATE 2004

To the Registrar
University of …../ Technikon

Dear Sir/ Madam/ Prof *(use name if available/ check website/telephone)*

I am undertaking research into the design of mathematics teacher education qualifications in the context of the incorporation of Colleges of Education into Higher Education Institutions (HEIs) and the publication of the Norms and Standards for Educators. This research forms part of a PhD study into the interpretation of policy in mathematics teacher education and the curricula developed for educating initial mathematics teachers.

I have put in a formal submission to the Council for Higher Education (CHE) and the Department of Education (DoE) for permission to access the documents submitted by the various HE Is for gaining accreditation and recognition for their teacher education programmes. I hope to use these documents as part of the baseline data for my analysis. I hope to be able to include qualifications offered at all higher education institutions in SA in the study.

The main purpose of this letter is to inform you about the study and to ask permission to access to the documentation that has been submitted through the CHE/ DoE by your institution. The documents that I wish to access are your formal submissions of qualifications for educators. The CHE and the DoE have been approached and have indicated that they would be prepared to release the data for research purposes if individual institutions give the go ahead. The rationale for gaining access to this documentation though the CHE and DoE is to ensure that the curricula considered in the study only include those which have gained formal accreditation and are recognised for employment purposes.

Any information obtained from the IJC or DoE will be dealt with in the strictest confidence and individual institutions will not be named in the final research report. I will uphold all possible ethical standards in relation to confidentiality and use of documents collected for analysis.

Please complete the attached reply slip to inform me of your decision in these matters. Please make use of the prepaid envelope to send your reply at your earliest convenience.

Yours faithfully

D Parker

Diane Parker
School of Education Training and Development
Faculty of Education
University of Natal, Pietermaritzburg Campus.
parkerdc@nu.ac.za

Please fill in the following reply slip, and return it by post using the enclosed envelope.

Reply slip.

Name of Institution: …………………………………………………………………………..

The above mentioned Higher Education Institution agrees to allow the researcher, Diane Cecile Parker, access to the formal documentation relating to the accreditation of their mathematics teacher education programmes submitted through the Interim Joint committee for registration (SAQA), accreditation (CHE), and recognition for employment purposes (DoE).

This documentation will only be used for the purpose of research into the design of mathematics teacher education programmes.

Signed: …..…………………………….. …………………………………………..

Name: ………………………………….

Capacity: ………………………………………………………………

Date: …………………….

Witnesses:
1 …………………………………….

2. …………………………………….

Official University/ Technikon stamp:

Appendix C.2: Request for information from the Dean/ Head of Education

Letter sent to the Dean/ Head of Education at each institution requesting information about their initial MTE programmes

UNIVERSITY OF
KWAZULU-NATAL

PIETERMARITZBURG CAMPUS
School of Education, Training and Development
Private Bag X01,
Scottsville, 3209, KwaZulu-Natal
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Telephone +27 (0) 33 2605368
Facsimile +27 (0) 33 260 5080
DATE 2004

The Dean/ Head of School/ ….*(Check for name on website/ obtain telephonically)*
Faculty of Education/ Education section/ … *whatever is appropriate for the individual institution*
University/ Technikon of …..

Dear Sir/ Madam/ Prof *(insert the name if possible)*

I am undertaking research that focuses on the design of mathematics teacher education qualifications in the context of the incorporation of colleges of education into Higher Education and the publication of the Norms and Standards for Educators. This research forms part of a PhD study into the interpretation of policy in mathematics teacher education and the curricula developed for educating initial mathematics teachers.

The main purpose of this letter is to inform you about the study and to ask for access to information from your institution.

The focus of the research is on the education and development of Senior Phase and FET mathematics teachers. That is, on university qualifications and programmes aimed at the initial education of mathematics teachers for Grades 7 – 9 and 10 – 12.

I expect that the particular programmes you offer for mathematics teachers could be options within an undergraduate Bachelor of Education degree (B.Ed) or even a specialised degree in itself. Alternatively they may be offered as an initial general formative degree with mathematics followed by a Post-Graduate Certificate in Education (PGCE).

I have written to your registrar, to request permission for access to your formal submissions to the Council for Higher Education (CHE) and the Department of Education (DoE). It is, however, often the case that formal documentation does not reflect the substantive detail, ethos and methodological approach used in actual programmes. For this reason I am requesting information directly from you, as detailed below:

1. Details of all qualifications for initial mathematics educators (for grades 7 – 9, 10 – 12, or 7 – 12) offered by your institution. This could be in the form of a handbook, rulebook, prospectuses, etc. giving details of the course requirements for successful completion.
2. Descriptions of the individual mathematics or mathematics education courses that make up each programme. This information could be in the form of leaflets/ course outlines/ descriptive notes, etc that you would provide for students.
3. I have also attached a brief questionnaire to help me with the organisation and collection of the data. It would be very helpful if you could complete it and return it together with the information described above.

I hope that your institution will agree to be part of this study and that you will be able to provide the basic information for the survey. Any information obtained from your institution will be dealt with in the strictest confidence and individual institutions will not be named in the final research report. I will uphold all possible ethical standards in relation to confidentiality and use of documents collected for analysis.

You will receive this request in both hard copy and in electronic form. If possible please submit information requested in electronic form to parkerdc@nu.ac.za. For information not available in electronic form, please make use of the prepaid envelope to send your reply at your earliest convenience.

Yours faithfully

D Parker

Diane Parker
School of Education Training and Development
Faculty of Education
University of Natal
Pietermaritzburg Campus

Summary of information required:

1. descriptions of qualifications/ programmes for initial mathematics teachers ☐
2. information about mathematics and mathematics education courses that are included in the programmes ☐
3. completed questionnaire ☐

Please complete this questionnaire and return it together with the information about your qualifications requested above. If possible please submit in electronic form to parkerdc@nu.ac.za. Alternatively use the prepaid envelope provided. I am aware that this 'one size fits all' questionnaire may not be appropriate for the diversity of programmes you offer. Please feel free to change the questionnaire to make it more appropriate for describing the programmes offered by your institution. Use additional space if required.

A: Institution

Name of Institution:

Position you hold in the institution:

Please provide your e-mail address (for follow up queries):

B: Qualifications

What qualifications does your institution offer for initial mathematics teachers specialising for grades 7 – 9, 10 – 12, or 7 – 12? Please name them all:

Qualification 1:

Qualification 2:

Qualification 3:

Etc. (please use additional space if necessary)

C: Curriculum Information

For **each qualification** offered please answer the following:

1. Please provide a list of the specialist mathematics and/or mathematics education courses required for the completion of this qualification (if there are options, please indicate these). Use the grid below.
   Please provide course descriptions for each of the courses listed (e.g. handbook entries or student information sheets, including credit weightings and form of assessment).

	Mathematics courses	**Mathematics Education courses**
Qualification 1		
Qualification 2		
Qualification 3		

2.	What proportion of the courses required for the whole qualification are related to mathematics and/or mathematics education? (In relation to any general Education courses/ courses required for other specialisations) Qualification 1: Qualification 2: Qualification 3:
3.	In regard to the specialist courses for mathematics teachers, what proportion of the courses required are focused on mathematics or statistics (pure/ applied) as opposed to mathematics education? Qualification 1: Qualification 2: Qualification 3:
4.	Are studies in mathematics and mathematics education integrated in any way in this qualification? Please explain. (e.g. Is a distinction made between mathematics and mathematics education in the qualification? Do students study mathematics education courses separately from the mathematics courses?) Qualification1: Qualification 2: Qualification 3:
5.	Are studies in mathematics education and education integrated in any way in this qualification? Please explain. (e.g. Is a distinction made between education and mathematics education in relation teaching practice or other aspects of learning to teach such as say, management of learning/ design of learning materials? Do students study education practices separately from the mathematics education courses?)

D: Teaching of courses
(Please complete the grid below to answer these questions)

Who teaches and develops the mathematics and mathematics education courses?
(use **M** for Mathematicians located in the Mathematics Department (located in the Science faculty) or **ME** Mathematics Education specialists attached to the Education section of the institution). If deemed necessary give additional details.

Where and **with whom,** are students taught these courses? (use **C** if they are taught centrally together with students studying for other qualifications , or **A** if are they are taught separately as prospective mathematics teachers apart from students studying for other qualifications). If deemed necessary give additional details.

Qualification	**Who teaches?** (**M** or **ME**):	**Where and with whom are students taught?** (**C** or **A**)
Courses in Qualification 1		
Mathematics courses		
Mathematics Education courses		
Courses in Qualification 2		
Mathematics courses		
Mathematics Education courses		
Courses in Qualification 3		
Mathematics courses		
Mathematics Education courses		

E: Norms and Standards
Did the publication of the Norms and Standards for Educators (February 2000) influence your thinking about the provision of initial qualifications for mathematics teachers?
…………..………………………………………………………………………..….YES/ NO

If yes, in what ways were you influenced? Please give as much detail as possible.

F: Incorporation of Colleges of Education

1. Did your institution incorporate a College of Education? ..………………YES / NO

2. If yes, please give the name of the college that was incorporated.

3. If yes, what has happened to the college premises and how are they used?

a) They have become part of the wider university ……………………………YES/ NO

b) They are used exclusively for teacher education …………………………YES/ NO

c) They are used for teacher education **and** programmes leading to qualifications for other purposes …………………………………………….……………………YES/ NO

If yes, please explain:

d) They are used for other university activities (not necessarily leading to qualifications) ………………………………………………….…………………….………YES/ NO

If yes, please explain:

e) They are **not** used for teacher education programmes ….……………………YES/ NO

f) If none of the above apply, please explain

g) How close (in kilometres) are the college premises to the main campus? Give an estimate:

4. In the context of the incorporation of the college, has the provision of qualifications for mathematics teachers changed? ……………………………………..….YES/ NO

If yes, in what ways has it changed? Please give as much detail as possible.

Thank you for taking the time to complete the questionnaire and for submitting the information requested.

Appendix C.3: Responses to requests for information

Table 1: Responses to requests for information from the various institutions.

Higher Education Institution (code)	Permission from registrar (Y/N)	Tel contact with offices of dean/ head (Y/N)	Tel contact with head of maths section (Y/N)	Questionnaire complete (Y/N)
U6	Y	N	Y	Y
T2	Y	Y	Y	Y
T1	Y	Y	N	N
U12	N	Y	Y	N
U15	Y	Y	N	N
U5	Y	Y	Y	Y
U3	Y	Y	Y	N
U20	N	N	N	N
T3	Y	Y	Y	Y
U2	Y	Y	Y	Y
U1	Y	Y	Y	Y
U10	Y	Y	Y	Y
U11	Y	Y	Y	Y
U19	Y	Y	Y	Y
T5	Y	Y	Y	N
U9	Y	Y	Y	Y
U18	Y	Y	Y	Y
U14	Y	Y	Y	Y
U13	Y	Y	Y	Y
T4	Y	Y	Y	Y
U8	Y	Y	Y	Y
U17	Y	Y	Y	N
U7	Y	Y	Y	N
U4	Y	Y	Y	Y
U16	N	N	N	Y
Total: 25	22	22	21	17

Note:
Each university/ technikon is given a code Ux/ Tx which is used throughout the tables to maintain consistency.

Appendix C.4: Formal regulatory documents

Format for the submission of formal curriculum documents for regulatory purposes is stipulated in the Criteria (DoE, 2000).

The Criteria stipulates that:

- "All the competences must be developed and demonstrated in all seven educator roles in all initial teacher education programmes" (Ibid., page 12, first bullet).
- "First Bachelors degrees should include sufficient credits in appropriate subjects so that the teacher will be competent in his/her chosen specialisation. Detailed definitions of approved qualifications and a list of approved school subjects are contained in later sections of this document" (Ibid., page 13, first bullet).
- "… publicly funded teacher education qualifications must meet the criteria laid down by the Minister of Education in the Criteria .." (Ibid., page 15)
- "… providers must submit their qualifications to the Department of Education for evaluation for purposes of employment. To apply for recognition and evaluation of their qualifications providers must use the following format: (Ibid., page 15 - 18)
    1. Name of Institution:
    2. Title of Qualification:
    3. Purpose of qualification:
        - The purpose of the qualification states clearly the roles, specialism(s), level, target learners, employability and articulation routes.
        - The purpose is in line with national and/or local needs
        - The purpose informs the statement of applied competence, curriculum design and assessment strategy.
    4. Target learners and learning assumed to be in place:
        - Assessment of entry knowledge of learners,
        - Promotion of access to the programme and the providing of learner support,
        - Processes for the recognition of prior learning and experience.
    5. Exit level outcomes and applied and integrated teaching competence:
        - The critical cross-field outcomes are integrated into the exit level outcomes of the qualification.
        - The contextual roles (all six of them in the case of a 480 credit B Ed) and their applied competence are integrated into the seventh specialised or elective role that is described in the exit level outcomes, and is clearly related to the purpose of the qualification
    6. Credit specifications:
        - Total number of credits required for the qualification.
        - Minimum or maximum credits required at specific levels, including evidence that the minimum specialist requirements in the case of a 480 credit B Ed, as described in the *Norms and Standards for Educators,* are complied with.
    7. Applied and integrated assessment:
        - The assessment strategy is clearly related to the purpose and exit level outcomes of the qualification.
        - The assessment criteria are based on the practical, foundational and reflexive competence described for each in the *Norms and Standards for Educators.*
        - The seven roles are assessed through the specialism.

- The ability of learners to integrate theory and practice should be assessed. Learners must able to integrate their competence to perform important teaching actions (practical competence), their understanding of the theoretical basis for these actions (foundational competence) and their ability to reflect on and make changes to their teaching practices (reflective[3] competence).
- Knowledge of the specialism (discipline, subject, learning area, phase of schooling) is central to the learning programme and the assessment of content knowledge, concepts and theories, procedural knowledge and strategic knowledge should form a key part of the assessment strategy.
- Teaching experience is integrated in a structured manner into the learning programme and is associated with part of the assessment strategy.
- Detailed diagnostic records of learners' progress should be kept.

8. Articulation with other qualifications:
9. Quality assurance mechanisms:
   - Brief description of the internal quality review process that is in place to ensure own quality- improvement and the effective and efficient delivery of the teacher education learning programme
   - Last and next review date of the qualification and learning programme.
   - Most recent report findings of the external review of the programme by an ETQA.
10. Mode of delivery of the programme:
    - Full-time, part-time, face-to-face contact, school-based and workplace integrated, distance, telematic, electronic, on-campus or mixed mode, off-campus, satellite-campus, outsourced to or in partnership with other providers.
11. Date of implementation of the programme for the first time:
12. Approval by Council and Senate:
13. Date of submission:
14. Contact information:
    - Name of contact person
    - Physical address
    - Postal address
    - Telephone number (Telkom/Cell phone)
    - Fax number
    - E-mail

In addition to the above, the following statement is also relevant:

- *Specialisation* is a phase in brackets after the qualification type, for example, Diploma in Education (Senior Phase: Human and Social Sciences). It indicates the *particular purpose* of the qualification and could include a phase specialisation (such as Foundation Phase), a subject/ learning area specialisation (eg Further Education: Mathematics), a specialisation in a particular role (e.g. Education Management), or a professional or occupational practice (e.g. Curriculum Studies). There is no predetermined set of purposes/ specialisations. (italics in original, Ibid., page 26)[4].

[3] This is an interesting slip. In the NSE it refers to reflexive competence not reflective competence.
[4] This is a repeat of the statement on page 23 of the Norms and Standards. Point 5, pages 25 to 30 of the Criteria are identical to Point 4, pages 23 to 25 of the N&S. This point defines each type of qualification and its purpose, as well as giving the minimum specialist requirements for initial teaching qualifications. The three initial qualifications mentioned are – the Diploma in Education (DE), the Bachelor of Education (B.Ed) and the Post Graduate Certificate in Education (PGCE). The DE is seen as an exit point from the B.Ed, the PGCE follows a general Bachelor's degree or 360C qualifications that provides a foundation for teaching a particular specialisation.

Appendix C.5: MTE programmes offered by HEIs

Table 2: Specialist MTE programmes offered by different HEIs (Source:DoE (2002) and information obtained from HEIs' questionnaire returns)

HEI	HD	HA	College incorporated	Rural	Urban	English	Afrikaans	PGCE SP	PGCE F	PGCE S+F	B.Ed SP	B.Ed F	B.Ed S+F	DoE recognised
U1	0	1	1	0	1	1	1	1	0	1	1	1	0	1
U2	0	1	1	0	1	1	0	1	1	1	1	1	1	1
U3	0	1	1	0	1	0	1	0	0	1	1	1	0	1
U4	0	1	1	1	0	0	1	0	0	1	0	0	1	1
U5	0	1	0	1	0	1	0	0	0	1	0	0	1	1
U6	0	1	1	0	1	1	0	0	1	0	1	1	0	1
U7	0	1	0	1	0	1	1	0	0	1	0	0	0	1
U8	0	1	0	0	1	1	0	1	1	1	0	0	0	0
U9	0	1	1	1	1	1	1	0	0	1	0	0	1	1
U10	0	1	0	0	1	0	1	0	0	1	1	1	0	1
U11	0	1	1	0	1	1	0	1	1	1	1	1	1	1
U12	1	0	0	1	0	1	0	?	?	?	?	?	?	0
U13	1	0	1	1	0	1	0	0	0	0	0	0	1	0
U14	1	0	1	1	0	1	0	0	0	0	0	0	1	1
U15	1	0	0	1	1	1	0	0	0	1	0	0	1	1
U16	1	0	1	1	0	1	0	0	0	0	1	1	0	1
U17	1	0	0	0	1	0	1	0	0	1	0	0	0	1
U18	1	0	0	0	1	1	0	0	0	1	1	0	0	0
U19	1	0	1	1	0	1	0	1	0	1	0	0	1	1
U20	1	0	1	1	1	1	0	0	0	0	0	0	0	1
T1	0	1	1	1	0	1	0	0	0	0	0	0	1	0
T2	0	1	1	0	1	1	0	0	0	0	0	0	1	0
T3	0	1	0	0	1	0	1	0	0	0	0	0	1	1
T4	0	1	1	0	1	1	0	0	0	0	0	0	1	1
T5	0	1	1	0	1	1	0	?	?	?	?	?	?	0
Tot	9	16	16	12	16	20	8	5	4	14	8	7	13	18
% (N=25)	36	64	64	48	64	80	32	20	16	56	32	28	52	72

<u>Notes:</u>

Institution U12 and T5 did not provide any information with respect to its programmes and had not taken any of its programmes through the DoE processes. It is unknown if they offer any of these programmes – hence the '?' in the columns. They are therefore excluded from the survey results on the programmes presented in Chapter 5.

U20 had taken its qualifications through the processes required, but did not offer any PGCE or B.Ed programmes.

Some institutions have rural and urban campuses: U9, 15 and 20; while others are dual medium institutions: U1, 7 and 9.

Appendix C.6: Positioning to official discourse

Table 3: Table showing positioning of various HEIs to official discourse

HEI	HD	HA	Rural (1)/ Urban(0)	College incorporated	Offer a specialist B.Ed[5]	Compliant (1)/ non- compliant (0)	Official (1)/ unofficial (0)	Form: holistic (1)/ atomistic (0)	Influence of NSE in design? (Q) y(1) n(0)	Why/ how?
U1	0	1	0	1	1	1	1	1	1	NQF levels / own history/ institutional tradition/
U2	0	1	0	1	1	1	0	1	0	own history/ institutional tradition/ NCSM more relevant
U3	0	1	0	1	1	1	0	1	n/a	n/a
U4	0	1	1	1	1	1	1	0	1	competences used to structure learning programme
U5	0	1	1	0	1	1	0	1	0	own history / institutional tradition
U6	0	1	0	1	1	1	0	0	0	an inset qualification; roles not considered
U7	0	1	1	0	0	1	0	1	n/a	n/a
U8	0	1	0	0	0	0	0	n/a	0	reject attempted regulation by state
U9	0	1	0	1	1	1	1	1	1	expand focus: roles
U10	0	1	0	0	1	1	1	0	1	4-years; competences; SGB doc
U11	0	1	0	1	1	1	1	1	1	expanded focus: roles
U12	1	0	1	0	?	0	n/a	n/a	n/a	n/a
U13	1	0	1	1	1	0	1	n/a	1	competences and focus on assessment; also NCSM
U14	1	0	1	1	1	1	1	1	1	applied and integrated competences
U15	1	0	1	0	1	1	1	0	1	n/a
U16	1	0	1	1	1	1	1	0	1	focus more on school M
U17	1	0	0	0	0	1	0	1	n/a	n/a
U18	1	0	0	0	0	0	0	n/a	1	political/ Ed faculty at risk
U19	1	0	1	1	1	1	1	1	1	organised around roles;
U20	1	0	0	1	0	1	1	?	?	? (no information)
T1	0	1	1	1	1	0	n/a	n/a	n/a	n/a
T2	0	1	0	1	1	0	1	n/a	1	specialist role NB
T3	0	1	0	0	1	1	0	1	0	institutional tradition traditions/ SAQA registered/ decision deferred
T4	0	1	0	1	1	1	0	1	0	own history / institutional tradition
T5	0	1	0	1	?	0	n/a	n/a	n/a	n/a
Tot	9	16	10	15	18	18	11	12		

Note: Here the *main* centre of the university is considered in deciding whether rural/ urban. '?' are used where no information is available.

[5] In this table SP only B.Eds are not considered as specialist. This follows the analysis which shows that they are generalist rather than specialist.

APPENDIX D

INFORMED CONSENT AND SCHEDULES FOR COLLECTING EVIDENCE FOR CASE STUDIES 1 (INSTITUTIONAL ANALYSIS)

Appendix D.1: Documents relating to informed consent.

a) Information letter given to the programme director, head of department and all lecturers interviewed

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Private Bag X01,
Scottsville, 3209, KwaZulu-Natal
South Africa
Telephone +27 (0) 33 2605368
Facsimile +27 (0) 33 260 5080
DATE TO BE INSERTED

Dear NAME TO BE INSERTED

Thank you for agreeing to participate in this study. The following provides some background information about the purpose of the study and provides details of the information I hope to collect about your programmes and courses.

Since the early 1990s we have seen a wave of curriculum reform in South Africa. This has been in response to changing political, social and economic forces both internationally and within the country, and changing forms of knowledge, brought about by amongst other things the increasing use of technology and greater insight into how children learn. In teacher education these changes have come about in a context of radical transformation of the sector with the incorporation of colleges of education into higher education institutions (HEIs) and the publication of the Norms and Standards for educators, and the implementation of the new curriculum in schools.

The starting assumption of this project is that those involved in mathematics teacher education have responded to these changes positively and have been involved in designing new mathematics teacher education programmes for specialist mathematics teachers which try to make a qualitative and quantitative difference to how teachers teach mathematics and how students come to know mathematics within the context of a transforming society.

In terms of policy we know that teacher educators have been asked to design programmes in which the **specialist role** is marked out as the '*the overarching role into which the other roles are integrated, and in which competence is ultimately assessed*' (DoE, 2000: 12). In terms of the policy FET teaching is seen as a *specialist domain.* The policy states that initial qualifications must be designed for FET mathematics teachers so that they gain access to "*the disciplinary basis of content knowledge, methodology and relevant pedagogic theory*" (DoE, 2000: 28). However there is no prescription of what ought to be taught, how it ought to be taught, or what this 'content knowledge, methodology and pedagogic theory' is in substantive terms, how this integration should take place or how competence should be assessed. It is left up to the teacher educational professionals to produce the criteria for the specialisation.

We know that those involved in specialist FET mathematics teacher education programmes and courses draw on a wide selection of knowledge and practices to provide teachers with access to what they consider appropriate understandings of mathematics and mathematics education to enable them to become 'good' mathematics teachers in schools. However we know very little on the form and substance of these selections across different institutions and what the criteria for the selections are based on. How do we make selections? What criteria do we use to make the choices and how do we organise and make these available to our students? We also know very little across such activity, about how different selections assist student teachers' learning and influence the way they will teach mathematics in the classroom.

The aim this project is to describe and explain how particular institutions have responded to the full incorporation of teacher education into the higher education sector, specifically in relation to initial *specialist* mathematics teacher education, with a specific focus on how they have designed and selected contents and made these available to student teachers. The focus is on the different aspects included and conceived of as specialist and how these are related to non-specialist contents within the curriculum and what image of the *kind* of teacher this aims to produce. What vision of mathematics, of mathematics education and of mathematics teaching is produced through these programmes and why is it seen as appropriate for mathematics teaching in our context. A further focus is on how student teachers respond to these offerings, how they recognise the intended image of teaching and whether they recognise themselves within this image, that is, the extent to which they are able to take this up as part of their identity – of who they are or wish to become as mathematics teachers.

From these case studies I hope to be able to present a detailed account of various approaches to educating mathematics teachers and the selections of specialist mathematical knowledge for teaching across different institutions, the relationship of these various approaches to the identity construction of initial mathematics teachers as specialists in the field, and the images they produce of teaching and learning in mathematics classrooms.

In order to do this I need to consider the courses you offer for initial FET mathematics teacher education – the combinations that result in a PGCE or the B.Ed undergraduate degree for teaching grades 10 –12. The following gives details of information I hope you are willing and able to provide.

Textual information to collect from case study sites

At the programme level:
Please provide **all information handouts, pamphlets, brochures you have about your programme.** In addition please provide the following if it is not included in the above:

- The programme descriptions showing the overall design and aims of the PGCE and the B.Ed for FET (mathematics) qualifications, the combinations of courses required and their relative credit weightings.
- A flow chart or map which indicates the ordering of the various courses that make up the qualification over time (e.g. by semester).
- When and how specialist mathematics teaching practice is incorporated into the qualification.
- Entry requirements or selection criteria for the specialist qualification (e.g. what prior mathematics courses for entry into the PGCE/ what matric mathematics result for entry into the B.Ed; other specific requirements)
- Student numbers – how many students on the programmes in 2004; 2003; 2002?

Specialist courses
Please provide as much **individual course material** as possible. In particular we would like to receive for each specialist course included in the qualification (e.g. mathematics/ mathematics education/ mathematics methods/ mathematics teaching practice):

- A course outline (if possible give details of the organisation of the course, the aims of the course and the major content areas included)
- Target audience (e.g. prior qualifications/backgrounds of student teachers etc.)
- Credits and learning hours allocated to the course (both contact hours and additional hours of expected self study and work on assignments and tasks) as they relate to the major content areas
- Any readily available course handouts/materials that are provided to students (e.g. reading lists, course materials; tasks). As much detail as is possible would be appreciated.
- The assessment requirements for the course (overview of different items e.g. exams, assignments, tutorials etc and the % weighting of each in the final mark allocation.)
- Copies of assessment tasks given to students in each course and if possible the criteria used for evaluating the students work
- Any other information you think would be of interest

In addition if it seems appropriate and you are in agreement I hope to be able to observe some of the contact sessions on selected courses running over the period I will be visiting your institution.

Thank you for your participation.

Yours sincerely

D Parker

Diane Parker
(Lecturer: Mathematics Education)

b) Letter of informed consent, to be signed by the programme director, head of department, and lecturers

INITIAL MATHEMATICS TEACHER EDUCATION RESEARCH PROJECT

UNIVERSITY OF KWAZULU-NATAL DATE xx/xx/ 2004

LETTER OF INFORMED CONSENT

This letter confirms that I have been fully informed about the three phases of a PhD research project into 'the organization of discourses of knowledge in initial FET mathematics teacher education programmes' being carried out by Diane Parker of the University of KwaZulu-Natal and that I am a willing participant in the third empirical phase of this research. This information is contained in the "Letter to the Dean" attached'.

I know that this phase of the project involves in-depth case studies at two institutions, and that my institution is a willing participant in this phase of the research.

I know that the researcher will ask me to provide specific information about the B.Ed undergraduate programme, and the specialist courses for educating specialist FET mathematics teachers. The required information is detailed in the attachment entitled: "Textual information to collect from case study sites".

I know that the materials I provide giving details of the programmes and courses will form part of the empirical information collected for the PhD research project being carried out by Diane Parker, and I give my permission for the material I provide to be used for this research.

I know that I will also be interviewed to clarify information and to discuss design of the curriculum and the reasoning behind the particular selections of knowledge and practices included in the programmes and courses. I know that the interviews will be recorded, transcribed and analysed as part of the data.

I know that some of the lectures of mathematics teacher education classes will be video recorded, transcribed and analysed as part of the data.

I know that when information provided is used to report the research my name will not be used and neither will the institution's name. Full confidentiality will be adhered to and suitable pseudonyms will be used to identify the institution and myself in the report.

I know that students on my courses will be included as participants in the case study and that whatever information they reveal will remain confidential.

I know that all materials provided and information recorded during the visit to my institution provided shall ONLY be used for this research project as explained to me.

I know that at anytime during the research process, I have the right to withdraw my participation.

RESEARCHEE
Name: ______________________________ Institution: ______________________
Signature: ______________________________ Date: ___________________

RESEARCHER
Name: Diane Parker
Signature: __________________ Date: __________________

c) Information letters given to all participating students

UNIVERSITY OF
KWAZULU-NATAL

PIETERMARITZBURG CAMPUS
School of Education, Training and Development
Private Bag X01,
Scottsville, 3209, KwaZulu-Natal
South Africa
Telephone +27 (0) 33 2605368
Facsimile +27 (0) 33 260 5080

DATE 2004

Dear University of XXXX B.Ed student 2004

Re: Consent for participation in the 'Initial Mathematics Teacher Education' research project

This letter to inform you about a research project that involves a case study of the qualifications for mathematics teacher education offered at your institution. I will be at your institution for a period of three weeks from XXX to XXXX to collect information and invite your participation in the project.

Below I have given details of the project, the purpose of the visit and how (I hope) you as a student would be involved in the research.

The visit is related the third phase of my PhD study focussed on 'discourses of knowledge and applied competence' in initial mathematics teacher education curricula in SA higher education institutions (HEIs). The project is funded through an NRF grant.

The first phase of the study involved an analysis of teacher education curricula reform in SA since the publication of the Norms and Standards and in the context of the incorporation of colleges of education into the higher education sector. The second phase of the project involved a survey of the all 23 HEIs offering programmes for initial FET mathematics teachers. Here I obtained formal documents relating to the design of their new 'Norms and Standards' aligned curricula for specialist initial mathematics teacher education. I was able to get a broad view of the way different curricula for the PGCE and the B.Ed undergraduate degree (for FET mathematics) are organised. I am now moving into the third phase of the study where I am looking at a more in-depth empirical study of what has been put into place at two HEIs, selected on the basis of the survey.

The aim this phase of the project is to describe and explain how particular institutions have responded to the full incorporation of teacher education into the higher education sector, specifically in relation to initial *specialist* mathematics teacher education, with a specific focus on how they have designed and selected contents and made these available to student teachers. The focus is on the different aspects included and conceived of as specialist and how these are related to non-specialist contents within the curriculum and what image of the *kind* of teacher this aims to produce. What vision of mathematics, of mathematics education and of mathematics teaching is produced through these programmes and why is it seen as appropriate for mathematics teaching in our context. A further focus is on how student teachers respond to these offerings, how they recognise the intended image of teaching and whether they recognise themselves within this image, that is, the extent to which they are able to take this up as part of their identity – of who they are or wish to become as mathematics teachers.

From these case studies I hope to be able to present a detailed account of various approaches to educating mathematics teachers and the selections of specialist mathematical knowledge for teaching across different institutions, the relationship of these various approaches to the identity construction of initial mathematics teachers as specialists in the field, and the images they produce of teaching and learning in mathematics classrooms.

Your lectures have selected you as a possible research participant, because they see you as a student who is successful and is demonstrating the qualities of a good future mathematics teacher. This letter formally invites you as a successful specialist mathematics student teacher to participate in the project.

Your participation will involve:

1. A first meeting with the group of student participants at which an overview of the research will be explained and a discussion will be held. This meeting will video taped if all participants agree.
2. At this meeting you will be provided with a biographical questionnaire that you will be asked to complete. This involves providing background information about your previous schooling experiences, your mathematical history and your motivation for becoming a mathematics teacher
3. A series of interviews held over the three-week period in which you will reflect on your university experience and learning leading to your becoming a mathematics teacher. In these you will be provided with a selection of items that will be used to probe your conceptions of mathematics, mathematics education and mathematics teaching and learning. These include excerpts from the FET curriculum statements, mathematics questions; lesson plans, written learner responses to math tasks, ideas about math concepts, and examples of classroom practice (video clips). The times and places of these meetings will be arranged to suite your individual time-table.
4. Providing examples of work you have done while studying to become a mathematics teacher (e.g. items marked for assessment on the courses/ any other items you would like to share). Items that you are particularly pleased with or that you really enjoyed doing and believe made an impact on your development as a mathematics teacher would be most helpful.
5. A final group meeting in which we reflect on the research process (again to be videotaped if all agree).

I hope you will benefit from involvement in this research. You will be given an opportunity to reflect on you own education and development as a beginning mathematics teachers. You will also receive some material benefits in relation to resources for teaching mathematics. Please be assured that everything you say and do will be kept confidential. Your name will not be used to identify the source of any particular information you provide.

A more formal consent form has is attached to this letter. If you do agree to participate please complete the form and return to it to me.

Yours Sincerely

D Parker

Diane Parker
Mathematics Lecturer
Tel: (033) 260 5898
Cell: 0845140222
e-mail: ParkerDC@ukzn.ac.za

d) Student Consent form

CONSENT FORM

I, ………………………………………, (*please print your full name)*
as a final year student currently studying towards a B.Ed undergraduate degree/ PGCE specializing in mathematics for the FET (*please circle the correct one)* I am aware of all the data collection processes in the research project as listed in the information letter above.

I give consent to the following:

- **Completing a biographical questionnaire.**

  Yes / No (*Please circle your response)*

- **Videotaping of group discussions to be held at the beginning and end of a three-week period in INSERT MONTH 2004**

  Yes / No (*Please circle your response)*

- **Copies being made of selected assignments, class work and other items I produced while studying to be a mathematics teacher. The items will be those that I have selected and am willing to share with the researcher during interviews.**

  Yes / No (*Please circle your response)*

- **Being interviewed at various agreed upon times over a three-week period in INSERT MONTH 2004 and having these interviews taped and transcribed.**

  Yes / No (*Please circle your response)*

I am aware that the data collected will be used in a research project focused on mathematics teacher education.

I know that the material collected from me and the information I provide will be used for this research and not for any other purpose.

I know that all information provided and used in the research report will not be connected to me personally and my name will not be used. Full confidentiality will be adhered to and a suitable pseudonym, selected in consultation with me prior to use, will be used to identify my contribution in the report.

I know that if at any time during the research process I feel I would like to withdraw my participation, I will have the right to do so.

Signed: ………………………………………….
Date: ………………………………….

e) Consent for recording the MTE lecture observations

Consent form for Videos of classes.

X DATE X 2004.

Dear (CU or RU) student

During the weeks of XXX to XXX, Diane Parker, a lecturer and researcher from the University of KwaZulu-Natal in Pietermaritzburg, will be conducting research into mathematics teacher education on the XXXX campus. She will be observing a variety of lectures during her stay. She hopes to be able to make video recordings of some of these lectures.

This letter has two purposes: first to inform you of her visit, and secondly, to gain your consent for capturing some of your classes on video. The video may capture you personally interacting in the lecture theatre with your lecturer and other students. The videos will be taken over the next three weeks and may include one or more of your classes. If you do have any objection to being part of such videos, please inform your lecturer. If you do not have any problem and are willing to take part in such videos, please complete the following form and return it to XXXX (Lecturers name) by XXXX.

Thank you

Student Name: ……………………… Qualification: ………………..

Student Number: …………………….

I am aware that video recordings of some of my mathematics classes will be taken and will be used in a research project focussing on initial mathematics teacher education.
I am willing to be part of the class captured on these video recordings. (YES/NO)

These videos may also be used at a later stage for training purposes if my lecturers give their consent. If I am captured on the video I am willing to allow the video to be used for such purposes. (YES/NO)

Signed: ……………………………… date: ……………………………..

Appendix D.2: Interview Protocols

a) Interview protocol with programme co-ordinators/ designers at each institution.

Interview schedule - programme director/ designer
Open ended interview schedule. The focus is the overall design of the qualification/ programme (for each programme independently). In red are possible probes.

1. In relation to the B.Ed degree please describe the process through which the overall programme was designed. (Process). Who was involved in making the decisions about what contents would be included and the weighting given to each one?
2. Please explain the overall structure of the FET programme and what made you think of doing it that way and not some other way? (Draw a map of structure please – have paper ready. Probe responses.)
3. How are the different contents related (on a theoretical level – practical level)? E.g. Time and space given to each type of content and the distribution/ delivery over time. The mode of delivery? Who teachers what and why?
4. Did the incorporation of the college of education effect the development of the BEd in any way? Did any college staff/ university staff become involved in the programme? (Need to know for each site) - What happened to the college of education staff and the college campus(es) that were incorporated into your institution? Were they kept for the secondment period only or were they absorbed into the university staff? Did ex-college lecturers/ ex-university become involved in designing the new curriculum structure for the B.Ed? And if so what were their respective roles …)
5. Is there a specific rationale for the design of the FET programme? Is there any difference between this design and the structure of the GET programmes e.g. for foundation phase/ intermediate phase.
6. How is what you are doing now different from what you were doing before the publication of the Norms and Standards and the incorporation of the colleges of education? Probe – get elaboration.
7. The overall courses - is there any connection to the roles of the educators described in the NSE? E.g. the specialist role as the ‘overarching role’: how is that understood? Different types of competences e.g. foundational/ practical/ reflexive: how do these fit in? Applied competence: what do you understand by it and how do you assess for that? How, theoretically, is this envisaged in the particular design you came up with. Have you reflected at all on its effectiveness? Have there been changes along the way?
8. Possibility of single specialisation for FET teachers? Has this been considered and what is the reasoning for doing/ not doing it.
9. Organisation of the time table. Why this organisation and not another? Flow of courses over time?
10. Practice teaching – how is it organised, what schools are selected and how is the selection done?
11. Problems experienced? Evaluation – how is it going? How do you know?
12. Describe your attitude to new policy and relationship with the national DoE.

b) Interview protocol used with all mathematics specialist lecturers at each institution.

Interviewees - specialist lecturers

Interview schedule used with the head of department and all who the lecturers who co-ordinate/ are responsible for the individual modules in the B.Ed programme. The interview is openended. (Main question/ focus in black. Probes in are red, to use if necessary.)

1. About the overall design: Please give me an overview of the various specialist courses involved in specialising as a FET mathematics teacher in this qualification (B.Ed).
   Probes: e.g. Are these connected in any way? **(Please draw a map/ flow chart).** NB – ask questions about practice teaching: Is it a specialised course? How is it evaluated? Use the model – M; ME, MT - as a guide to probe understanding of the whole curriculum. Why were the particular choices made for the different courses (content wise) and if changes are being made, why these changes?
2. About the content and design of a particular course that the lecturer coordinates or teaches.
   Probes: Did you design the course(s) yourself? How did you make decisions over what to select for teachers? What do you hope to achieve through this course? Can you describe what you see as the main (theoretical/ knowledge/ practical) focus of this course? Is there a theory or selections of theories that are used (i.e. probe the theoretical resources made available to student teachers – ask the lecturer to **name** them if possible). What do you hope the student teachers will internalise from this experience and how do you go about trying to ensure that?) **NB need textual evidence for this course: Please provide all handouts given to the students, outlines, assignments, tests, other tasks etc and explanations of assessment if you do them, e.g., marking memos/ assessment criteria.**
3. Do you use a particular approach in the delivery of the programme – i.e. do you try to 'model' a way of interacting and teaching math/ math education? Can you describe this and how you attempt to put it into practice?
4. Do you teach this course(s) by yourself or with others? (who – where – spaces and agents/ what pattern of delivery do you use in the classes/ numbers of students/ pacing of material/ time table)
5. How do you assess achievement on this course? How do you go about evaluating the students work? What do you see as the most importance aspects of their work?
6. Please explain how you see this course(s) fitting into the whole degree programme? Does it in anyway connect to other courses in the programme (specialist/ generalist) and if so how?
7. Have you evaluated this course? If so how? What did you find?
8. At the end of the day you are involved in producing mathematics teachers – can you describe what image you have of a successful student – how they will think and act as a teacher (e.g How you hope they will act and be as teachers – both in terms of their orientation to knowledge (what they think is important – about mathematics, about mathematics education, about mathematics teaching) and their ways of carrying out their actions?)
9. By the way, we have been talking a lot about the courses etc … Please tell me briefly about yourself. How did you become involved in this course? (This needs to be somewhere in the middle. Probe - try get qualifications/ background/ major research interests and activities/ involvement with state upgrading, workshops etc/ other projects etc.)
10. Do you think the NSE influenced you in your design and selection of contents for these courses? How? Would you say the specialist role is the overarching role in this qualification? In what way? How do the different types of competences fit in? (foundational/ practical/ reflexive/ and applied). Applied competence –what do you understand by it and how do you assess for that? How, theoretically, is this envisaged in the particular design you came up with. Have you reflected at all on its effectiveness? Have there been changes since starting out?
11. What about the NCS? Have these influenced you and if so how? (e.g. what are you doing now that you hadn't been doing before?)

c) Interview protocol for initial group interview

Student group discussion # 1 – framework
The discussion is fairly open and tries to elicit the overall structure of the curriculum from the students' point of view as related to different types of knowledge contents, their relationship to one another; over time and space in the curriculum given to different types of content; modes of delivery etc and their perceptions and experiences of these.

This is required to help me understand: the way the acquirers respond to the various contents; where they think there is clarity and where they think there is none; how they imagine why these things have been included by their lecturers/ people who designed the programme and courses. It also gives me an opportunity to see how different members of the group interact and to establish initial lines of communication.

The framework provides some leading questions – that allow for probing and further discussion depending on the responses given.

All students are brought together in a room. The interview is recorded on video so that accurate transcriptions can be facilitated.

Setting the scene:
The focus of the group discussion will be on the overall programme that you have experienced and how you think it has helped to orient you in your 'becoming' a specialist secondary mathematics teacher.

Please reflect on the whole programme: your experiences across all the parts and how they come together in educating you as a teacher; how you think about that whole programme and your experiences of it. Pause and give the students a few minutes to individually think back before leading the discussion.

Leading questions:
1. Describe the different types of modules that make up the B.Ed programme as a whole and what you feel you have learnt from doing them. [Try to elicit: any distinctions made between mathematics/ mathematics education/ teaching mathematics in practice; other types of contents; to what extent they recognised a focus on practical issues/ professional issues/ academic development and theoretical ideas; what is dominant from their point of view]
2. Are there any connections between the various modules of the same type/ different types of modules? (Try to elicit: e.g Are the modules all independent of each other in design and delivery or is there an overarching idea holding them together? Do they follow on from one another? Are they sometimes repetitive/ contradictory?; Does there seem to be a coherence in purpose? If so describe. and so on).
3. Describe the mode of teaching experienced (e.g. How do lecturers approach the work – is a lecture mode used/ workshops/ tutorials/ discussions? etc.)
4. How are you assessed in the various parts? Are there any differences and if so what are they?
5. How does practice teaching fit into it? How is it organised (e.g. Do you have specific tasks etc to do? Who assesses you in practice? Specialists/ generalists? Is there a focus on specialist knowledge and practices in practice teaching? Do you get help with teaching the mathematics when assessed or is it more general? etc.)

6. How do you interact with other students in the programme (B.Ed) and outside of the programme? (e.g. Interaction with PGCE students or other university students studying other degree programmes? Are any courses taken together? Any other forms of interaction? Study groups? etc.)
7. What about time and space in the curriculum? (Probe: physical and mental time and space; time table; spread and organisation/ lecture spaces/ time for self study and intellectual discussion outside of the classroom etc.)
8. Reflections on what is learnt (e.g. what is helpful/ useful/ interesting/ inspiring/intellectually challenging … etc.) and how it is taught (e.g. lecture format/ tutorials/ workshops/ modelling teaching etc…). Is there a difference across different contents?
9. Is there anything else you would like to add that I have not mentioned already?
10. Discuss some housekeeping issues in relation to the whole research visit. Check dates for individual interviews. Sort out agreement over the final day and the presentations of what has been significant to them as beginning mathematics teachers. Suggest 3 pm as the time for presentations, with 10 min presentation time for each student, followed by a 'function' involving some food and farewells. Ask if there are any special food requirements.
11. End session by thanking the students for participating in this discussion and being willing to participate in the process as a whole.

APPENDIX E

ARCHIVE OF INFORMATION COLLECTED AT CU AND DATA PRODUCTION

Appendix E.1: Textual material collected from CU

Table 4: List of material and assessment items provided by the mathematics specialist lecturers during the site visit in 2004

Semester	Module name	Description of course material collected	Assessments related to this course	Knowledge discourse visible (M, ME. MT)
1 (6 – 8 lectures per week)	Mathematics for Teaching 101: Functions and Algebra	A selection of works sheets and tutorials (topics: linear functions; exponential functions; absolute value functions; intersection of functions; inverses of functions; logarithmic functions)	A selection of assignments and the final examination (June 2004)	School M – but re-learnt to focus on the graphical representations of the functions. Students expected to explore relationships and to explain why graphs behave this way. Use of computer technology, specifically worksheets
2 (6 – 8 lectures per week)	Mathematics for Teaching 102: Trigonometry and Geometry	No material provided for this course		
3 (6 – 8 lectures per week)	Mathematics for Teaching 103: Calculus	A selection of tasks. A student's written feedback on the course (one of the students selected in the sample)	a selection of assignments: writing in mathematics – based on 'the cycling problem' done in class; assignment on exploring rational functions; average gradient of a curve (using GSP); local linearity (using GSP); analysing function (GSP) June Exam 2004	M – not easily identifiable as school M nor as traditional University M – a construction of MfT. Significant use of computer technology, specifically GSP
3+4 (year long) 3 lectures per week	Curriculum 103	A selection of practice related tasks: Mathematics mini-lesson instructions. Teaching experiment (with grade 8 learners) Mathematical language (an exercise looking at	Mathematics extra-lessons project reports. School Experience assignment. Mini-lesson;	MT (mini lessons, extra lessons, school experience projects) ME – some reading but mostly in

		an extract from a textbook); looking at language in learner's work (2 exercises); word problems; an exercise based on Kilpatric et al's "Strands of Mathematical Proficiency"; two short articles: Herscovics, N & Kieran, C. (1980) Constructing meaning for the concept of equation. *Mathematics Teacher*, November 1980, pp 572 – 580 and an article Behr, M., Erlwanger, S & Nichols, E (1980). How children view the equals sign. *Mathematics Teaching*, 92, Sept1980, pp 13 -15.	Class work assignments June Test 2004 (examination only at end of year). 2 ½ h test. Open book.	tasks which deal with learner productions of school mathematics and a text book extract.
4 (6 – 8 lectures per week)	Mathematics for Teaching 104: Linear Algebra	A course outline; a selection of worksheets and tutorials (for topics: Vectors in R^2; Three dimensional spaces; Area and Volume; Lines and Planes; Systems of Equations; Using Matrices to Solve Problems);	Assessed tutorials; 3 class tests; no examinations. Exam still to be written.	This appears to be focussed entirely on M; University level mathematics.
5 (6 – 8 lectures per week)	Mathematics for Teaching 105: Mathematical Modelling	No information provided		Not yet developed – to be taught for the first time in 2005
6 (6 – 8 lectures per week)	Applied Mathematics 101: Mathematical Statistics	Comprehensive course notes provided (week by week). (for first part of the course – probability not provided) Recommended text book.	Assignment on distributions; computer lab task; class test 1; journal entry; summary assignment; open book test.	(taught to 2nd year B.Eds and 3rd year HDE in 2004)
7 (6 – 8 lectures per week)	Mathematics for Teaching 106: Mathematical Connections	No information provided		Course still to be developed – to be taught for the first time in 2006 (?)
7 + 8	Curriculum 105	No Information Provided		Course still to be developed: to be taught for the first time in 2006
8 (6 – 8 lectures per week)	Applied Maths 102: Financial Maths/ Maths literacy	Selection includes: focus on Financial maths in the NCS; tutorials (working with spread sheets); ads on bank rates (same add different rates); selection of spread sheet tasks	portfolio on financial math; spread sheet tasks. two tests. Exam still to be written at end of year	M – use of spread sheets; working with real tasks …. (taught to 2nd year B.Ed and 4th year HDE)

Appendix E.2: Coding and analysis of a CU Curriculum 103 lecture transcript

Curriculum Studies C: Video record analysis - Chunking into evaluative events and coding.

The lecture was video recorded on 28/09/04. The audio tack of the video was transcribed. All transcriptions quoted in Appendix 7.2 are direct quotes from this transcript.

The transcript has been chunked into five main events, each consisting of sub-events. The movement through the events is marked out and coding is shown. A summary of the coding can be found in Table 5; which appears at the end of the chunking of the transcripts.

EVALUATIVE EVENT 1 BEGINS

<u>Event 1.1 (duration 12 minutes: 0:00:00 – 0:12:21)</u>
In the first minute of the lecture the main object to be acquired is announced: 'word problems'.

The lecturer puts up the problem (see Plate 1) on the overhead projector.

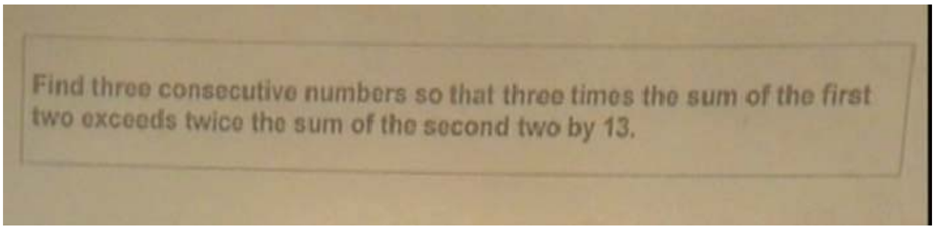

Plate 1: Word problem given at the beginning of the lecture.

The lecturer asks students for their solutions and elicits three different solutions. He tells them to check the solutions to see which ones work. Three minutes into the lecture the lecturer tells the students:

L: […]. We didn't get an answer on Thursday, or we were not convinced that we did have one. So now we have three sets, or at least three possible sets of numbers up here. We are trying to figure out if they are all correct, or only one correct, and if so what is wrong with the wrong ones. And as we said on Thursday this is one of those grotty problems where it is not easy to check, you can't just read it and say the sum of the three numbers is [gestures with hands] and add them together like some of us try. Ok, its not one of those, so you really have to get into the problem in order to check it. You need to understand the problem to check it. [some students come in a few minutes late] For those who have just come in, has anyone got different answers to the three on the board?

For the next while the lecturer walks around, watching, listening to student explanations and asking some questions to probe their thinking. Some students are discussing the problem in a group of three, and others work independently or in pairs. The lecturer asks one student (Precious) write her solution on the board. While she writes the group discussions still go on. Students must convince the lecturer and one another that the solution is correct or incorrect. For example, in the following interaction:

Zeenath: They all work
L: They all work? Ok, can you convince me?
(silence – lecturer waits)
L: If you think they all work can work can you convince someone else that they all work?

The Lecturer never says yes or no in answer to a student. For example at one point Two students, Nicole and Debbie, stop him and explain their position. The lecturer listens and then says:

L: That is assuming that -5 is the first number, right? What happens if you assume that -3 is the first number?

A discussion about position on the number line follows while the lecturer L moves to another group.

The above is identified as the first sub-event. It begins with the word problem on the OHP and continues until the punctuation when the lecturer brings the whole class's attention to the solution on the board. During this event students are expected to work out which if any of the solutions on the board are correct. They work independently and in groups with the lecturer actively interacting with them but always insisting that they appeal to mathematical processes to check their arguments. The object of acquisition throughout is M (checking solutions to a given word problem).

In terms of the methodology Event 1.1 is coded as follows:
Primary object to be acquired: M (solving a word problem)
Secondary object/s (assumed/ implicit): m (there is no focus on learners/ what learners might think/ the only background knowledge required is assumed mathematical knowledge)
means: individual independent work/ group discussions/ lecturer questioning
Pedagogic judgements
E – yes (the word problem is put on the board; three solutions are put on the board)
R – yes (all legitimating appeals are made to mathematics)
N – no (meaning is not fixed, the situation is still open – necessity is not reached)

The lecture then moves on, and a new (sub) evaluative event is introduced

<u>Evaluative event 1.2 (duration just over 4 minutes; 00:12:21 – 17:12)</u>
Precious has written her solution on the board as shown in Plate 2.

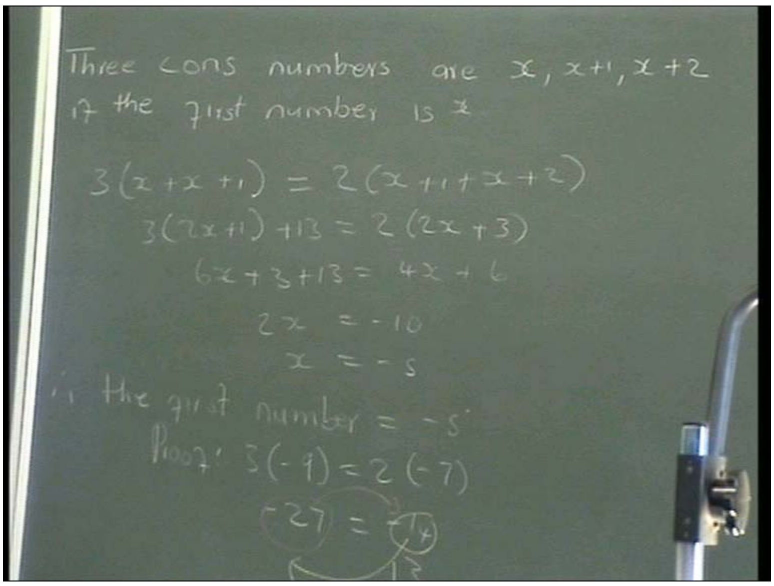

Plate 2: Precious' solution

The focus now moves to *unpacking* her solution. The lecturer suggests,

L: Ok. I've asked Precious to write hers on the board.
(Precious moves to sit down.)
L: Precious please stay because I want you to talk to us.
L. I've asked Precious to write hers on the board. Ignore the bottom bits. Lets just focus on the bit until x equals negative five. Because algebraically that all looks correct. But some of you are saying that that doesn't work. Ok. So in fact. Sorry. Precious, have a seat. Let's all just have a look at it. Check that it is algebraically correct. That the manipulation is right. Ignore the bottom bit. Alright – we will talk about that just now. So where it says therefore the first number is negative 5, and then the proof stuff. Ignore that for now. Check whether algebraically we get the right answer and then check whether the meaning of what she has written links to the meaning of the problem that was set to start with.
(silence)
L: am I making myself clear? In other words has she captured the meaning of the words in the algebra – is it the same thing? And then we will get her to explain what she has done. Try to make sense of it on your own first.

The solution is therefore divided into two parts and this evaluative sub-event is focussed on the first part. The focus is on evaluating the algebraic correctness of the first part of the solution.

The lecturer leads a whole class discussion. He begins by focusing attention on the algebraic correctness of the first two lines of Precious' argument.

L: is the algebra correct?
(Silence - lecturer waits)
L: Solly is the algebra correct?
Solly: I'm very troubled. If I look at it, sometimes it makes sense and sometimes it doesn't. Maybe … (inaudible)
L: Say more? Sometimes it makes sense and sometimes it doesn't? Is the algebra correct? That's what I'm asking.
S7: If you look at the question there and then try to make sense of what she has said … it does make sense.
L: So. To multiply out, solve for x, is that mathematically correct? That's what I am asking?
(long pause - silence)
L: Ignore the actual words just look at the symbols written on the board. Is that mathematically correct?
S7: I think so.
L: When will you become convinced? Or what will it take to convince you?
(silence – lecturer waits)
L: Nelson?
Nelson: Ja, I think it doesn't make sense because…
L: No, no. That's not what I am asking. I am just asking if the algebra is correct.
Nelson: yes it is.
L: Agree? The algebra, the manipulation is correct? [Looks at whole class]
Nicole: But how do you go from the first line to the second line when you have added 13?
L: Ok. So is that what is confusing you Solly?
Solly: yes.
L: Ok – that's an important question. So lets go from line 2 down. Ignore the link from line 1 to line 2 for now because that might not be clear right now. From line 2 down – is that algebraically correct?
(Students all nod their heads in agreement)

This sub-event ends with the negation of the algebraic correctness of the move from line 1 to line 2. The correctness of the algebraic procedures in the rest of the first part of the solution is accepted.

Once again we see that the lecturer does not immediately take on the role of evaluating the solution himself but insists that the students consider it in terms of its mathematical structure – it is it examined for its algebraic correctness first, that is the technical features of the algebraic procedures used in the solution. The students are being taken through a process whereby they analyse the given solution mathematically – not simply whether it is right or wrong, but *unpacking* the structure of the argument itself. We recognise in this the idea of

MfT mentioned in the previous sections, that the lecturer indicated in the interview is the implicit focus in all his lectures.

This brings us to the end of this sub-event. At this point meaning is fixed about the correctness of the algebraic manipulation from line two down in the argument and the focus now moves to the connection between the algebraic expression and the word problem and the link between the first two lines in the argument.

In terms of the methodology event 1.2 is coded as follows:
Primary object to be acquired: M – examining the correctness of the algebraic structure of a mathematical argument (technical aspects of the given solution to the word problem)
Secondary object/s (assumed/implicit) – m (there is no focus on learners/ what learners might think/ the only background knowledge required is assumed mathematical knowledge)/
t (implicit object – as teachers we need to unpack the argument in a given solution to see the students thinking)
means – student presentation/ whole class discussion / lecturer questioning
Pedagogic judgements
E – yes (the student's solution is written up on the board)
R – yes (all legitimating appeals are made to the domain of mathematics)
N – no (meaning relative to the specific lines in the argument is fixed – but overall the situation is still open – necessity is not reached)

<u>Event 1.3 (duration 5 minutes; 00:17:12 - 00:22:07)</u>
In the previous sub-event (1.2) the link between the line 1 and line 2 was questioned. This sub-event begins with the lecturer asking the student to explain:

L: Ok so that part is correct. So Precious, what we are not clear on is how you … just explain to us what line 1 means in relation to the problem and how you went from line 1 to line 2.

The student tries to explain what she was doing. The lecturer listens as she explains and probes her thinking. He concludes:

L: so you are saying [pointing to first line] that's number one, the first number and second number add them together and multiply by 3.
Precious: yes
L: and then you said that's the second number and the third number [underling in yellow on the board – see Plate 3], right. Add them together and multiply by 2. And you are saying that those two are equal?

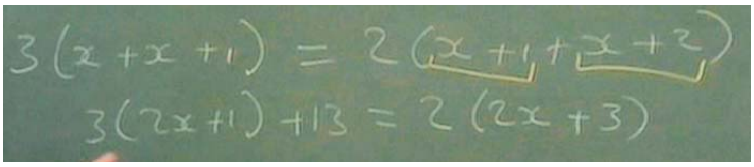

Plate 3: Lecturer focuses on the translation from word to symbols

Precious: yes
L: then you said …
Precious: that one exceeds that one by thirteen
L: this one [L points to 3(2x +1)] exceeds that one [L points to 2(2x+3)] by thirteen, so you put the 13 in here [L points to the 13].
L: Comments? Let's focus on the first line.

At no time does the lecturer indicate whether this is correct or incorrect. He works to assist the student to express what she intended and in this way reveals her thinking. He then opens this up to the whole class to discuss. What follows is an unpacking of the thinking involved in translating from the word problem to the algebraic equation used to solve the problem.

Nicole: Ok. They never said to us that those two are equal. But if she wants to make them equal that's fine. But then you can't in the second line add thirteen and still make them equal. If they were originally equal in the first line – which they are not - but if they were – then they can't still be equal in the second line, you can't add the thirteen in the second line and still say they are equal.

L: so the logic from the first line to the second line is not working? If they are equal, and you add 13 to one side and not the other then they can't still be equal. So there is a problem with the logic from here to here (pointing).

Debbie: It never states in the question that those two are equal. It states that three times the first two is thirteen more than the other two, so they can never be equal.

L: so the first line is not correct.

Lecturer looks at the rest of the class

L: Agree?

Nelson: It seems like an inequality if you read the question

L: an equality?

Nelson: an inequality.

L: OK.

Nelson: because, there is no way by which we can understand, you know, that we have to equate something, so I don't know how she thought about putting that equal sign in. I don't know how.

L: are you talking about the first line or the second line?

Nelson: in the first line

L: Alright. So maybe what we are saying is that this thing is a way of writing something up here. And it would be from there, three times the sum of the first two, right [L goes to the OHT and marks off in sentence: see Plate 4]. That is an expression for saying three times the sum of the first two. […] And then the right hand side is an expression for saying twice the sum of the second two. So that is this part to there [marking it off on the OHT]. With me?

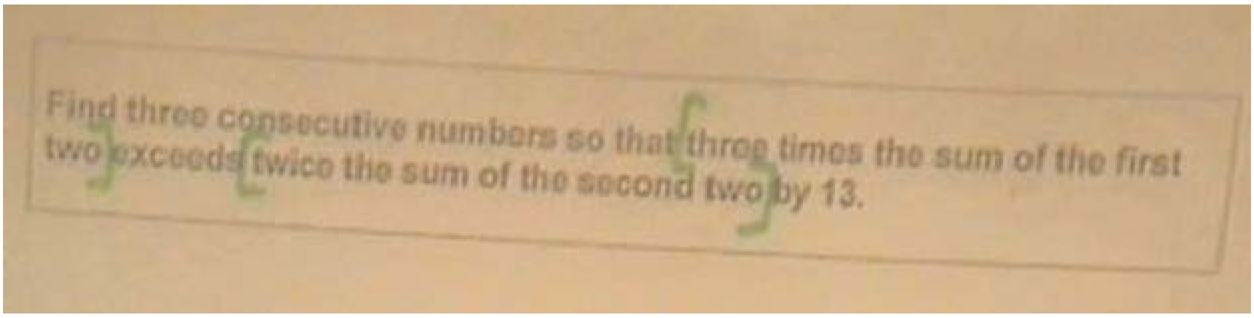

Plate 4: Lecturer brackets off two expressions

Students all nod

L: So they are just two expressions. They are not equal. [L rubs off the equal sign in the first line]. So that is one way of representing one phrase [points to 3(x + x +1)] and that's an algebraic way [points to 2(x + 1 + x + 2)] of representing another phrase. And now we are trying to set up the relationship between this one and this one [points to the first and then to the second]. So that's why you bring in the equals because it has got something to do with the thirteen [pointing to the second line]. Ok. I think what you [Precious] were meaning was right. But what you wrote mathematically in terms of the symbols was wrong. Ok so I'm taking out the equals and I'm assuming that you are trying to express two different ideas. Now is this thing [pointing to line 2] valid? So is that equation expressing the relationship that is in here? [L points to the problem statement on the OHP]

What we see here is how the lecturer uses the class discussion to come to the conclusion that the first line is not correct. This is done in such a way that the meaning of the line is revealed and it is corrected (by taking out the equality). Again all appeals for legitimation are to mathematics itself and negation of the equality in line 1 expressed in the original solution is achieved through the judgement based on the class discussion, not through the lecturer asserting his authority or superior knowledge. The move now is to focus on whether the second line expresses the relationship described in the word problem or not. What is being illustrated is a method of interrogating a solution to reveal the thinking behind it so that the meaning is revealed. Again this can be recognised as a form of MfT, however the focus is explicitly on the mathematical ideas and notions of teaching are completely implicit in the modelling.

In terms of the methodology event 1.3 is coded as follows:
Primary object to be acquired: M – the translation of a word problem into symbolic notation (expressions)
Secondary object/s (assumed/ implicit) – m (there is no focus on learners/ what learners might think/ the only background knowledge required is assumed mathematical knowledge)/
t (implicit object - how to evaluate a solution)
means – whole class discussion/ lecturer questioning/ student presentation
Pedagogic judgements
E – yes (the first line of the student's solution is written up on the board)
R – yes (all legitimating appeals are made to mathematics)
N – no (meaning relative to line 1 in the argument is fixed – but overall the situation is still open – necessity is not reached)

<u>Event 1.4 (Duration just over 8 minutes; 00:22:07 - 00:30:22)</u>
The focus now moves to the meaning of the second line, that is, setting up the equation to solve the problem. And the question being addressed is does this (line 2) adequately represent the relationship as expressed in the original problem statement. The lecturer waits while students think about it. One of the students (Nicole) immediately wants to answer. Lecturer indicates that he has seen her but wants others to participate. He draws out one of the students who hasn't said anything before and encourages him to express the relationship.

Nathi: [inaudible]
L Why?
Nathi: Because from the statement it said that three times the sum of the first two, which is the one there [points to board]. They also said that the sum of these first two exceed the sum of the second two when multiplied by two. So if we have to equate them, then the sum of the first two is equal to the sum of the second two multiplied by two and add thirteen. You are supposed to add the thirteen to the one on the left.
L: so you are saying that …
Nathi: it says the sum exceeds that one by thirteen, so it should make them equal if you add thirteen. [looks at the lecturer]
L: on which side of the equation?
Nathi: on the second side, on the left, I mean on the right hand side
L: this right? [L waves his right hand]
Nathi: yes.
L: so you are saying it shouldn't be plus thirteen there?
Nathi: Yes. I mean like, two open brackets two x plus three then plus thirteen, because
L: so you are saying she added thirteen to the wrong place? What do you think Precious? How do you respond?
Precious. Hey. They are saying, um, that the first two numbers by 3 exceeds the other part …(in audible)
L: The left hand side is bigger than the right hand side by thirteen? Ok. Is that correct? Is that what the statement is saying? That the left hand side is thirteen bigger than the right hand side?
Some students: yes
L Correct?
L Alright, one two [pointing at other students who want to say something]
Nicole: Okay, I agree that the right hand side is thirteen more than the left hand side, but the left hand side as we have got it is 3 times x plus x plus 1, so they are saying that is already thirteen bigger than 2 x plus 1 plus x plus 2 . But now in the second line to that first side, 3 times x plus x plus 1, you have added another thirteen, so now you have made it twenty six bigger than the right hand side. They are already telling you that the one circle in purple chalk is thirteen bigger than the circle in yellow chalk. Now you've kept them on the same side of the equation, and to that one that is already thirteen bigger you've added another thirteen. You have made it twenty six bigger now.
Precious: (inaudible)
L: Does that make sense? Ok. So if Nathi is saying, add the thirteen to the right hand side, not the left hand side, is that going to solve the problem?
Precious: If?

L : He said add the thirteen to the right not the left.

Precious: Yes, that is where I cancelled

L: No, no, but we haven't got it on the left. He is saying don't [walks back to the board] put it on the left. So this should not be here, it should be over there [draws on the board] and this is not here. So they are not going to cancel because its not here. And that is not just a question for Precious, that is a question for everyone. Is that going to, Zeenath?

Zeenath: […] three times the sum of the first two, that is including the number 13, because it is thirteen greater than twice the sum of the second two, but then in her equation she says it is equal to, so you have to make the first term equal to the second term, but you know it is greater by thirteen so you have to subtract thirteen to make it equal to the smaller number. Because you want to make it equal to the smaller number. So we know if something is greater, to make it equal we subtract the number instead of adding.

L: Which is then different to what Nathi was saying.

Zeenath: because, ja

L: Its OK. Its not wrong, but its different.

Zeenath: Its just that it gives a different meaning to getting the thirteen on the right hand side, to getting the thirteen on the left hand side.

L: So you are saying, this should not be a plus thirteen it should be a minus thirteen. [L changes the +13 on the LHS to a -13 on the board]

Zeenath: yes, because you want

L: because you are saying because this thing [pointing to the LHS in the first line] is bigger than that [pointing to the RHS] by 13. So you are saying take thirteen off it and it will be the same size? [looking at Precious] that is what she is saying. How is that different from what Nathi was saying?

All students murmuring

L the *meaning* is different [emphasis in L voice]

(Pause)

L It comes out to be the same thing, but the meaning is different.

(Silence)

L : Do you see a difference in what you were saying? [looks at Nathi]

Nathi: ja

L Ok so say it again. Now listen for the difference between the subtract thirteen to what you were saying. Say it again.

Nathi: The one in the purple chalk, they are saying it is thirteen bigger than the one in the yellow chalk. So to make them equal, because that one is already bigger by thirteen , you see you must add thirteen on that one, on the yellow one. So that they are equal.

(L waits.)

L: so what is the difference between what he is saying and what she is saying.

(Silence)

Emmaneul: Both sides got 13. For example, if you say, add thirteen on the RHS, you can say both of them are now equal. That's because the first statement that we came up with was they cannot be equal because we were not told they were equal. But we came up with the fact that the LHS is bigger than the RHS by 13. So now if we add 13 to both sides then obviously they could be equal.

L: If we add 13 on both sides we have still got the same problem [L comes back to board]

Emmaneul: We already have 13

L: Ignore this . Nathi is saying don't add it here [pointing to LHS], add it there [pointing to the RHS]. He is saying take this out. [L rubs off the + 13 from LHS on board]. And he said because this is already bigger, right. So we want to add 13 [writes + 13 on the RHS] to make them equal to each other.

(Long pause. Silence.)

L: the other version was, take this away [rubbs off the +13 on the RHS]. We've got the 13 here. Precious said add it (to the LHS), but Zeenath is saying, uh, uh, subtract it [from the LHS] [L writes -13 on LHS and puts down chalk].

In this exchange we see how the relationship that was originally on the board is negated by referring back to the problem and using the students to construct two alternative expressions that are identified as correct. Again all the appeals for legitimating any text are to mathematical arguments[6].

[6] Note that we can see from the discussion that it is not necessarily the case that all the students have access to the realisation rule, however the recognition rule is being fixed: the legitimate text is one which is produced through appeals to the mathematical meaning embedded in the problem statement

In terms of the methodology event 1.4 is coded as follows:
Primary object to be acquired: M – the translation of the problem statement in a word problem into a symbolic equation (relationship between expressions)
Secondary object/s (assumed/implicit) – m (there is no focus on learners/ what learners might think/ the only background knowledge required is assumed mathematical knowledge); and t (implicit object - implicit t object how to evaluate a translation from word problem to equation)
means – whole class discussion; lecturer questions
Pedagogic judgements
E – yes (the second line of the student's solution is written up on the board)
R – yes (all legitimating appeals are made to mathematics)
N – no (meaning relative to line 2 in the argument is fixed – but overall the situation is still open – necessity is not reached)

PAUSE IN EVENT 1

EVALUATIVE EVENT 2 BEGINS

At this point there is another shift in the IP. Up to now the focus has been on the word problem and on solving it. In 1.1 students were checking solutions that had been put up. In 1.2 the focus was on the algebraic correctness of the first part of the solution. In 1.3 the focus moved to the meaning of the first line and the link between the first line and the second line of the argument. In 1.4 the focus became the meaning of the second line and whether this represented the problem accurately or not. All of these are sub-events of the Event 1 (an orientation to solving and evaluating solutions to word problems), and in all cases the legitimating appeals are made to mathematics itself. Students are required to base their evaluation of the solution to a problem on the mathematical correctness of procedures (is the algebra correct) and the sense it makes (with respect to representing the relationship the problem statement). The focus now moves from M as the major object of acquisition to T as the major object of acquisition, which signals the beginning of a new event,

<u>Event 2.1.1 (Duration: 1 minute; 00:30:22 – 00:31:26)</u>
This is very a very short sub-event, but it introduces a new object of acquisition, and it is the first time that a T object is explicitly signalled in the lecture. Before this there may have been some implicit understanding that the reason we are looking at the word problem in this way is because the students are learning to become teachers, but the focus has always been on the mathematics of the problem itself and the students own mathematical thinking about the problem. The shift here is to focus on listening for differences in the way students express their understanding, and the need to do this because we are teachers. This is a teaching object rather than a mathematical object.

L: It comes out to be the same thing, but the thinking behind it is take this one [points to the LHS] down to match it to that one [points to RHS].
(Pause and looks at students.)
L: OK, take the left hand side down by thirteen to make it equal to this. The other one was, take this one [points to RHS] up by thirteen to match it to this one [points to LHS]. The difference is subtle, but it is important. Obviously the equations at the end of the day, when we do all this stuff we are going to get the same answer. But the thinking behind it is different. **And as teachers we have got to be sensitive to hear those differences.** Ok, so that is something we have got to work on. Um. Do you see the difference now? [looking at class]. Either we are taking this one and dropping it by thirteen which is the same as saying subtract thirteen on the left, or we are taking the right hand side and increasing it by thirteen, to meet this one [pointing to the LHS].
(Pause)

L: Obviously the net effect is the same, but the thinking is not exactly the same.

This is simply signalled here (E). The grounds for legitimation are simply asserted (on the lecturers authority) – “**And as teachers we have *got to* be sensitive to hear those differences.** Ok, so that is something we have *got to* work on.”

While this signals the beginning of an event, it is punctuated by going back to the previous event, as one of the student’s interrupts and brings up another possibility.

In terms of the methodology event 2.1 is coded as follows:
Primary object to be acquired: T –teachers must listen to learners to hear meaning in their thinking and be sensitive to the differences in their thinking
Secondary object/s (assumed/ implicit) – m and t
means – lecturer exposition
Pedagogic judgements
E – yes (lecturer asserts that teachers have got)
R – begins (only appeal is to lecturers assertion of this (teachers have got to) – on the lecturers authority)
N – no

EVALUATIVE EVENT 1 CONTINUES

<u>Event 1.5 (Duration about 2 minutes; 00:31:36 – 33:31)</u>
Here we return to the translation of the problem from words to symbols. Another version is added.

Nicole: Another way you can think about it is as a subtraction sum. They are saying that the 3 times 2 x plus 1 exceeds the two, twice two x plus 3, obviously the three times 2 x + 1 is the bigger one, so you take your bigger one minus the smaller one [L listening and writing up on the board: see Plate 5] and the difference between them is 13. And then you can see that if you take your second number over to the right hand side you will get 2 times two x plus 3 plus 13.

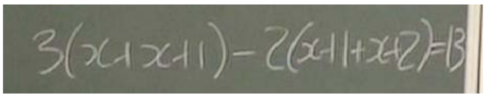

Plate 5: equation describing the word problem in terms of a subtraction

L: [looking at class] Follow? So we can interpret this as saying, take the smaller one from the larger one, the gap is 13. So there are at least 3 ways that we can write this thing. [points to new equation written on the board]

L: Ok. That is subtraction to get 13. This one is balancing, so we are dropping the bigger one by 13 to make it equal to the smaller one [writing second equation on the board: see Plate 6]. The other way is what Nathi was saying, [writing third on the board] add 13. So in other words we increase the smaller one so that it is the same size as the bigger one.

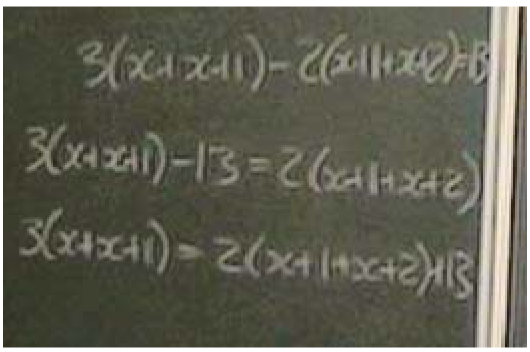

Plate 6: three different equations for solving the problem

L: at the end of the day when we solve this we are going to get the same answer. In fact the next step of all three equations could be identical. But the meaning behind these three is slightly different. Ok. Is the answer going to come out to be negative five?

(Students shake their heads)

L: It comes out to be?

Students: eight

L: Eight. Ok. So the final answer we get is eight, which means the next one is nine and the third one is ten. Alright.

The event 1.1 appears to ends here, having moved through from 1.1 to 1.5. At this point the problem is solved[7] and the meaning is fixed. Implicit in the pedagogic practice that is illustrated by the event is an understanding that the mathematics of doing such word problems: is a process that involves translation from words to symbols that depends on carrying mathematical meaning; that there are different (equally correct) ways in which the meaning can be expressed; that all correct ways of expressing this meaning will result in the same correct solution; that the grounds for making decisions and legitimating a text (in this case a particular expression) as correct is to be found in the mathematical meaning itself. Note this event supports the conclusion that framing with respect to selection, sequencing and pace is relatively weak – the student was able to interrupt Event 2 and take the situation back to the previous event, inserting new content and resulting in a stronger message being transmitted.

In terms of the methodology event 1.5 is coded as follows:
Primary object to be acquired: M – there are a number of different correct ways of expressing an equation for solving a problem
Secondary object/s (assumed/ implicit) – m and t (implicit message about mathematics teaching: we are doing this because you will become teachers, this is an example of teaching that is being put up here, we are unpacking an M problem and its solution which is an essential skill for the work of mathematics teaching; also listen for differences in how solutions are expressed)
means – whole class discussion; lecturer exposition (summary and closing of event)
Pedagogic judgements
E – yes (previous two expressions)
R – yes (culmination of event 1.1 – all appeals made to mathematics)
N – yes (the problem is solved and it illustrates the idea, necessity is reached in the context of this problem)

EVALUATIVE EVENT 2 CONTINUES

Event 2.2 (Duration 1 minute; 00:33:31 – 34:22)
The focus now moves back to Event 2 which had been announced shortly before the final sub-event 1.5. Again the mT object comes into focus. You need to *hear and see the difference* between different mathematical forms and you must *anticipate* them in your planning.

L: I hope you have got those three different versions. And that you can explain in words how they differ. Because it is quite typical that you could walk around the class and see all three of these in learners books. And it's important that you are able to hear the distinction between them. So in setting up that

[7] Note that the process does not include the normal checking of a solution against the original problem which would be typical of this kind of problem, and would generally be expected. However within this context the meaning is contingently fixed.

problem, three of the things I anticipated was that I would get one of these three different versions (points to the 3). And that is one of the things we need to anticipate. What are the different ways they could set up an equation in order to answer this thing. Okay. And this one is particularly difficult because the language is so mushed around (gesturing with hands). And there are so many different clauses inside there. Okay. So this one is not correct [pointing at one of the solutions written up at the beginning of the lesson]. Based on one little error, Okay.

Again we see here that this is simply announces (E). The only reflection is limited to what they have observed in the lesson so far – that is the Lecturer is setting himself up as the model that the students are to reflect back on in order to ground the meaning of the text to be acquired. No discursive resource is brought to bear on the notion except an appeal to their experience of learning that has taken place so far. The only grounds for the legitimate text is to an appeal to the lecturer's performance as model of what is to be expected, and take it on the lecturers authority that this is the correct course of action[8].
There is no signal to let us know if this event will be continued later or not.

In terms of the methodology Event 2.2 is coded as follows:
Primary object to be acquired: T –teachers must hear and notice the difference between different mathematical representations and must anticipate them in planning
Secondary object/s (assumed/ implicit) – m and t
means – lecturer exposition
Pedagogic judgements
E – yes (lecturer asserts that teachers have got to …)
R – begins (only appeal is to the model the Lecturers has provided through his teaching and his assertion of this – i.e, on experience and the lecturers authority)
N – no

EVALUATIVE EVENT 3 BEGINS

Event 3.1 (duration approximately 4 minutes; 00:34:22 – 00:38:18)

The lecturer now goes back to Precious' solution written on the board and announces a different focus. He marks off the bottom part of the solution that he had bracketed off earlier on in the lecture (see Plate 7). He draws the students' attention to this.

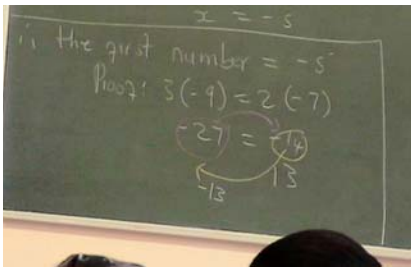

Plate 7: checking the solution of a word problem

L: Alright, Precious, lets explain what you were thinking here. And then I want people to go off and think about this. I don't want to spend any more time on this in class. So the context was, you were trying to check if this one works, alright. So tell us what you were doing there.

Precious: I worked out that the difference between the two is 13. … (explanation not clearly audible)
L: [to rest of class] Did you follow that explanation? It was so fast. The negative nine came from?
Precious: from the first two, from 5 and 4

[8] We note that throughout the IP this appears to be the case whenever the focus moves to the T object – whereas when it is on M the criteria are clear, even if they are arrived at through a fairly 'invisible' pedagogy.

L: Ok, you needed to say that in the beginning, hey. Slow down and give a bit more detail. And the negative 7 came from?

Precious: from the negative 3 and 4.

L: Ok

Precious: So when I multiplied the left hand side by 3 [i.e. 3 times (-9)] I got -27, and when I doubled the right hand side I got -14 and I worked out the difference between the two as 13… (becomes inaudible)

L: So, [asks the class] in terms of, if a learner is trying to use that to check, can you see how they could argue that this one is correct? You want the difference to be 13, so what do you do? You take this one to the right and find the difference is 13. I don't know what is on the left now? Probably zero. So if we continue this story, we are going to end up with zero equals 13. And the learner could say, oh well there is the 13 I am looking for so there is the answer. But mathematically there are a few funny things going on here. I'm not going to spend time on this now. I want you to go away and think about it. If a learner gave this as a justification [Lecturer uses hands to indicate quote marks in the air], if they gave that as a justification, how would you respond to it? Or maybe [think of it] as a [learner] confusion, like, I'm not really sure what is going on because if I take the 13, or if I move the 27, or if I move the one way, I'm going to get positive 13 and if I move the other way I'm going to get the negative. So how would you respond to this as a way of trying to check if this is correct.

Nicole attempts to engage lecturer in discussion of the situation, but the lecturer remains firm ending the event with

L: Ok now you are giving us your answer, thank you (cuts her off). Ok that's one more thing to think about. In relation to the original thing, there is some connections, but there is some understanding we must get a 13 somehow. So that is quite a feasible thing that you could see in the classroom, how would you deal with it? OK. And in order to deal with it, you need to think about the mathematics that is going one. Its not just a case of, oh well I would encourage them to think! That won't get you very far.[9]

The lecturer tells the students they must do this and write about it for submission. This will form part of the class work that is formally assessed – a large amount of work is formally assessed and marked by the lecturer in this module. They must bring it to the next class on Thursday where they will pick up on this question again.

In this sub-event, a new object of acquisition was announced (E): how do we respond to a particular learner justification/ confusion in checking a mathematical solution for a word problem. The lecturer clearly indicates that the grounding for thinking about and producing the response must be based on mathematical argument, and not on some vague teaching ideal. The event is truncated. Some clues are given (R) and evaluative principles are announced (must be based in M), but the full movement to fixing meaning is left for another time. The lecturer now shifts attention from doing the word problem and examining solution to the language of word problems.

In terms of the methodology event 3.1 is coded as follows:
object to be acquired: T – how to respond to learners inappropriate checking mechanisms
object/s assumed – m (know how to check and what appropriate mathematical checking mechanisms are) ; t (assumed t knowledge)
means – student presentation; lecturer questions
judgements
E – yes (pointing out the written solution check on the board)
R – yes (some discussion is provided as to the thinking involved – appeal to maths)
N – no (still to be continued after further reflection, discussion and negation)

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[9] Here the lecturer asserts authority taking control of the selection, sequencing and pace once more – the event is incomplete. Students must go away and think about it. They must write out their thoughts and hand it in. This will be returned to later once they have done this work. The event will continue in the next lecture

EVALUATIVE EVENT 4 BEGINS

The object of acquisition changes from the mathematics of doing word problems and analysing and evaluating a solution to language issues in teaching word problems. That is from being predominantly focused on M towards T. The beginning of the event is marked by the lecturer putting up the same word problem that was dealt with in Event 1, but rewritten by one of the students, Jayna, to make it more accessible to grade 9 learners (see Plate 8). This is a version that was produced during the previous lecture.

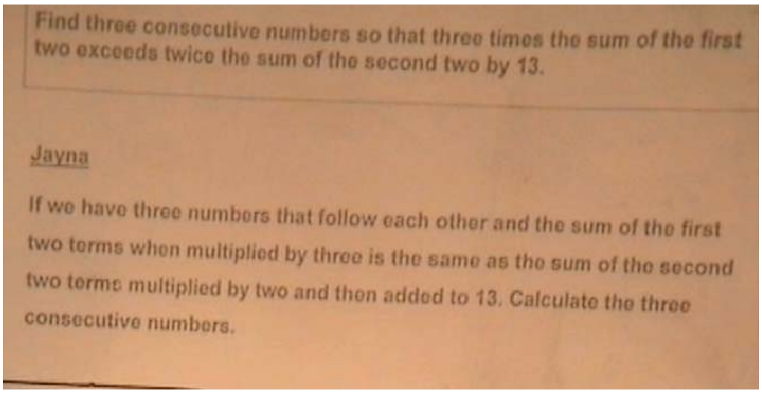


Plate 8: Jayna's rewording of the problem

The object of acquisition moves from the mathematics itself to the language used to frame word problems, which can be identified as an object of teaching T. Its existence is announced by putting up the reworded problem. The legitimate text for language use in constructing word problems becomes the focus of evaluation. We now see how the event unfolds in the pedagogic context and note with interest how, with the object changing from a substantially mathematical object to an object of teaching, the legitimating appeal for grounding the meaning of the pedagogic text become more diffuse. We will also see that it is also a feature of this particular pedagogic practice that MT and ME are practical accomplishments rather than being grounded in a discursive field (i.e. when it comes to focussing on T, the imaginary becomes dominant, whereas when M was the focus, the symbolic was paramount).

<u>Event 4.1 (duration xx minutes; 00:38:18 - ……)</u>

We presume that in the previous lecture this event was started[10] although we have no access to that part of the event and so label it here beginning with 4.1. The event begins with a reminder

L Ok. On Thursday we talked about rewriting this in a way that would make it easier. More accessible to learners. So the original is in the box here. And then we have the version from Pius and one from Jayna. I want to look at one at a time. So lets look at Jayna's one. Ok, that is Jayna's attempt to rework it in a way that is more easily understandable.

(L projects Jayna's problem on the OHP (see Plate 8))

S? I've got another one.

L Ok. Lets focus on these two for now because I want to move onto something else. So maybe you can insert some of your new stuff in there as we discuss is. Right, those of you who were here on Thursday which is not many of you, were supposed to have looked at this and done it for today. Some of you are probably seeing this for the first time. Ok that's your fault. You should have caught up your work. Ok so those people who were here on Thursday, comments? Debbie?

Debbie: Ok. She starts off by saying we have three numbers that follow each other, and then at the end she says calculate the three consecutive numbers. She doesn't make the connection between three numbers that follow each other and consecutive numbers.

L: Is that bad?

[10] We speculate that this was set up in a previous lecture, in much the same way as the evaluation of Precious' incorrect procedure has been set up in this lecture as homework for the next lecture.

Debbie: Well I, if you look at it. If you don't know what consecutive numbers are, to start off by saying three numbers that follow each other and then consecutive numbers, I think you can cause confusion. Maybe instead of saying consecutive numbers, say calculate the three numbers. Because you originally said the three numbers that follow each other.

L: This is a grade 9 problem. It comes out of a grade 9 text book. Is it feasible to expect grade 9s to understand consecutive?

(Students' mumbling (inaudible))

L In your class? Say this is your grade 9 class. Is it feasible to expect them to know what that word means? And let's assume that none of them speaks English as a first language. Can you expect them to know?

The event continues with a wide ranging discussion. Emmanuel says he doesn't think you can expect them to know and he refers to himself and says that earlier in the year he got something wrong because he did not understand that word (consecutive), and in this he appeals to his personal experience. Nicole suggests is not a commonly used work so you "can't just expect them to know it" so she would have to make sure "I teach it to them" because it is an important mathematical word to know. Musi suggests he would expect them to know this, because if a grade 4 can do it then a grade 8 should be able to and he appeals to the curriculum to suggest that this word is introduced as early as grade 8. Someone else suggests that when they gave the grade 8s a test there was a question about consecutive numbers and all of them just couldn't do it.

This discussion about the word consecutive continues and the lecturer ends it saying:

L: so you are saying that they should be able to understand it, but the reality in your experience is that they don't.

Another student interjects suggesting that the real problem is not understanding the word consecutive but it comes when they have to translate it into symbolic form. There is general agreement and stories are told from practice teaching, with Nicole relating

Nicole: when I was teaching word problems to grade 11 they had problems seeing that x and x+1 are consecutive. They want to write x, y and z. because they see that x can mean anything…

L ok so when we write x, x+1 and x + 2 … this x can mean anything here, and this x can mean anything and it can be different to the first x …

(Others agree)

L Ok there are two issues here – one understanding what the word means and the other understanding how to represent it in an algebraic form.

What we see here is a far more diffuse situation. The original statement that Jayna had produced has resulted in a discussion that has now moved away from the language of the statement to general problems learners have. The appeals made are to personal experience of learning, the curriculum, experience of teaching, general feelings about what grade 9s should know, but there is no grounding in any discursive field – this had been dominant in the previous the 40 minutes, that is appeals to the symbolic domain of mathematics.

After a little why this discussion is concluded by saying:

L: Consecutive is a word we want them to know. But they won't get the meaning unless we teach it to them. So either before they see the problem they must know the meaning, or we use the problem itself to help them understand what consecutive means. And that's a separate issue from learning to represent it.

We note that this is not referred back to the wording of the problem on the OHT – there is no reference back to either negate or approve the use of the word consecutive in the wording of the problem. The legitimate text in this case is obscure – is it Ok to have three numbers that follow each other … and then end with consecutive numbers? This is not addressed in the event.

In terms of the methodology event 4.1 is coded as follows:
Primary object to be acquired: T – how can word problems be made more accessible to learners through use of appropriate language
Secondary object/s (assumed/implicit) – t (as a maths teacher you need to know and understand how to use the English language for constructing word problems) and m (know how to express mathematical relationships in words)
means – whole class discussion; lecturer questions; student presentation
pedagogic judgements
E – yes (reworded problem written on the board).
R – yes (appeals are made to a wide range of things including personal learning experiences, teaching experiences, curriculum and local knowledge of learners, i.e., in summary to experience and the school curriculum)
N – no (no reflection back and negation and replacement of the original reworded problem)

<u>Event 4.2 (duration ….)</u>

The focus is still on Jayna's problem. However there is a change in what is being evaluated within the problem statement. A student points out that the wording in the problem moves from talking about three numbers and then moves into using terms and this doesn't seem to be right.
The lecturer emphasises this
L: the language is important. So you used numbers there, then terms and terms and then back to numbers […] that could be a source of confusion.

They continue looking at the wording. It is suggested that the use of '*and then'* is a problem. The lecturer leads a bit of a discussion around the wording of the problem looking at the sentence structure and the use of if and then, making marks on the OHT as he goes along (see Plate 9).

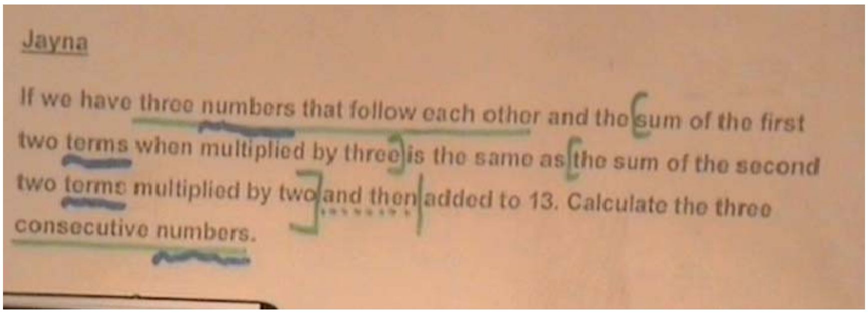


Plate 9: deconstructing the wording in Jayna's problem

The lecturer asks Jayna to comment.
L: This is a particularly difficult problem that's why I gave it. And sometimes when we thing we are making it easier we are changing the meaning, or there is an ambiguity that is brought in.
L: do you want to comment on it? (addressing Jayna)
Jayna: the reason I put the then in is because I wanted to make it clear that the 13 was then added.
L: So you were tying to get the language clear?
Jayna: Yes
L : but now for Nicole it has added another meaning. Not everyone will interpret it that way, but it is possible. Other comments?
(Silence)
L: Ok there is a linguistic thing here as well. You have got an if. Followed by stuff and a full stop. There is no then part. In terms of your sentence construction. So if, here is a scenario, what? If to full stop is not a sentence. You need a comma, calculate. Linguistically there is a problem. Its not actually a sentence. One of the things that is difficult if you are working in an additional language is this if then stuff. So its better, easier for people to understand if we rather take out the if then stuff and make them into separate sentences.

The event ends with the Lecturer suggesting they drop the 'if' from the formulation. They don't need the 'if'. He then suggests they move on to another reworking (second example) of the word problem.

Again we see in here, while the lecturer attempts to appeal to their knowledge of grammar, the students are left with a suggestion. In the end they leave Jayna's reformulation without having made a clear judgement on what is problematic with it and what would be a better formulation.

We also note that while the Lecturer has chosen the example of Jayna's problem to consider, the focus of the discussion (selection of focus and sequencing) is determined by two students' comments on the wording. While in all cases the framing has been relatively weak with students being able to provide ideas and to some extent control the direction of the lesson, in this case it is far weaker than when the mathematics was the focus – the criteria here are also very weakly defined and the resource that the lecturer wants the students to appeal to (knowledge of English grammar and sentence construction) which they do not use in a confident manner.

In terms of the methodology event 4.2 is coded as follows:
Primary object to be acquired: T – how poor the structuring of a question in the English language (grammar) can lead to confusion
Secondary object/s (assumed/ implicit) – t: as a teacher you must know the rules of grammar in the English language and be able to structure word problems unambiguously
means – whole class discussion; lecturer questions; student presentation
Pedagogic judgements
E – yes (points out structure of word problem).
R – limited (appeals are made to the structure of English grammar)
N – no (no reflection back and negation and replacement of the original reworded problem)

<u>Event 4.3: duration (…… - 00:59:15)</u>
The focus is still on the use of language to structure word problems. A different version, produced by Pius is projected from the OHP.
L: Lets move onto Pius' one
(L Puts it up on the OHP (see Plate 10))

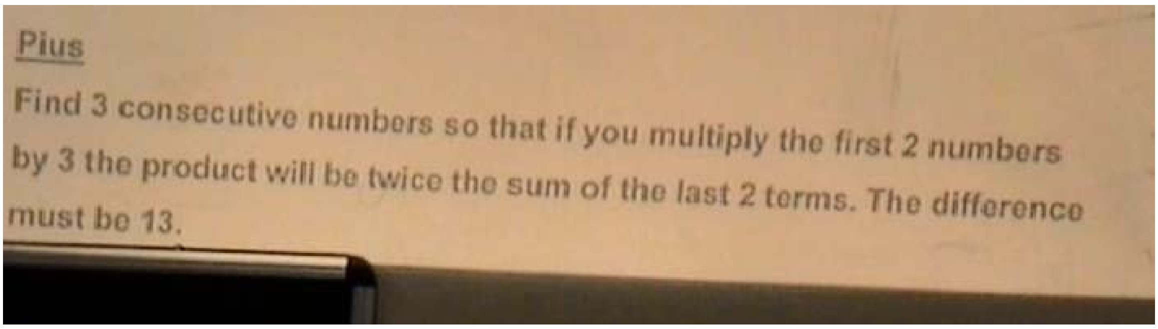


Plate 10: Pius' problem

Here the lecturer does not ask the class what they think first, rather he immediately focuses their attention on the use of the digits 3 and 2 in the formulation of the problem and attempts to tell them about conventions for using digits and words for numbers in writing of problems. However mixed messages are transmitted: He suggests "write out word for numbers less than ten and use digits for numbers greater than ten" But then tells the class: "I'm not sure it's a bad thing in maths problems to use digits in this way". Next he explains how sometimes we use numbers to indicate quantity and sometimes value and that this might be how you decide when to use number words and when you use digits. He then looks back at the original question and shows the class how “three” and “two” were used to describe the quantity of numbers as in “three consecutive numbers”, where as ‘13’ was used to indicate the particular value of a number.

After this the lecturer moves back to discussion mode

L: Ok so this version had lots of digits in it. Does it change the meaning? Does it work?

(L asks Pius to comment on it himself first.)

Pius: With the way that I have written it I just wanted learners to write it in the same stretch. You’ve got the number you subtract this and the answer is ..

L: so you wanted to lead them into this version. To make it easier for them to construct this version, OK.

(L waits. Hands go up … L gives order of those who can speak)

Two students say there is a problem because it looks like an equation is set up and then suddenly there is a difference. The tape ends and the end of this is exchange is missed. The students go out for a break.
When the students return from the break, the lesson resumes with a move to the next event.

In terms of the methodology event 4.3 is coded as follows:
Primary object to be acquired: T – conventions for the use of numerals and words for referring to quantities of things or value of a number in word problems
Secondary object/s (assumed/ implicit) – m (know how to recognise the difference between ordinal and quantitative use of number); t
means – lecturer exposition/ learner presentation/ lecturer questions/ whole class discussion
Pedagogic judgements
E – yes (reworded problem written on the board.)
R – yes (begins; appeal to lecture’s experience)
N – no (no reflection back and negation and replacement of the original reworded problem)

EVALUATIVE EVENT 5 BEGINS

<u>Event 5.1: duration approximately 30 minutes (00:59:15 – 01:30:30)</u>
This is announced by the lecturer and focuses on working with word problems arithmetically – that is without recruiting algebra.

L: I want to shift now to do some other ones. I want you to do this in your head [see Plate 1] On your own. Not talking. What’s the answer?

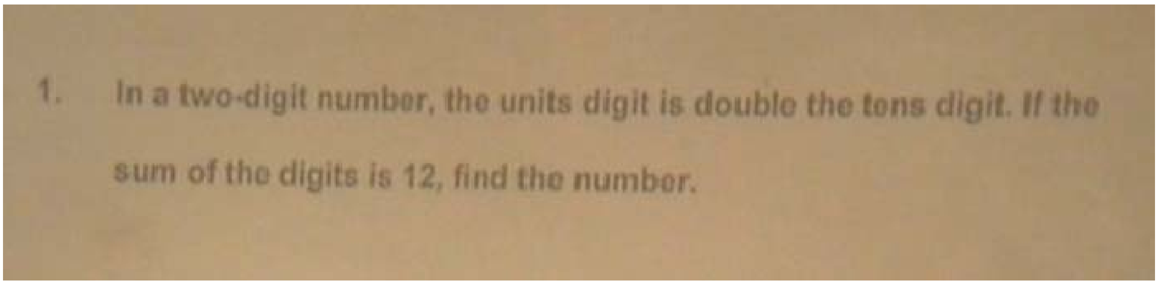

1. In a two-digit number, the units digit is double the tens digit. If the sum of the digits is 12, find the number.

Plate 11: Problem to be solved arithmetically

(L waits)

L got an answer? No writing in your head.

S 48

L 48

S 84
L 84
S 48
L 48 pointing to others and repeating
S 48
L: Ok that's two options so far. Did anyone else have 84.
S: Yes but I was wrong.
L: Why
S: Because the unit is double …
L: agree.
L Ok this one. (Lecturer changes the question on the OHP; See Plate 12) No pen no paper

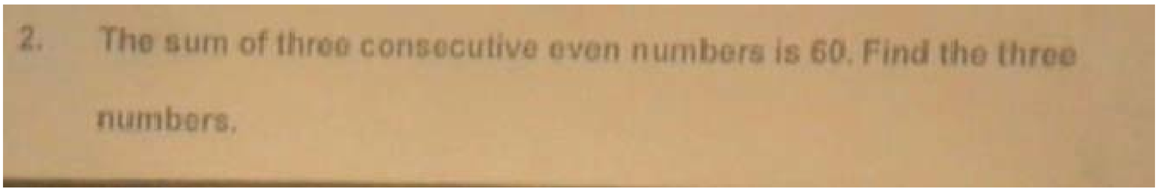


Plate 12: Problem to be solved using mental arithmetic (without pen and paper)

L: you see the primary school teachers are much faster than the high school teachers.
(All laugh)
Silence
L: Nelson?
Nelson: No.
L: Ok if you have got an answer that's fine, I want you to write it down. You may not use equations. You may NOT use equations and I want you to write down the answer. I want explanations. I want no equations. No x's, no y's, no z's!
Nicole: can we just write down the numbers?
L: Ok. And then how do you know they are right.
Nicole: I can explain that, its just a lot of writing to do.
L: oh shame.
(Ss work on own; L walks around checking what is being done.)

L: Ok one of the things we do when we come to this consecutive stuff is that we straight away go for x plus whatever or whatever the case may be and we do it. And a grade 8 comes along and says I know the answer, its ding, ding, ding. Can you explain it without any Xs?
(Ss continue working)
L: Sometimes because its actually easier just to guess it rather than to write a whole lot of equations. Or maybe because they can't write the equations. They are struggling to do that.
(Ss continue working)
L: Alright. I want to leave that one. I want you to work on that one for Thursday as well. So I want you to stop on that one, and I want you to look at this one.

The lecturer is presenting problems to the students, challenging them to solve them without relying on the algebraic methods which have become a habit. He continues presenting further problems.

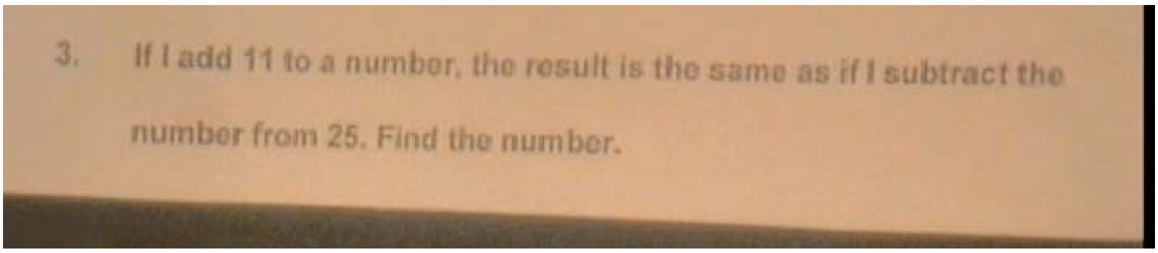


Plate 13: A further problem to be solved arithmetically

(L asks students to read problem. Waits until they all seem to have read it. Then L reads the question aloud.)
Ss: Can we write for this one?

L: you can write for this one, but I don't want you to use equations. You can work with the person next to you. But there are no equations. So there is no let x equal to stuff. Try to solve this one without the convention of writing an equation.

(Students start working. Lecturer walks around observing them.)

L: Oh you've got x's. It's like the x disease!

(L walks around interacting with students. Students continue working.)

L: You've all got infected hey. The problem with word problems is that teachers teach them.

Ss: We can't think of this without x.

L: Go and do this with grade eights!

(Students continue working.)

L: You've still got an equation, you just didn't use x's. Some of us have got boxes instead of x's.

(All laugh)

L: What's the answer, have you got an answer?

Elsie: yes

L: Cheat!

(L goes to look.)

L: No not a cheat!

L Ok. Write it on the board

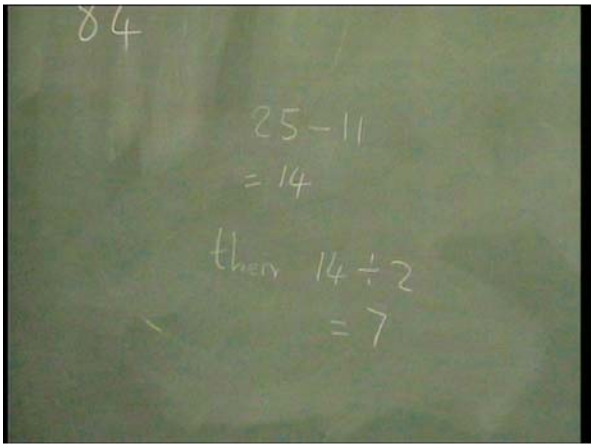


Plate 14: Elsie's Solution for problem 3

L: Ok let's try and make sense of what Elsie has written and then we will ask her to explain.

(Waits)

L: Do you agree with the answer? Does 7 work? Yes. Ok. So why does that method work? Can anyone explain? Ok what did you do? Why did you do what you did?

Elsie: I started off with the equations. I had the equations

(All laugh)

L: So you used an equation? Ok (big sigh) carry on

Elsie: Because I know that the twenty five will be on the other side… … (difficult to hear but talking about sides and moving from one to the other)

L: Ok you are infected! This other one, the other one. In English we don't say that, we talk about the one side and the other side. Ok? (correcting language use) So you were working with equations in your head, you just didn't write it down that way. You disappointed me.

L: If we try not to think in equation mode, is there a way of explaining why this works?

(Silence)

L: You need to go and observe again. Grade 8s.

(Silence)

L Ok (moving to the OHP). There are two problems here. No 4 and no 5. What I want you to do is to get into groups of 3, so there, I think lets just do it as you are sitting. So three here, three there, three here, three there (pointing out 4 groups). Ok?

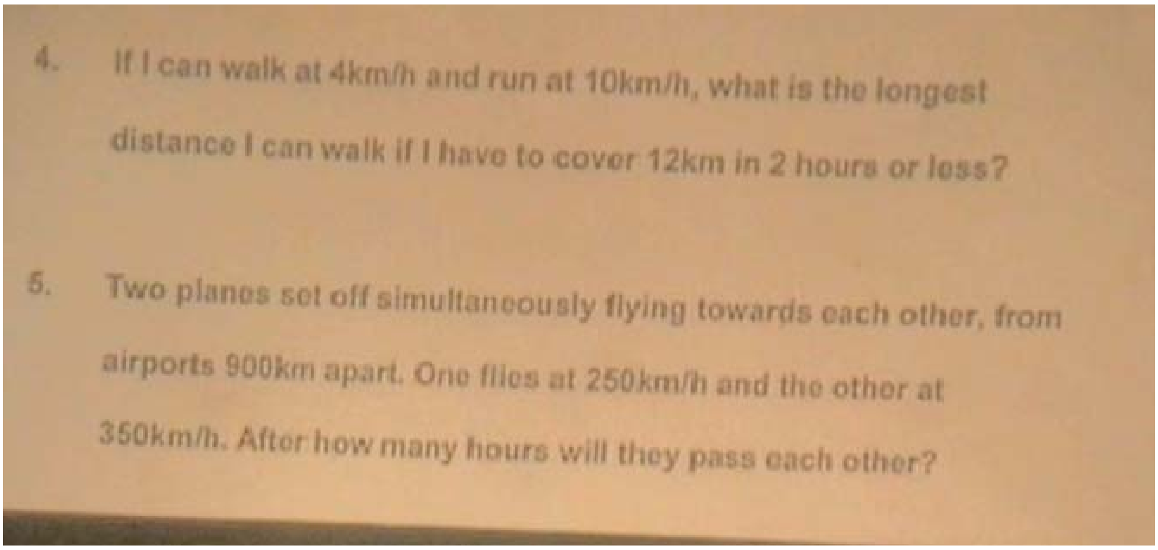


Plate 15: problems to solve arithmetically in groups

L allocates each group one problem (either no 4 or no 5).

L: Can you do it without using equations? I'll give you copies. Let me just tell you in terms of what is coming after this. Um I think you do need to copy down your individual, your particular problem. Ok. All of this stuff is on a sheet but I wasn't sure how this was going to go. So when we are finished here I'm going to go back to my office and type up this stuff that we have been doing and you can come and collect it at my office by lunch time. Alright. Did you hear that?
So just copy down your own one and you can collect the stuff outside my office before lunch. I'll just make a list of all the things I've told you to do so far. And those of you who don't have the handout from last week, I'll put them outside my office and you can sneak them into your possession and no questions will be asked.

(SS copy down their problem).

L: Sit in your groups and discuss. Can you solve the problem? And can you do it without using an equation?

(Ss start working. Lecturer walks around from group to group. Listening to students and checking their explanations, asking questions, pushing them to think of alternatives.)

This is the final sub-event of the lecture. The lecturer presents students with five word problems which they work on during the last half hour of the lecture. The instruction is clear – do not use algebraic methods to solve these problems. Find the solutions arithmetically. The lecturer keeps insisting – and negates the methods used for all solutions. He insists that the students must work through and 'unpack' the problems without relying on habitual algebraic methods. He will not assist them. The lecturer appears to be setting up things for the next lecture.

In terms of the methodology event 5.1 is coded as follows:
Primary object to be acquired: M – solving a word problem arithmetically without recruiting any algebra
Secondary object/s (assumed/ implicit) – m; implicit t object (senior phase teachers must be able to unpack a simple word problem and solve it without resorting to algebraic methods)
means – individual work; group work/ discussion; student presentation; lecturer questions
pedagogic judgements
E – yes (announced and problems put up on board.)
R – yes (begins – all focused on M)
N – no (no possibilities for method considered – some negation of attempts to use algebraic methods)

The event will continue in the next period.

Table 5: Table summarising moments of pedagogic judgement in evaluative events in a Curriculum Studies lecture at CU (Coding of transcript from Video recorded 28/09/04)

MOVEMENT THROUGH EVALUATIVE EVENTS (IN ORDER OF OCCURRENCE IN PI)		KNOWLEDGE OBJECT(S)																			FORM OF PEDAGOGIC INTERACTION							
		MATHEMATICS									TEACHING																	
					Legitimating appeal									Legitimating appeal														
Event	Major object	*M* (c/pf/pr)	E	R	Maths	M.Ed	Ev.day	Auth.	N	*m*	*T*	E	R	Maths	M.Ed	Exp.	Curr.	Auth.	N	*t*	whole class discussion	small group discussion	individual work	Lecturer exposition	L question& answer	student presentations	lecturer questioning	student questioning
1.1	correctness of specific solutions wp	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0
1.2	algebraic correctness of the argument leading to a solution	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0
1.3	translation from words to expressions	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0
1.4	formulating an equation	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0
2.1	listen to Learners - be sensitive to differences in meaning	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0
1.5	producing different correct representations and a final solution	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
1	Orientation to solving and evaluating M word problems	1	1	1	5	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	4	1	1	1	0	2	4	0
2.2	must anticipate different math representations in planning	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0
2	in planning M lesson, anticipate learner thinking and different representations	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	2	0	1	0	0	0	2	0	0	0	0

3.1	how to respond to incorrect checking of a solution for wp	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0
3	how to respond to incorrect checking of a solution for wp	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0
4.1	evaluating wording in formulation of wp	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	0	1	1	0	0	0	0	1	1	0
4.2	language structure in formulating word problems[11]	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0
4.3	conventions for number words and numerals in problems	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	1	0	1	1	0	0	1	0	1	1	0
4	evaluating language in wp	0	0	0	0	0	0	0	0	1	1	1	1	0	0	2	1	1	0	1	3	0	0	1	0	3	3	0
5.1	solving wp arithmetically	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	1	0
5	solving wp arithmetically	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	1	0

[11] An additional appeal is made here – that is to the use of English grammar (linguistic knowledge) to structure a word problem meaningfully, in particular the use of conditional statements (e.g. "if … then").

Appendix E. 3: Analysis of formal assessment items from CU

Table 6: Categorisation of formal assessments across modules; where each row summarises the categorisation for each type of assessment. (Note: each question is counted as an event)

Module	Assessment type	No of events	M^+	M^-	T_k^+	T_e^+	T^-	$M^+t_k^+$	$M^+t_e^+$	M^+t^-	$M^-t_k^+$	$M^-t_e^+$	M^-t^-	$T_k^+m^+$	$T_e^+m^+$	T^-m^+	$T_k^+m^-$	$T_e^+m^-$	T^-m^-
Maths for T 101 (Functions and Algebra) Lecturer Mr/s X	Assignment 1	1	1																
	Tutorial 1	7	4	3															
	Tutorial 2 (Absolute Value)	9	5	4															
	Tutorial 3 (intersections of fns)	10	2	8															
	Final examination	9	1	6						2									
	All Types	**36**	**13**	**21**						**2**									
Maths for T 103 (Calculus) Lecturer: Mr/s X	Assignment (Exploring rational functions)	1	1																
	Assignment (ave gradient of curve)	1		1															
	Assignment (local linearity)	1	1																
	Assignment (Analysing functions)	5	2	3															
	June exam	10	5	4						1									
	All types	**18**	**9**	**8**						**1**									
Maths for T 104 (Linear Algebra) Lecturer Mr/s Z	Tutorial 1	8	1	6						1									
	Tutorial 2	7	1	5						1									
	Tutorial 3	6	1	5															
	Tutorial 5	8		8															
	Tutorial 6	4		3									1						
	Tutorial 7	5		5															
	Tutorial 8	7		7															
	Tutorial 9	5		5															
	Class test 1	4		4															
	Class test 2	5		5															
	All types	**59**	**3**	**53**						**2**			**1**						

Module	Assessment type	No of events	M^+	M^-	T_k^+	T_e^+	T^-	$M^+t_k^+$	$M^+t_e^+$	M^+t^-	$M^-t_k^+$	$M^-t_e^+$	M^-t^-	$T_k^+m^+$	$T_e^+m^+$	T^-m^+	$T_k^+m^-$	$T_e^+m^-$	T^-m^-
Applied Maths 101 (Statistics) Lecturer Mr/s Y	Computer lab task	1		1															
	Summary assignment (measures of central tendency)	6	2	4															
	Summary assignment (scatterplots)	3	1	2															
	Test 1	4	1	3															
	Test 2	5	1	4															
	Test 3 (open book)	1	1																
	ALL	**20**	**6**	**14**															
Applied Maths 102 (Financial Math). Lecturer Mr/s X	Spread sheet task 1 (teachers' salaries)	1		1															
	Spreadsheet task 2 (interest)	3	1	2															
	Financial Maths Portfolio	4	1												3				
	Assignment (Financial Maths in the new curriculum)	1																	1
	Tutorial 1 (interest)	10		9						1									
	Tutorial 3 (investments)	15	2	13															
	Test 1	4	2	2															
	Test 2	4		3						1									
	All types		**6**	**30**						**2**					**3**				**1**
Curriculum 103 Lecturer Mr/s X	CWk Assignment 1 (Maths lang in learners' work)	1													1				
	CWk Assignment 2 (5 strands)	1			1														
	CWk Task (Maths Language in texts)	2								1			1						
	TP Assignment 1	4													3		1		
	TP Assignment 2	6				1								1	4				
	Extra lesson Report	1												1					
	Mini lesson	1																1	
	June Test	4			1			1										2	
	All types	**20**			**2**	**1**		**1**		**1**			**1**	**2**	**8**		**1**	**3**	

Table 7: Summary of analysis of all assessment items across 6 specialist modules at CU

Module Name (Lecturer X, Y, Z)	No of events	M^+	M^-	T_k^+	T_e^+	T^-	$M^+t_k^+$	$M^+t_e^+$	M^+t^-	$M^-t_k^+$	$M^-t_e^+$	M^-t^-	$T_k^+m^+$	$T_e^+m^+$	T^-m^+	$T_k^+m^-$	$T_e^+m^-$	T^-m^-
Maths for T 101 (Functions and Algebra) (X)	36	13	21						2									
% (N=36)	**100**	**36.1**	**58.3**						**5.5**									
Maths for T 103 (Calculus) (X)	18	9	8						1									
% (N= 18)	**100**	**50.0**	**44.4**						**5.6**									
Maths for T 104 (Linear Algebra) (Z)	59	3	53						2			1						
% (N=59)	**100**	**5.1**	**89.8**						**3.3**			**1.7**						
Applied Maths 101 (Statistics) (Y)	20	6	14															
% (N=20)	**100**	**30.0**	**70.0**															
Applied Maths 102 (Financial Maths) (X)	42	6	30						2					3				1
% (N=42)	**100**	**14.3**	**71.4**						**4.7**					**7.1**				**2.3**
Curriculum 103 (X)	20			2	1		1		1			1	2	8		1	3	
% (N=20)	**100**			**10.0**	**5.0**		**5.0**		**5.0**			**5.0**	**10.0**	**40.0**		**5.0**	**15.0**	
ALL items	195	37	126	2	1		1		8			2	2	10		1	3	1
% (ALL items)	**100**	**18.9**	**64.6**	**1.0**	**0,5**		**0.5**		**4.1**			**1.0**	**1.0**	**5.6**		**0.5**	**1.5**	**0.5**
% (Modules)		**22.5**	**55.7**	**1.6**	**0.8**		**0.8**		**4.1**			**1.1**	**1.6**	**7.9**		**0.8**	**2.5**	**0.8**

APPENDIX F

ARCHIVE OF INFORMATION COLLECTED AT CU AND DATA PRODUCTION

Appendix F.1: Textual material collected from RU

Table 8: Log of material collected from RU in September 2004 and organised the archive

Semester	Module name	Description of course material collected	Assessments related to this course	Knowledge discourse visible (M, ME. MT)
1	Algebra	A booklet – the first three lectures cover: how to study mathematics; current issues on mathematics; and the mathematics teacher – no material relating to these content provided. The remained of the course - 37 x ¾ h lectures … is focussed on traditional topics in school level algebra (grades 10 – 12), and to aspects of linear programming. The text is comprised of extracts taken from a school textbook – but no indication is given of which one.	It appears that there are two class tests + an exam. No copies of these have been provided.	The fist three sections touch on ME and MT In rest (majority) the focus is on doing school level M
2	Errors and Misconceptions in Mathematics	No specific materials provided	No examples provided	ME/ MT
2	Space and Shape	The focus appears to be entirely on specific theorems from school mathematics – all seem to be theorems relating to parallel lines, various quadrilaterals and triangles (traditional grade 8 & 9?) Nothing seems to be related to Grade 10 – 12 ideas.	One test is provided	The outline and test provided indicate a focus on specific traditional school geometry theorems. Thus the focus is on school M. However in the interviews and observations, it was clear that the real focus is on *presenting* these theorems – developing confidence and the ability to explain a theorem in front of the whole group. This could be recognised as a form of MT
3	Instruction in	No specific materials provided. However the course	No examples provided,	The focus appears to be a mix of

	Mathematics	outline and some photocopied notes were found in one of the student's Portfolios. This indicates a focus on a variety of topics: Investigations; Numerical Skills; Calculators and data collection; equations and inequalities; perimeter and area; problem solving; problem solving in mathematics. The logic for the selection in this module is not clear from the outline.	But the outline indicates a combination of assignments, presentation, portfolio, tests and exams will be used.	aspects of ME and school M. Notes and work found in student portfolios indicate that problem solving was a main focus.
4	Calculus A	Copies of a calculus text book: S.L Salas Einar Hille and John T Anderson: Calculus – one and several variables (241 pages copied) … covering aspects of differential calculus	One exam provided	Entirely university level mathematics. M
5	Calculus B	Copies of a calculus text on integration – from a book "Understanding pure mathematics" (no authors/ publishers given) – chaps 12 – 20 (293 to 523).	No exams/ tests provided	Entirely university level mathematics. M
6	Preparing to Teach Mathematics	A module outline that appears to be divided into two sections. Fist section deals with planning teaching and teaching methods. It refers directly to the language of the OPD. The second section is focussed on working with school math – exponents and logs – grade 10 -12 work.	one 2 h exam (outline indicates two class tests – one on each of the sections – these tests not provided)	MT and school level M
7	Algebra and Statistics	A booklet on Number Theory and Stats. The focus in the Number Theory section is on arithmetic and geometric sequences and series (school level). In the statistics section, the focus is on descriptive stats and probability. Material is taken from specific text books – not indicated.	Outline indicates two 45 min tests and one 2h exam. Two tests and an examination provided (appears the major focus is on sequences and series)	Appears to be school level math. M.
8	Assessment in mathematics	No material provided. But a video taken of one of the classes.	No examples provided	ME?

Appendix F.2: Example of photocopied text used for first semester Algebra module at RU

QUADRATIC INEQUALITIES

Example : Solve for x : $x^2 - 3x - 4 > 0$

There are many different methods of solving an inequality of this type. Four method illustrated. Choose the method that you prefer and master it.

Method 1 : Algebraic Argument

$(x-4)(x+1) > 0$

Both factors must be negative or both factors must be positive.

$x - 4 < 0$ and $x + 1 < 0$ OR $x - 4 > 0$ and $x + 1 > 0$
$x < 4$ and $x < -1$ | $x > 4$ and $x > -1$
$x < -1$ | $x > 4$

Final Solution : $x < -1$ or $x > 4$ (Note the use of the words "and" and "or")

Method 2 : The Table Method

$x^2 - 3x - 4 > 0$

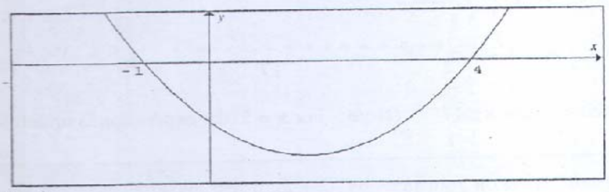
We first determine the roots of the equation $x^2 - 3x - 4 = 0$ which are referred to as the critical values of the inequality.
ie. $(x-4)(x+1) = 0$
$x = 4$ or -1

We now use a table as follows :

X	x < -1	x = -1	-1<x<4	x = 4	x > 4
x – 4	-	-	-	0	+
x + 1	-	0	+	+	+
(x-4)(x+1)	+	0	-	0	+

The values that make $(x-4)(x+1)$ positive are therefore $x < -1$ or $x > 4$

Method 3 : Using Graphs



$x^2 - 3x - 4 > 0$
$(x-4)(x+1) > 0$

We use the critical values to draw a rough graph of the function $y = x^2 - 3x - 4$.

It is clear from the graph that $y > 0$ above the x – axis. That is $x^2 - 3x - 4 > 0$ for $x < -1$ or $x >$

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Method 4 : The Number Line

This method is a combination of the graphical and table methods. It is a "short cut" approach to arriving at the solution.

Plot the critical values on the number line (ie. the x-axis) with the smaller number to the left.

$$\underset{-1}{+ + + + + +} - - - - - - - - - - - - - - - - - \underset{4}{+ + + + + +}$$

The critical values separate the number line into intervals, in this case into three intervals, viz. $x<-1$, $-1<x<4$, $x>4$. Select a value from each of these intervals and test by substituting into the inequality.

FURTHER EXAMPLES

Solve for x : 1. $2x^2-3x-5<0$ 2. $\frac{3}{x-2}\geq\frac{1}{5}$ 3. $x>\frac{6}{x}+1$

1. Find critical values :

$$2x^2-3x-5=0$$
$$(2x-5)(x+1)=0$$
$$x=\frac{5}{2} \text{ or } -1$$

$$\underset{-1}{+ + + + + +} - - - - - - - - - - - - - - - - - - - \underset{\frac{5}{2}}{+ + + + + +}$$

Substituting $x=0$ into the inequality, we obtain $-5<0$ which is true.

This means that the interval in which 0 lies is the required solution, ie. $-1<x<\frac{5}{2}$.

2. $$\frac{3}{x-2}\geq\frac{1}{5}$$

$\frac{3}{x-2}-\frac{1}{5}\geq 0$ .... Ensure that 0 is on the R.H.S.

$\frac{15-x+2}{5(x-2)}\geq 0$ .... Express as a single term.

$\frac{17-x}{5(x-2)}\geq 0$

Critical values are 17 and 2

$$- - - - - - - \underset{2}{} + + + + + + + + + \underset{17}{} - - - - - - - -$$

Answer : $2<x\leq 17$ (Note : For $x=2$ the expression is undefined.)

> NOTE : Multiplying on both sides by $(x-2)$ might make the example easier, but it will be incorrect. We cannot multiply an inequality by an unknown $(x-2)$ because we are not sure whether $(x-2)$ is negative or positive. Remember the rule about multiplying an inequality by a negative

3. $x > \frac{6}{x} + 1$

$$x - \frac{6}{x} - 1 > 0$$

$$\frac{x^2 - x - 6}{x} > 0$$

$$\frac{(x-3)(x+2)}{x} > 0$$

Critical values : x = 3, -2, and 0 :

- - - - - - - - + + + + + - - - - - - - - - + + + + +

-2 0 3

Note that there are four intervals here, $x<-2$, $-2<x<0$, $0<x<3$ and $x>3$. The answ will lie in two of the intervals.

Answer : $-2 < x < 0$ or $x > 3$

PRACTICE EXERCISES

Solve the following inequalities :

1. $x^2 - 2x - 15 \le 0$
2. $5 - 3x > x - 3$
3. $4 - 3x - x^2 < 0$
4. $x^2 < 81$
5. $x^2 \ge 3 - 2x$
6. $x^2 - 18 < 7x$
7. $\frac{3-x}{x+2} \ge 2$
8. $\frac{2x-3}{x} > -1$
9. $x \le \frac{9}{x}$
10. $\frac{x-5}{2-x} < 9$
11. $\frac{x^2+3x-4}{x+2} \le 0$
12. $\frac{(x+2)(x-1)}{1-2x} > 0$
13. $\frac{x^2-3x-3}{x+2} > 1$
14. $\frac{3+5x-2x^2}{2x+1} \le 0$

ANSWERS

1. $-3 \le x \le 5$	2. $x < 2$
3. $x < -4$ or $x > 1$	4. $-9 < x < 9$
5. $x \le -3$ or $x \ge 1$	6. $-2 < x < 9$
7. $-2 < x \le -\frac{1}{3}$	8. $x < 0$ or $x > 1$
9. $x \le -3$ or $0 < x \le 3$	10. $x < 2$ or $x > 2,3$
11. $x \le -4$ or $-2 < x \le 1$	12. $x \le -2$ or $\frac{1}{2} < x \le 1$
13. $-2 < x < -1$ or $x > 5$	14. $x \ge 3$

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Note: The quality of the original photocopy in the course notes was poor. The scan of the sample text here is close to the quality in the handout.

Appendix F.3: Coding and analysis of an Assessment in Mathematics Video Transcript

Assessment in Mathematics: Video record analysis – chunking into evaluative events and coding

The transcript has been chunked into one main event, consisting of 4 sub-events. The movement through the events is marked out and coding is shown. All transcriptions quoted in Appendix 8.3 are direct quotes from this transcript.

A summary of the coding can be found in Table 9; which appears at the end of the chunking of the transcripts.

EVALUATIVE EVENT 1 BEGINS

<u>Event 1.1 (duration approximately 10 minutes; 1:00:00 – 1:10:05)</u>
In the previous lectures students had been exploring the question 'Why focus on assessment?' and Dr A suggests

> And I think now we are all convinced that we need to **look at assessment and consider it in the light of the curriculum changes** and in the light of changes from time to time in Mathematics teaching and learning. […] If assessment remains unchanged we might as well forget about the changes at the classroom level […] **Changes in the way we are supposed to be teaching mathematics**."

Dr A goes on to say that they now need to consider what to assess and how to assess it, and reminds the students that this is what they are busy with and that she had given them homework exercises to work on that will be the focus of this lecturer. Students had been asked to "come up with a question where you are trying to be looking at conceptual understanding" and to identify why they are asking the question and what concepts they are looking at in asking that question. Secondly they were required to produce a "problem solving type question" and to identify what they are trying to assess when they use "problem solving, investigations etc".

Dr A suggests to the students in his introduction to the lesson

> What are the kinds of things you may be looking at? There are **no fixed rules about how to do it**. That's why I'm saying this discussion is open, er this type of assessment is open for discussion. Because nobody is go to say to us 'this is how you do it', isn't it? But here **we need to come to some kind of consensus**, to say **maybe if we are focussing we want to check the concepts, we want to look at understanding, conceptual understanding**, these are the kind of things we should be looking at. And maybe if we are asking a problem solving type of question, these are the things we should be looking at. And eventually, I am hoping we achieve in this class, in the end we will be having **some kind of consensus**, where we will say **as far as we are concerned … these are the kind of things that our assessment scheme should incorporate.** There **are no fixed rules** about these things. But these things can be discussed as long as we can say, OK, we are putting this because we want to focus on this and this and this … because we think this important. Then it's OK. Isn't it? Wouldn't it be nice if this semester at least we go out to schools next year, and we say this is how I am going to be assessing my students? And maybe for this particular piece of work, these particular aspects, assessment aspects are going to be important. But let me go back and look at how we did it in our classes. Isn't it? Wouldn't that be nice? Always to have to refer back to what you did once you were here? Isn't it? […] what should I be doing? […] but you have something that you can always refer to. Again it is something that is **subject to change** from time to time, but as long as you have, so it's like, there is like a parcel in this basket, in this basket there are quite a number of things, isn't it? You know this, at this hour I think I am interested in having an apple or an orange. Is an orange going to be ok for this time of the day? If it's okay then I pick up an orange? Isn't it? Maybe tomorrow I may be interested in something else. Isn't it? So a basket full of quite different things. But we know what those things are, we know the importance of, we need to know what the importance of those things are.

The lecturer ends this introduction when she asks for volunteers to come and share their ideas (in relation to the work they had been asked to do in preparation; i.e. bring examples to show how they think ‘conceptual understanding’ and ‘problem solving’ should be assessed)

Here we see the main object of acquisition being announced: ‘why’ assess, ‘what’ to assess and ‘how’ to assess in mathematics, particularly in relation to problem solving and investigations. This is announced in the form of a recap on what went before and setting the scene for what will happen now. This may be connected to messages from the ORF – e.g. directly from the National Curriculum statements – the section on assessment suggests this is important (Why/ what/ how to assess). There is also a mention of curriculum change as a justification for considering assessment. It is noted that Dr A mentions a number of things more than once in this opening part of the lecture, in particular: 1) problem solving needs to be assessed. 2) assessing conceptual understanding is important 3) that everything is subject to change[12].

There is a focus on the class coming to a consensus in order to decide what it is that they should be assessing when they se out to assess ‘conceptual understanding’ and ‘problem solving’. They are told that there are no fixed rules. We come to know what to do by discussing it and coming to a consensus – we need to know why we assess, what to assess and how to assess – but to know these things we need to discuss them and come to a consensus.

The above introductory comments are identified as the beginning of the event. The event continues for the duration of the lecturer, and presumably will continue into the next lecturer. What will signal the end of this event will be the final fixing of the consensus around what (concepts) should be assessed and how the ‘what’ should be assessed when dealing with problem solving/ investigations in a mathematics class. The rest of the lecture consists of sub-events which appear to build towards this main purpose. That is there is one main event in this lecture.

In terms of the methodology Event 1.1 is coded as follows:

1. Primary object to be acquired: T (what to assess and how to assess ‘conceptual understanding’ and ‘problem solving’ in the mathematics classroom)
2. Secondary object/s (assumed/implicit): m (background knowledge is assumed mathematical knowledge in the form of how what it means to have ‘conceptual understanding’ and to ‘problem solve’)/ t (why one should assess)
3. means: lecturer exposition
4. Pedagogic judgements
   E – yes (the focus is explicitly announced in the introduction)
   R – no (no possibilities are generated; L simply asserts that they will get to fix meaning through consensus; and appeals to the curriculum to justify *why* this is important to know, but no indication of what it is)
   N – no (meaning is not fixed, the situation is still open – necessity is not reached)

<u>Event 1.2 (Duration approximately 14 min; 1:10:05 – 1: 23:45)</u>
The first sub-event event begins when the first volunteer comes forward to put his example up for discussion in the class. The lecturer has asked for two volunteers. Dr A reminds them that they must first give an example of a problem used to assess conceptual understanding. Thus the focus of the sub-event is an example of a question constructed to assess conceptual understanding - the general pedagogic object for acquisition is a notion of ‘conceptual

[12] This was clearly something that impressed Phiri – who expressed the idea that the importance of the teacher to be an assessor is that things are always changing.

understanding' as a *what* to assess in the mathematics classroom, and some idea of *how* to construct a problem to assess this understanding.

The volunteer, Mr Mpe[13], comes forward and presents his example of a problem which assesses conceptual understanding.

> My problem was on Pythagoras' theorem. Basically on conceptual understanding. Firstly I looked at it as if we have already done the chapter of Pythagoras' theorem. So first of all I look at the definition, what is defined as Pythagoras' theorem so that we can [Dr A interrupts by giving him a piece of chalk and he stops talking and moves to the board]. Firstly, [Mr M writes on the board: 'Pythag theorem']. So firstly, because I look at it as if we have already done the chapter of the, of Pythagoras' theorem, so I ask for the definition on the conceptual understanding [writes on the board: 1. define]. So you see if they have understanding of the definition. So first they should define it. Secondly, I looked at the formula that is used when you are getting the sides of a triangle, of a right angled triangle, like this one is a x squared plus y squared is equal to and then I put a question mark [writes on the board: 2. $x^2 + y^{2\,=}$?]. Like we have already done it before. So they know if they add the square of these [pointing to x^2 and y^2] they will get what? They should put r^2 [writes r^2 on the board]. So this is like looking at the conceptual understanding of the Pythagoras theorem. Then I get it like, what, the next question is, "What is the name given to the longest side of, what, a right angle triangle? So that they can see if they can relate the definition of what, of Pythagoras' theorem with what they have seen, for instance on what? [draws a right angled triangle on the board] On a right angle triangle. What is the longest side? So therefore they know from the definition of what was given to them, or the definition of that has been formulated out of the classroom while I was teaching the concept, therefore they know that this side is called what? The hypotenuse [draws an arrow and writes hypotenuse on the board]. Ok. So this is the kind of things. I don't know if there are any questions. (see Plate 16 below for a view of the board at the end of this presentation).

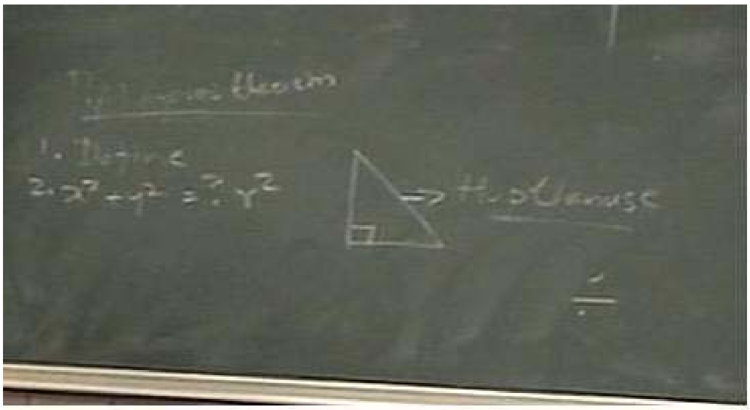


Plate 16: Mr Mpe writes up his example of a question to assess conceptual understanding

At this point there is a pause. We note, in this presentation the student has suggested that (1) testing for 'conceptual understanding' is the same as checking that the learner has knowledge of the definition – i.e. what is meant by conceptual understanding here is related to knowing the 'content', and (2) that to test for conceptual understanding you need to asses if they can 'relate' the definition to things they have 'seen' – i.e., can they relate the definition to a 'model', drawing' or some or other 'visualisation' (example define Pythagoras' theorem, and relate it to a right angled triangle). The lecturer comes back to the front of the lecture theatre and begins a discussion of Mr. Mpe's problem. The following interchange takes place:

(1:14:58)
Dr A Ok. So in other words you wanted them to start defining things first, isn't it?
Mr. M Yes
Dr A Ok. Ok. Thank you very much.

[13] This is a feature of the context – all students refer to their lecturers as Dr A and Dr B, using their formal titles and surname. The lecturers refer to the students as Mr X and Miss Y etc. No one uses first names to address a colleague or student.

Mr M It was not a question of defining. It is a question of. Because I looked at it as if they already done it in class. So I am asking questions, so maybe if I haven't done it I would look at it in terms of lets first develop the definition of the Pythagoras' Theorem. Then when they understand then I can focus on asking.

Dr A Maybe before you sit down. What is it that you wanted them to define here? Can we come to the specifics?

Mr M The specifics are 'What is the Pythagoras theorem?'

Dr A Pythagoras Theorem?

Mr M Ja

Dr A Ok. [Starts writing on the board] So in other words, you wanted them to define certain terms, isn't it?

Mr M yes

Dr A Certain terms of the theorem isn't it? State the theorem. [writes state the theorem on the board] Right. Thank you very much. Yes, and then in number two?

Mr M In number 2 to give them the formula, then they are going to put in what, …

Dr A: Ok. Lets say, the formula, …

Mr M … [not audible]

Dr A Ok, they were expected to complete the formula in relation to the Pythagoras' theorem. Isn't it? [writing on the board – see Plate 17]

Mr M yes

Dr A The formula, it had to do with the formula, isn't it? Ok. Thank you. Something else?

Mr M The very last one was just to see if they can identify the hypotenuse on the right angled triangle. The hypotenuse. Because I have had learners that are … [inaudible]

Dr A OK so it was still a way of saying okay, the new terms, that learners have to define certain things in the data, what is the hypotenuse? What is this side? Isn't it?

Mr M yes

Dr A Ok, very good. Thank you very much. Isn't it. It's a very good example.

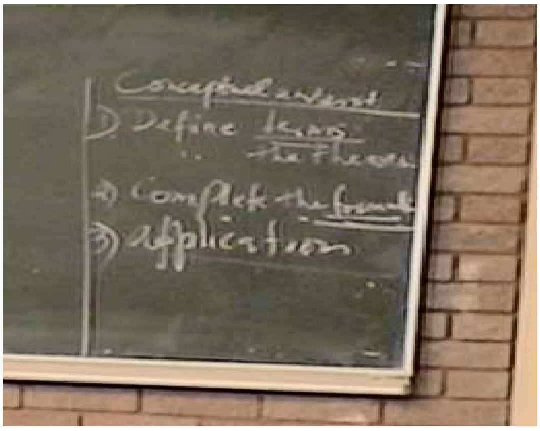


Plate 17: Dr A's summary of what to assess when assessing for conceptual understanding

The lecturer seems to question Mr Mpe so as to clarify his position – and then affirms him. The exchange that takes place here is a form of lecturer questioning, but it does not probe thinking – or move towards an evaluation of what has been offered as an example to assess 'conceptual understanding'. There is no evaluation here in the sense of seriously examining the text offered and negating any of these as possibilities of what is to count as a 'good example'. However there is *affirmation* (positive reinforcement). Dr A uses questions to get Mr Mpe to confirm what he was saying, and then tells him that his example is "good … a very good example". No grounds are appealed to justify why this is "good". As the lecture unfolds we see this is a pattern. Students are continuously affirmed. They have important contributions to make, they are knowledgeable, what they say or do is always interesting, good, excellent. Students are never told that what they have said or written is wrong, or through discussion brought to any point of affirmation or negation by appealing to any specific grounds for legitimating their text. Their offering is accepted. It is clarified but accepted *as is*. They are positioned as knowledgeable, they will bring to the discussion things that will be helpful for the class to use for working out what to assess and how to do it - they will bring examples which will form one basis for developing the consensus mentioned in E 1.1.

This sub-event continues with further focus on what Mr Mpe has written on the board. Dr A now focuses on the list she started earlier and attempts to get the rest of the class involved in developing it.

(1: 17: 20)

Dr A [Asks the class] Can you extend this list a bit? [pointing to the list she wrote while getting Mr M to clarify his questions.]

Mr Sphe: Yes. I was going to ask the question about the, the question that is going to need the application of the formula.

Dr A The application of the formula? Ok. Can you give us an example, for instance? Application of the formula [writes on board extending the list he started earlier]. This is very good. Example? Whereby we apply.

Mr Sphe: I can give them the adjacent side and also the opposite side

DA Do you want to show us? (gives him the chalk)

Mr Sphe: [inaudible]

Mr A Sure. Not a problem. You can put in whatever numbers, Ok.

Mr Sphe: (at the board) Lets say we are given x equal a number [moves to where the triangle was drawn before] Lets say this is the adjacent side [writing on the board], just give me a number [looks at class], three [writes 3] and here is the opposite [writes opp on the board] and here it comes to? [look at class who respond] four [writes 4 on the board]. Ok, so then what is the value for r? r squared is equal to x squared plus y squared [writing on the board] so x is, three squared plus four all squared [plugging the values into the formula and writing on the board – see Plate 16], and that is equals to

[Whole class says 9]

Mr Sphe: nine plus

[Whole class 16]

Mr Sphe[14]: Sixteen. Is equal to [pause while class gives answer, then repeats and writes it down] r squared is twenty five. So r is 5.

Mr Sphe looks at lecturer and puts down chalk.

Dr A: OK, good. Excellent yes. This was an example of the application of the formula. Isn't it. Ja. Ok can we, [pause] Have we exhausted the kinds of things we can look for in conceptual understanding? [looks at class?] yes?

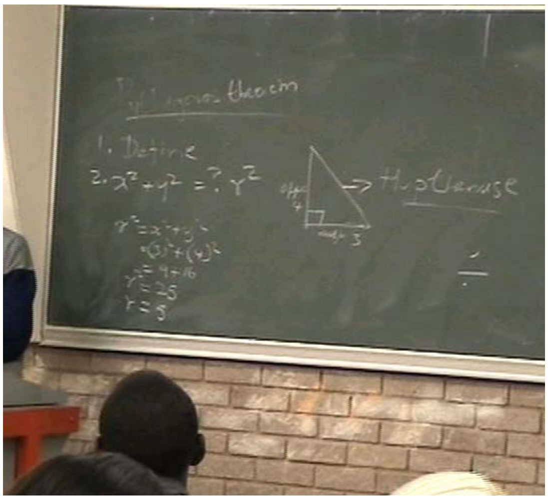


Plate 18: Mr Sphe's example of an application type question

It appears that what Mr Shpe's application has been affirmed in the same way as Mr Mphe's example of questions to assess conceptual understanding. There seem to be a 'taken for

[14] This is an interesting exchange. It reflects a common pedagogic pattern observed in disadvantaged schools in SA. The teacher asks questions for which the answers are completely obvious, and the class chants the answers, thus participating in the lesson. That this is rehearsed in the MTE lecture room, as an accepted practice, is revealing.

granted' meaning of 'conceptual understanding", that has not being exposed at this stage. The event continues as Mr Mpe wants to clarify his position in relation to Mr Sphe's offering.

Mr Mpe: It is why I didn't put the application with the conceptual understanding. I was going to, I put it in the problem solving.
Dr A: OK. This same question is also the problem solving aspect.
Mr Mpe: yes
Dr A: Oh. Is it? Ok. And then the application you wanted to?
Mr Mpe: the application I just put it in the problem solving
Dr A: Ok, can you tell us more about that? Because that is interesting. In one question we can identify it as a problem solving type or as a simple … the kind of problem that we come across all the time. Isn't it? Ja the kinds of problem that is straight forward that is about the formula, the rules etc, etc. But also what is coming out is that we could also look at it in a problem solving type manner. OK. That's interesting. What question for instance are you thinking of? Do you want to write it?
Mr Mpe: No I can just say it. I said from triangle, I gave a triangle ABC. AB equals 4cm and BC equals 5 cm, it is of the same type (points to the board). Then find AC, which is the hypotenuse. But the thing is I looked at it as a problem solving example instead of conceptual understanding type.
Dr A: Ok sure. Class what do you think? [pause] Can we identify that question as a 'problem solving type'? (short silence)

Again it is noted how the students are affirmed – what they say is always interesting and worthwhile. In this exchange – Mr Mphe appears to be suggesting that an application assesses problem solving (rather than conceptual understanding), which is why he did not put up an application. Dr A here seems to be implying that the application is not a 'problem solving' type of question, although she asks the class to say what they think about it and does not assert her authority. She also does not suggest that the 'application' shown by Mr Sphe was inappropriate as a question to test conceptual understanding. The event continues, with Dr A saying:

Dr A: Ok. Do you want to think about that? (short silence again). OK. I don't know the answer, isn't it? [gestures with his arms in air]. Is it Ok? But maybe we can come to some more other examples and then maybe we can agree or disagree on what he is saying.
Dr A looks back at the list he started earlier
Dr A: Is this list OK. Have we exhausted this list? Can we , are there other things we can do if we want to check conceptual understanding of learners? Conceptual understanding of learners. What else can we do? [short silence] OK. We can come back to it. In the meantime some ideas can come up for what is it, what other concepts you can actually be looking at here.

The event ends with Dr A attempting to solicit some comments from the whole class, and asking if someone else would like to share their example of a question that would assess 'conceptual understanding'. Nobody responds, and the sub- event is brought to a close with a second volunteer invited to come up to show their example to assess 'problem solving'.

We note here that in this last exchange, Dr A signals that the matter is not closed – it is being left open. What it means to assess for conceptual understanding is not as yet established. She signals that she is not willing to provide the answer (I don't know the answer, isn't it?) – and she wants to know form the class if what has been put up is "okay". There is an implication that the class will come back to this issue later – that is, the event will continue sometime in the future.

In term of the methodology Event 1.2 is coded as follows:

1. Primary object to be acquired: ME/MT (what to assess in relation to 'conceptual understanding' and how to assess it)
2. Secondary object/s (assumed/ implicit): m (background mathematical knowledge - Pythagoras' theorem); t (what is meant by 'conceptual undersatnding')

3. means: student presentations (Mr Mphe and Mr Sphe) and lecturer questions (aimed mainly at clarification)
4. judgements
   E – yes (the focus is announced and the student puts up an example that stands in the place of an 'assessment of conceptual understanding')
   R – begins (possibilities are being put up, BUT there are no clear legitimating appeals are made with respect to the object to be acquired – it is presented as given and accepted as is, while at the same time there is an implicit suggestion that there is more to it than this. However it appears that the possibilities presented are affirmed without any appeal to grounding – what is presented is accepted – it is grounded in the student teachers experience)
   N – no (meaning is not fixed, the situation is still open – necessity is not reached)

<u>Event 1.3 (Duration approximately 11 minutes; 1:23:45 – 1:35:09)</u>

This begins with a change in focus from assessment of conceptual understanding to assessing 'problem-solving' in mathematics. The lecturer invites Mr Mtwe (the student known as Phiri in this research project) to come up and present his example of problem solving. (I will use the name Phiri here). Phiri comes up the board and Dr A gives him the chalk. Phiri starts cleaning the board and Dr A addresses the class:

DA: Thank you. Ok people, this was a good example wasn't it? I found this to be a quite an interesting example, because the 'what' aspect is a very important aspect. Isn't it? Teachers are asking, saying, but we don't know what we should be assessing the learners on. And this is what we are trying to do.

Silence while Phiri finishes cleaning the board.

Phiri: So my problem will be based on problem solving. So I will write this down here because it is so short. (Says the question as he writes it down). The sum of the two integers is 2. And the sum of their squares is 34. (repeats it) It's just a word problem. (See Plate 19)

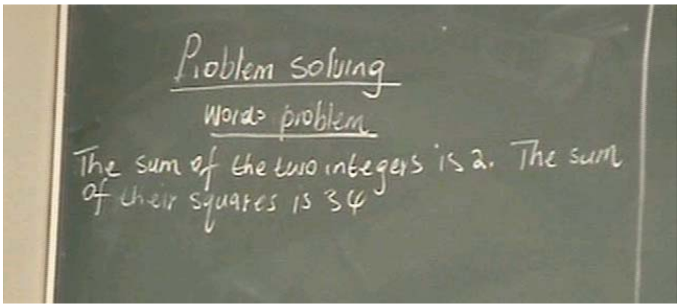


Plate 19: Piri's problem for assessing problem solving

Phiri: So what I am trying to take here is the technique, let me write it on that side (writes on board), technique or the strategy used by the learner to solve this problem. So this is what I am going to be assessing here. So, since the sum of the two integers is 2. So what are those integers? Which technique is this learner going to use to get those integers? Then the question can say [writing on the board as he speaks], find the integers. How do we get these particular integers, because we are also told, that the sum of their squares is thirty-four. So from getting the technique or the strategy of solving that, then I will be looking at the method. [writes on board] The method for solving that particular problem. Because from here [pointing at the first phrase] you can interpret and say the sum of the two integers is 2. One can simply come and say, 'its one plus one, obviously'. Then we get two. So how do we get the first integer is one and then add one again? So from here, you may give one integer is x, because you don't know those integers yet. And plus, lets say its y, then you get two. (writes x + y = 2 on the board) The sum of the two integers is two [pointing at the equation] And the strategy that is used by this learner, is to give thse particular integers these particular alphabets. x and y. Then we are told that their squares is what? Its thirty four, so x squared plus y squared is 34 [writes equation on the board]. Now the learner has used this particular strategy to solve the problem. So now getting this strategy of solving the problem, now lets come to a method of solving it. With the method how are we going to solve this problem. So obviously that method, because we are having one, two unknowns, so we will be using the simultaneous one. That's what I'm going to be assessing them on, the method of using simultaneous equations.

Dr A: Ok. So basically you are looking at that problem and you are saying you want to assess the technique or the strategy …

Phiri: the technique or the strategy used by the learner to solve this particular problem. Yes.

Dr A: Oh. That is another interesting example. But, let me find out. Let me find out. He says he wants to assess the strategy. Could we have more that one strategy? For instance ,in the same example? Could, can anyone think of another strategy by which this problem can be solved? Because remember we are assessing, we are assessing the strategy. So in other words what it means there must be more than one strategy. I don't know?

Phiri: goes back to his example and changes what he has written on the board

Dr A: Oh. Strategy stroke strategies? Techniques? (Phiri goes to change what he has written on the board from technique to techniques - Class laughs)

Dr A: Oh we are assessing strategies – not only one strategy?

Phiri: Yes. Not just one. Because there can be so many ways of solving one question.

Dr A: Oh that's good. That's good. … Can someone think of another strategy for solving one and the same thing. Or technique? (silence – long wait)

Dr A: Can anyone think of another one? (waits)

Dr A: Another one? If indeed we do want to look at strategies that learners embark on in doing problems of this nature. So? (waits- silence) Did you think of something? Good.

S5: No I was just saying that it might happen that (becomes inaudible) ….

Dr A: Oh yes. So it can be strategies .. we can put the s in brackets. Or technique or technique(s).

Dr A: But coming back to this [Phiri moves to sit down] Thank you Mr Mw. That is a good example. Coming back to this particular example. What do you say? Does it lend itself to one particular strategy or is it possible to think of something else? Another strategy? (waits - silence) What do you think? Yes?

We see here that the a similar pattern emerges, the lecturer affirms the students problem, but this time there is the suggestion that in a question that assesses 'problem solving', there could be more than one strategy for finding a solution. Again this is couched in a way that suggests as a lecture she does not know and will not force her 'opinion' on them – the class must decide. On what basis this decision will be made is completely obscure. There is no consideration of the actual problem presented at all. Dr A, however wants to know if someone has a different strategy for solving it (other than the simultaneous equations that Phiri has suggested). The Minister suggests,

TM: I can't say I'll come with another strategy. But maybe you can look, as an educator, you can look at the processes that the learner, or steps that the learner engaged while trying to find that strategy.

Dr A: Oh. good, good

TM maybe you can look at the learner, why (inaudible) how did they come up with this thing… {I writes on the board]

Dr A: so in other words, there is a possibility

TM: … processes used to interpret that into the numbers

Dr A: processes, skills. Ok, can we identify?

S6: [in audible] to be able to subtract, to interpret those words into numbers or to those letters,

Dr A: OK. Excellent. Ok, that was one of the skills that were required to do this problesm. Yes. Have we exhausted this list? Is there anything else that we can add to the list? (The Minister) has talked about processes that I think indeed are very important for a problem solving type question – isn't it? [silence] Does somebody else want to give us his/ hers? An example of a problem solving type nature? [silence] Yes S7? Do you want to us yours? Have you thought about yours? Yours?

Nobody volunteers to add anything more.

(….)

Dr A: … and what is coming up here is that **if I really want to test on conceptual understanding, there are certain things we can look at**. Isn't it? And **if we are considering a question of a problem solving type, what that means**. **Maybe we will come back to that**. Ok now what I want us to do. I want us to leave these examples as they are. I want to do, I want to give you another example and I won't say much about this example. So you rather work through it with somebody, your neighbour. So it's important that you sit with somebody with whom you are on talking terms. [everybody laighs] Because I want you to talk, I want you to talk now. Because we will come back to these examples. [hands out sheets] I want you to look at problem task 1.

At this point the focus is moved from the examples that the students have brought to an example the lecturer has brought in. This signals the end of the sub-event and signals the move in focus to the next sub-event.

In terms of the methodology Event 1.2 is coded as follows:

1 Primary object to be acquired: t (what to assess in relation to 'problem solving' and how to assess it)
2 Secondary object/s (assumed/ implicit): m (background mathematical knowledge -); t (what is meant by 'problem solving')
3 means: student presentations (Phiri), lecturer questions (aimed mainly at clarification) and whole class discussion
4 Pedagogic judgements:
E – yes (the focus is announced and the student puts up an example that stands in the place of an 'assessment of problem solving')
R – some indications of a beginning (the suggestion that there could be more than one way of solving a 'problem solving' type question – the grounds for this assertion are not at all clear; and that to think about how to assess we need to think about how learners might think (experience). The implication is that later on criteria will be agreed upon.)
N – no (meaning is not fixed, the situation is still open – necessity is not reached)

<u>Event 1.4 (Duration approximately 15 minutes; 1:35:20 - 1:50:00)</u>

Students are handed out some problems. They are asked to begin by *solving the problem* themselves. (it is an 8x8 grid and they are asked 'how many different squares' – a investigation type 'problem' that is fairly common)

Dr A: Right, problem task 1. I want you to keep your examples that you have. And then maybe after this discussion this afternoon, maybe you may want to take away your examples and rework them. Isn't it? I don't know? You may want to give it to me or you may want to rework it. Keep a copy for yourself of the example but you should discuss it in twos.

(L gives them a 8 x8 square grid – calls it a 'checker board' … how many different squares are there).

Dr A So its problem task 1. now using the exsisting lines on the checker board, the lines on the checker board … here is the question. How many different squares are there. You will remember what we said last year. It is important to do what first? If you want to solve a problem what is it that you must do first?

Ss all murmur

Dr A: Understanding of the problem – isn't it?

Ss: yes

Dr A: Ok. So, How many different squares are there? Let us try and do it. So you will check with your, if there is a problem of any nature then we can discuss. Right. Ok, I'll give you some few minutes to do the problems. Ok what type of a square is that one? (pointing to sheet) It's a? It's a ? What type of a square is it? (no response) It's an 8 by 8 square isn't it?

S: yes

Dr A yes you see – one two three .. and you can count those 8 squares this side and 8 squares this side, isn't it. So its an eight by eight square, isn't it. Now we are trying to find other squares, how many different squares. We are trying to find, ok let me not talk too much, maybe I talk too much. Let me just see …

At this point the students start working quietly on problem. Students work in pairs. They talk quietly among themselves. L tells them he will give them about 10 minutes to work on the problem. Students continue to work together, talking softly amongst themselves

After a few minutes the lecturer moves from group to group along the edges (lecture theatre layout prevents access to students sitting in the middle) looking at what S are doing. L moves listening and

saying things like: good; I like your thinking. He is very affirming. He moves down the other side talking quietly to students – checking what they are doing. That's interesting etc. He doesn't seem to ask them probing questions, he appears to admire their attempts and praise their efforts.
After a while the L goes back to the front.

Dr A: Ok. Its quite a fascinating problem isn't it? Very interesting isn't it? And the good thing is that X she is doing her thing, her stuff the way that she wants to do it, and Y and Z they are doing it their way, isn't it. OK. But what is our point? What do we want to do with this problem? We want to answer the question, but we also **we want to try and identify the things we could be looking at if we are assessing a problem of this nature**. Isn't it

Ss: yes

Dr A: The question is how many different squares. Ok. I don't want to rush you. In fact this problem is proving quite a fascinating one, isn't it? It is very interesting listening to the kinds of things you are saying about this example. So I don't want to rush you. You just relax. You go home. You think about the question that has been asked, isn't it. What is the question?

Ss (all): How many different squares?

Dr A: How many different squares? That's the question, isn't it?

There is no attempt to explain what he means by different squares here.

The lecture ends with Dr A reminding the students that they not only need to solve the problem they need to come up with some ideas on how they would assess problem solving using this questions. Again no criteria are discussed.

In this event students work in groups on solving the problem. No direction is given by Dr A. They must do the problem. He affirms them as they attempt to do it. He is happy that they are coming up with different strategies etc. We presume that this class sets up the beginning phases of the learning that is to happen in the future.

In terms of the methodology Event 1.2 is coded as follows:

1. Primary object to be acquired: T (to solve a specific maths 'problem' – an investigation – to be done for the purpose of identifying *what* they would look for if they were to assess a learner's "problem – solving" on the basis of the learner having 'done' this problem)
2. Secondary object/s (assumed/ implicit): m- that the students know how to approach an investigation; t – that the students will know *how* to identify, on the basis of their experience of doing the problem, what should be assessed in terms of the notion "problem –solving"
3. means: small group work
4. Pedagogic judgements:
   E – yes (the focus is announced and the student are given a problem/investigation which stands in the place of)
   R – begins (the students are working on the problem – reflection will begin once they have come up with a solution)
   N – no (meaning is not fixed, the situation is still open – necessity is not reached)

Table 9: Table summarising moments of pedagogic judgement in evaluative events in a Assessment in Maths Education lecture at RU (Video record, 7/09/2004)

		KNOWLEDGE OBJECT(S)																			MEANS OF PEDAGOGIC INTERACTION						
		MATHEMATICS									TEACHING																
					Legitimating appeal									Legitimating appeal													
Event	**Major object**	***M* (c/pf/pr)**	**E**	**R**	**Maths**	**M.Ed**	**Ev.day**	**Auth.**	**N**	***m***	***T***	**E**	**R**	**Maths**	**M.Ed**	**Exp.**	**Curr.**	**Auth.**	**N**	***t***	**whole class discussion**	**small group discussion**	**individual work**	**Lecturer exposition**	**student presentations**	**lecturer questioning**	**student questioning**
1.1	know why/how and what to assess	0	0	0	0	0	0	0	0	0	1	1	o	o	o	o	1	o	o	o	0	0	0	1	0	0	0
1.2	what & how to assess for concept understanding	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	0	0	1	0	0	0	0	1	1	0
1.3	what & how to assess for problem solving	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	0	0	1	1	0	0	0	1	1	0
1.4	what to assess for problem solving	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
1	**what & how to assess**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**3**	**1**	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**2**	**2**	**0**

Appendix F.4: Analysis of formal assessment items from RU

Table 10: Summary of all evaluative events across all assessment types collected in the RU archive

Module Name Lecturer (A,B)	Assessment type	No of events	M^+	M^-	T_k^+	T_e^+	T^-	$M^+t_k^+$	$M^+t_e^+$	M^+t^-	$M^-t_k^+$	$M^-t_e^+$	M^-t^-	$T_k^+m^+$	$T_e^+m^+$	T^-m^+	$T_k^+m^-$	$T_e^+m^-$	T^-m^-
Space and Shape (B)	Test 1	5		5															
	Examination	5		5															
	All	10		10															
%	**All**	**100**		**100**															
Calculus A (A)	Examination	4		4															
	All	4		4															
%	**All**	**100**		**100**															
Calculus B (A)	Assignment	2																	2
	Test	6		6															
	Examination	4		4															
	All	12		10															2
%	**All**	**100**		**83.3**															**16.7**
Planning for Teaching (B)	Examination	9	1	4															4
	All	9	1	4															4
%	**All**	**9**	**11.1**	**44.4**															**44.4**
Algebra and Statistics (A)	Test 1	2		2															
	Test 2	2		2															
	Examination	4		4															
	All	8		8															
%	**All**	**100**		**100**															
All	**All**	**35**	**1**	**30**															**6**
%	**All**	**100**	**2.9**	**85.7**															**17.14**

Note: The Instruction in Mathematics portfolio task could not be analysed in terms of the mode

APPENDIX G

SCHEDULES FOR COLLECTING EVIDENCE FOR CASE STUDIES 2 (PEDAGOGIC SUBJECTS)

Appendix G.1: Biographical Questionnaire

Student Biographical questionnaire.

Please complete this questionnaire. The information provided will remain confidential.

1. Student Name: ……………………………………………………………….

2. Contact details:
   Tel: ………………. Cell: ……………….. e-mail: ……………...

   Postal address:

3. Age: ……………… Gender: …………………

4. Parents occupations: Mother …………………… Father …………………

5. Qualification registered for ………………………………….

6. High School attended (name, district) …………………………………….

7. Year of matriculation ………..

8. Matric Maths (mark achieved and grade): ………………….

9. Describe what you have been doing between completing your matric and starting your PGCE or B.Ed degree. (Please write this description on the paper provided).

10. What motivated you to become a mathematics teacher? Please describe as fully as you can. (Write on the paper provided)

11. Please write about your personal school mathematics story – i.e. your history and experiences as a learner of mathematics at school. Try to include a description of your feelings about mathematics at school, how you coped with mathematics learning, what you thought about the way mathematics was taught, what your best memories are of learning mathematics and what your worst memories are. You can also write about any teachers, or other people, who influenced you, both positively and negatively. (Please give as much detail as possible – write a page or two if possible. Please write on the paper provided.)

12. Your university mathematics autobiography. Please give details of all the mathematics courses, mathematics education courses and mathematics teaching courses you have taken since attending the university. Explain how you coped with these – any problems and successes, your feelings towards mathematics as a subject, towards mathematics learning and towards teaching it. (Please give as much detail as possible. Please write on the paper provided)

13. Your experience of teaching mathematics in practice in a school situation, as a student teacher while doing this qualification, and in other contexts if applicable. (Please give as much detail as possible. Please write on the paper provided)

Appendix G.2: Schedules used to guide the student interview# 1.

a) Pre - Interview

Before the interview students are provided with two booklets – the one contains the 'old' curriculum (still in schools) together with a set of past matric exam papers for Higher Grade mathematics, and the other contains the 'new' curriculum due to be implemented in 2006.

They are informed that during the first two interviews they will be asked to reflect on these curriculum statements in different ways.

Students are given the first 4 questions to consider in preparation for the first interview.

b) Interview # 1 (40 - 50 min)

Welcome and thank you for agreeing to be part of this process. Before we begin, I gave you the biographical questionnaire to complete did you manage to do that? (Take it in if complete) If complete, probe: What did you feel as you wrote down your stories? Was this a useful exercise for you to do? Have you ever done such and exercise before?

I will ask you questions. We will tape the responses. In addition I will make short notes as the interview proceeds - this is just for back up purposes in case the technology fails!

Section 1: (Imagined Practices)

Aim: This section attempts to elicit an overall image of what the student thinks in terms of M (1b), ME (4), and MT (1a, 2), and ML (3). Note: 4 is the 'best shot at the moment, but it is not clear what it will produce.

1. Reflecting on these documents and what you have learnt throughout your teacher education programme/ degree and experiences of teaching and learning mathematics:
   - What would **you say** are the **four most important** aspects of being a 'good' specialist mathematics teacher within the South African context? Why do you choose these?
   - What do **you think** are the **four most important basic** (fundamental) **mathematical** concepts/ processes for FET mathematics learners to be taught– and why do you choose these?

2. Imagine that you are a grade 10/11 mathematics teacher in a school. What image do you have of yourself in the classroom and the school? Describe how you think you would act and what you would do?

3. How do you think ‘good’ mathematics learners should behave? How do you see yourself getting learners to behave this way in the classroom?

4. What would **you say** are the four most important things a **specialist mathematics** teacher needs to know:
   - about learning and development,
   - about teaching, and
   - about assessment?

c) Section 2 (The school curriculum: general focus and scope of school mathematics)

Aim: This section focuses on the broad nature of M (and also implicitly ME and MT) – and tries to elicit their view of the ‘old’ and the ‘new’ and their positioning in relation to these projections.

Now we are going to discuss the contents of the new curriculum statements now.
Have you seen the document before?
If yes, where did you see it and what was your first impression?
What about the other document – the old statements – have you seen that before?
Where?
Okay so let us look at the NCS. At some stages I might ask you to write down what you mean. (Provide paper).

5. Look at page 10 – first paragraph following the bullets – “ …” – It speaks of Mathematics as a ‘discipline’ - What do you understand by that?
   (Prompt: what are its main features/ nature)
   (Purpose – What question hopes to elicit: do they know what a discipline is/ what is their view of the nature of the discipline mathematics?)

6. What do **you think** is the difference between learning mathematics as a discipline itself, and learning to teach mathematics to school learners? What would you say you have done in your qualification?
   (Prompts: One? Both? Separately? Together?… reflect on that.)
   (Purpose - tries to elicit their positioning in relation to M and MT – learning maths for the self and learning to help the other access maths)

7. In the new documents there has been a lot of focus on social justice, human rights, inclusivity etc (e.g. see page 1) – ‘mathematics for democratic and critical citizenship’ (e.g. see last line of the second last paragraph on page 11) – what does this mean in the context of a mathematics classroom do you think?
   (Prompts: What does teaching mathematics with this kind of focus look like? Is this in any way connected to what you teach? Or is it connected to how you teach? Or something else? ... wait for explanation)
   (Purpose - Tries to elicit whether they are consciously thinking about this in connection to M or not- and if they are what image is being produced … e.g. do they see this as something connected to M or does it belong elsewhere in the curriculum? Do they have an image of what his would mean “mathematically”)

8. There seems to be quite a focus on developing 'mathematical thinking/ reasoning' – what do you understand by 'mathematical thinking?' Give an example.

9. And 'mathematical processes'? Is that the same thing or is it different? Again give an example.

10. If you wanted to develop mathematical thinking/ reasoning/ processes in your learners what is it that you have to do?

11. If Q 8 – 10 **do not** illicit anything about investigating, specialising, making conjectures, generalising, justifying, etc … (go to page 18) ask: in the documents there is a lot of focus on 'investigations in mathematics on making conjectures, on generalising, justifying and proving' … here is one example. What does this mean? Can you give an example of what this is and how it is done? Why do you think this has been included in the curriculum?

12. Look at page 48 – 49. It suggests an investigation. Look specifically at the Grade 11 statement and the first three bullets.
    - In the first bullet: Can you identify what kind of function the second last equation defines? (Prompts – give time – if necessary ask them to look then at the third last one; ask them to write on paper if needed).
    - In the next bullet it suggests that the focus should be **on conversion between different representations** of these (and other) functions – what do you think that means?
    - The third bullet suggests that learners should investigate the effects of the different parameters on the (graphs) of the functions – how would you go about setting up such an investigation for grade 11 learners? What is it you would want learners to know at the end?

    (NB – do not expect them to be able to do this off hand …. Leave them with it to think about – will begin next interview session with this question – ask them to try and write some thing down on a piece of paper and bring it to you at the next interview)

13. Look at page 50/ 51 in the suggested contents section. Under grade 10 and 11 you can see this focus on a) algebraic manipulation and b) finding the solutions of various types of equations. What do you think is the purpose of focussing on manipulations and finding solutions? (Give examples of the ability to be developed … Please write it down).

14. What would be the best way of developing the ability to manipulate and solve equations, and how would you assessing this? (What type of questions? Can you give an example?) (This about procedural fluency – tries to elicit their views on the importance of this … and their recognition of some forms).

d) Section 3 (Focuses on specific assessment standards)

Aim: This section tries to elicit some image of the mathematical consciousness of the student teacher. It focuses on the conceptual descriptions of contents under each of the outcomes on M concepts which should be familiar to the student teacher – both in terms of explanation of the concept and its significance. A selection that focuses on some basic concepts, as well as some of the breadth , depth and height of the student teachers conceptual M knowledge. All that is available here is a glimpse of how they talk about it. It could tell us whether they have the concept in their immediate consciousness - but nothing about whether they could access it if given time – or whether they can fluently use it or not.

Now let's go back to the documents. If you page through the new curriculum statement you will see there is a lot of content – there will be some stuff you have seen before and that is in the old syllabus documents, but there may also be some other stuff you will never have seen before. We will simply look at the new document to identify some content. If you have never seen the thing I point to before just say so – and then we will leave it - otherwise we will talk about it. Remember this in not a test. I'm interested in what you think you know not in what you do not know. At some stages I might ask you to write down what you mean. (Provide paper).

Focus on outcome 1

15. Refer to outcome 1 – numbers and number relationships. The first bullet refers to different types of numbers and representations of numbers. Can you explain what a 'real number' is? And a 'non-real number'? What about rational and irrational numbers? Why is this important to know? (Ask them to write down their examples) (Explanation and significance of classification of numbers)

16. What about exponents and logarithms – are these numbers? What kind of numbers are they? Explain their meaning. Why do you think they are important? (Explanation and significance of representations of large and small numbers)

Focus on outcome 2

17. Refer to outcome 2 – functions and algebra. The concept of function is fundamental to this outcome - can you explain what a function is? Informally – to someone who has no clue (e.g. your granny)? More formally to a person who knows mathematics? Why do you think is this concept seen as something important? Can you identify the ideas that form the foundation for this idea of 'function'? (i.e. the underlying roots of the concept?) (Explanation and significance of the function concept)

18. Look at page 28 and 29 … across from grade 10 – 12: what would you say this is all about? (expect the answer calculus)
Can you explain what a derivative is? (Remind them to write on paper. If give a formal definition ask how they would you explain what this is all about to someone who has no formal mathematics education.)
What are the underlying ideas … how would you build the idea of a derivative? Where do you think it starts? Why do you think they include the study of derivatives in the curriculum? (prompts … what are derivatives useful for … what kind of applications? And modelling? …) (Explanation and significance of the derivative concept)

19. Although it is not in the school syllabus, you have also studied integral calculus – can you explain what an integral is? Do you think that there is any foundation work that is done in school math that lays the grounding for the study of integral calculus? If yes can you say what it is? (NB – only ask if there seems to be enough time … otherwise leave for the

Focus on outcome 3

20. Outcome 3: Page 32 'investigate alternative definitions' - can you give one? What is important about definitions? How do you think you go about getting to a valid definition? Can you give an example of what is meant here? (tries to elicit explanation and significance of definitions in geometry – related to polygons here – but should indicate a broader understanding of the significance of definitions and their structure)

21. Page 33 – second bullet – (a) what is meant by 'necessary and sufficient conditions'? (Leave this out if time is short)

22. P 34 - Why is similarity seen as fundamental to the trigonometric functions? (Tries to elicit an explanation of similarity and its significance in developing the ideas of trigonometric ratios)

The last two questions can be left out if there is no time

23. Please briefly explain: what is meant by the word transformation in relation to Geometry? A translation? Reflection? Rotation? Enlargement? (pge 34 -35: second bullet) Why do you think they have included this in the NCS? Can you connect this to trigonometry? To matrices? How – please explain? (Tries to see if this has been brought into their consciousness at all – asks for explanation and significance)

Focus on outcome 4

24. The final outcome – this is all entirely new - why do you think this has been included? Did you study statistics anywhere in your curriculum (degree/ or certificate?). (If yes go on. If no – leave here). What would you say are the most important concepts to learn for this outcome? (p39) What is meant by univariate/ bivariate data? Is that important to know – why? (p 40) It mentions the fundamental counting principle – what is that all about? Is that important? Why?

Thank you for your input. In the next interview we will be focussing on some student responses to some work – here is some material that we will use. You can look at it before the interview to prepare yourself if you wish.
End of interview 1 (approximately 1h).

Appendix G.3: Material and questions for Interview # 2

Introduction – 2nd Student Interview

Welcome again and thank you for agreeing to be part of this process and continuing with it! Last time we were discussing the curriculum statements and the contents to be taught – did you have any further reflections on that? (Did you think about it more afterwards? Was there anything further that you would like to say)

I left you with an investigation to think about (remind them – page 48). Did you manage to do that? Did you write anything down? Please can I take a copy of what you wrote. Briefly tell me about your response.

This interview will focus on some questions for FET mathematics learners. We will discuss some learners' responses to some questions, and discuss some of the questions themselves.

Note: the first questions look at whether students have been made aware of certain typical learner errors. And also the recognition of mathematical forms which could indicate the student teacher's own fluency. The focus is on algebra simply because some selection must be made, and these aspects should all be easily recognizable and well known to the student teachers

a) Section 1: Past matric exam questions

Some HG matriculation questions – potential learner errors.
(Ask them to look at the back of the 'Interim Core Syllabi' booklet.)
This section tries to elicit students' exposure to some typical error patterns (ME) and their responses to the reasoning that is involved (M) and what they can do to help a learner (MT

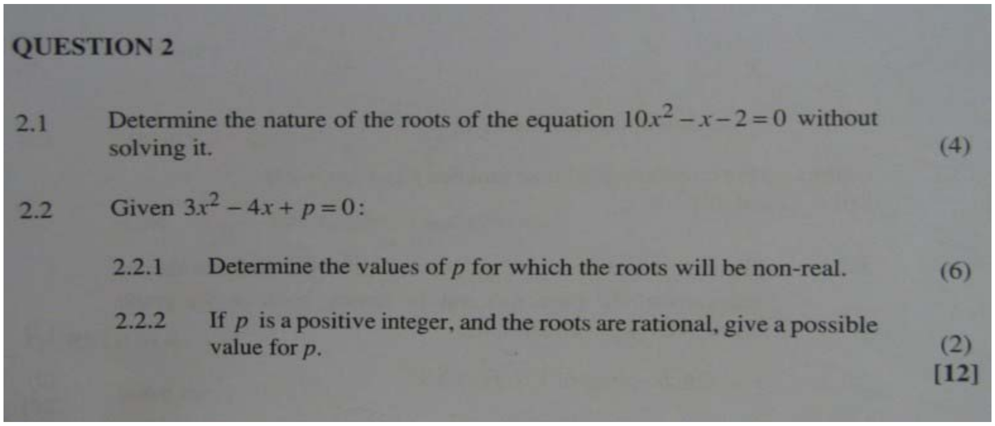
1. Turn to the HG P1 exam – p 3: 1.1.1 what would you say are typical error(s) that might be made in solving this equation. Why might it be made? What is the underlying idea that is drawn on here to successfully manage solving this type of equation? What would you say needs to be done in earlier grades to make sure that students cope with this type of question successfully?
2. Look at 1.2. What problems might be encountered here? What if a student goes on to write $x < 2(x - 3)$? Would that be correct? Why is that not an appropriate move? (What is the problem with doing that? What would be the consequence? If the sign was an = sign would that be appropriate? Why? Why do they write $x \neq 3$. What explanation would you give to explain that 'division by zero is not permissible'?)
3. Now turn to page 6 -8 in the same exam. Question 7.1 asks you to calculate the derivative of a function from **first principles**. What does that mean? (What are the foundations for that idea?) What do you think might be some obstacles for learners in working with this idea? How would you go about building understanding and fluency with this particular idea.

Some standard grade matriculation questions and student answers (Algebra)

The questions on the following pages are all from the Standard Grade Matric Paper 1, 2002.

In each case a questions and answer are shown. The answers given were produced by Grade 12 standard grade students during practice exams while preparing for the 2004 examination.
You are asked to look carefully at the solutions and to answer some questions relating to them.

A:



QUESTION 2

2.1 Determine the nature of the roots of the equation $10x^2 - x - 2 = 0$ without solving it. (4)

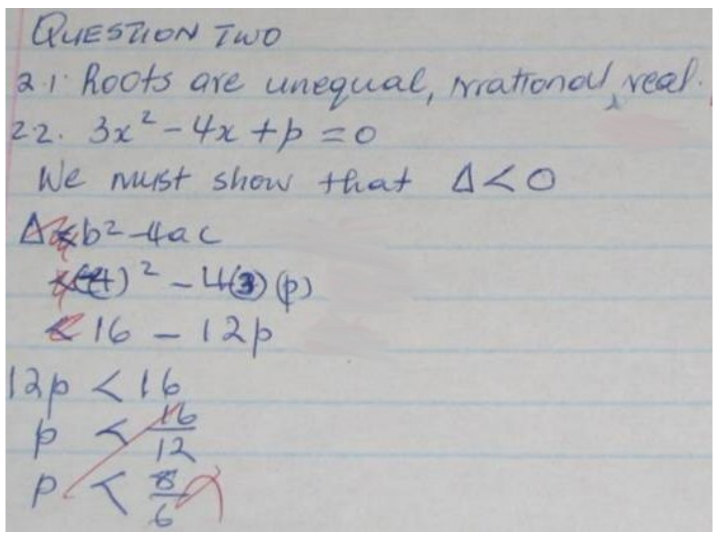
2.2 Given $3x^2 - 4x + p = 0$:

2.2.1 Determine the values of p for which the roots will be non-real. (6)

2.2.2 If p is a positive integer, and the roots are rational, give a possible value for p. (2)

[12]

A student's solution to Question 2 is given below



QUESTION TWO

2.1 Roots are unequal, irrational, real.

2.2. $3x^2 - 4x + p = 0$

We must show that $\Delta < 0$

$\Delta = b^2 - 4ac$

$= (-4)^2 - 4(3)(p)$

$= 16 - 12p$

$12p < 16$

$p < \frac{16}{12}$

$p < \frac{8}{6}$

1. Show how you would assess this student's answer?
2. What are the underlying mathematical ideas on which a successful solution to this type of question depends?
3. Is it important for learners to know this? Why? (What other concepts in mathematics does is this idea connect to? … quadratic fn and its graph … can you draw one?)
4. What would you do to help this learner improve?

B:

Here an exam question is given together with a student's response. The question has been marked by a teacher. In what way do you think the comments made would be helpful/ unhelpful to the learner? Explain.

QUESTION 4

4.1 Complete the following statement so that it is true:
If $f(x)$ is a polynomial and $f(a)=0$, then … (1)

4.2 When $2x^3-3x^2+kx-4$ is divided by $x+1$, the remainder is 4. Determine the value of the constant, k. (4)

4.3 Given $f(x) = x^3-12x-16$:

4.3.1 Show that $x+2$ is a factor of $f(x)$. (2)

4.3.2 Hence or otherwise, find all the solutions of the equation $x^3-12x-16=0$. (4)

[11]

Students' marked answer

Question 4.

4.1. $x - a$ is a factor [Factor theorem]

4.2.
$$\begin{array}{r} 2x^2 - 3x + 1 + kx \\ x+1 \,\big)\, 2x^3 - 3x^2 + kx - 4 \\ 2x^3 - 3x \\ \hline x + kx \\ x + kx \\ \hline -4 \end{array}$$

You must use the remainder theorem. $R = f(-1)$ i.e $f(-1) = 4$ Substitute and then solve for k.

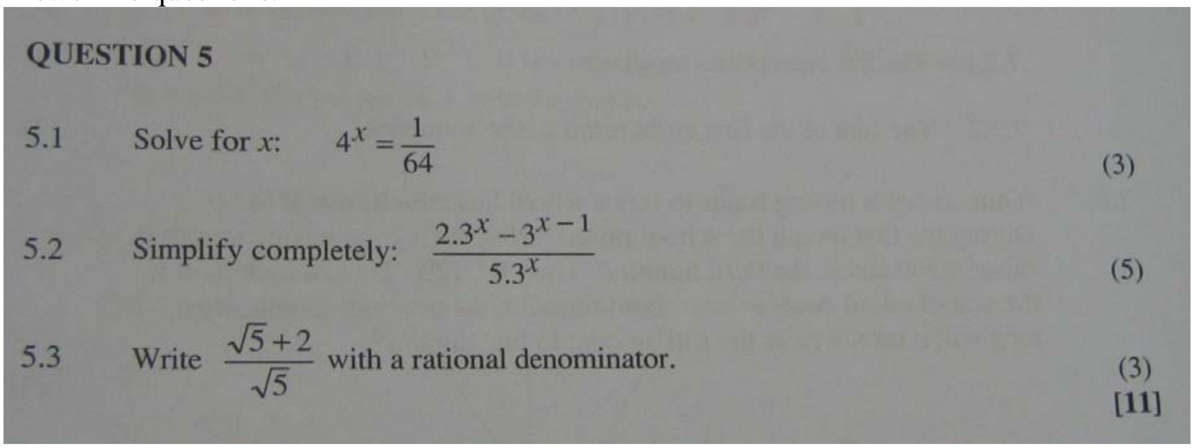
4.3.1. $f(x) = x^3 - 12x - 16$
$= (x+2)(x-4)^2$
$= x = -2$ or $x = 4$

No, Singathura! To show that $x+2$ is a factor you must show $f(-2) = 0$

4.3.2. $x^3 - 12x - 16 = 0$
$d'(x) = 3x^2 - 12$
$= 3(x^2-4)$
$= x^2 - 4 = 0$
$x^2 = 4$
$x = 2$

You were supposed to factorise and then solve for x

C:
A student has produced solutions to the examination questions. Study the solutions and then answer the questions.



QUESTION 5

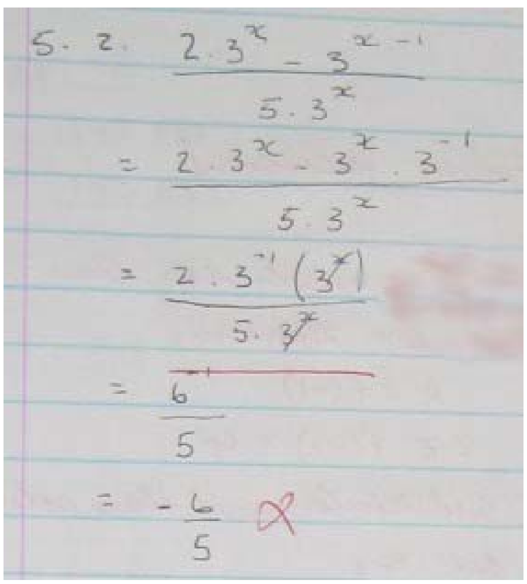
5.1 Solve for x: $4^x = \frac{1}{64}$ (3)

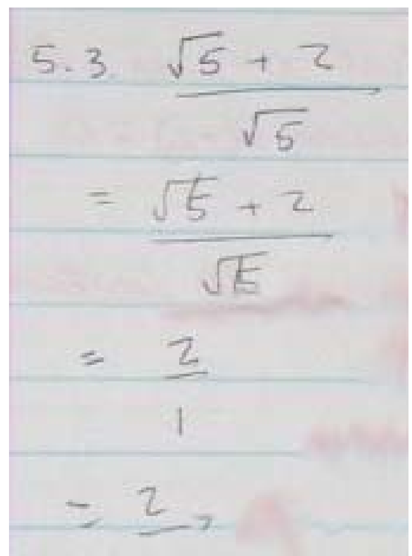
5.2 Simplify completely: $\frac{2.3^x - 3^{x-1}}{5.3^x}$ (5)

5.3 Write $\frac{\sqrt{5}+2}{\sqrt{5}}$ with a rational denominator. (3)

[11]

A student's solutions



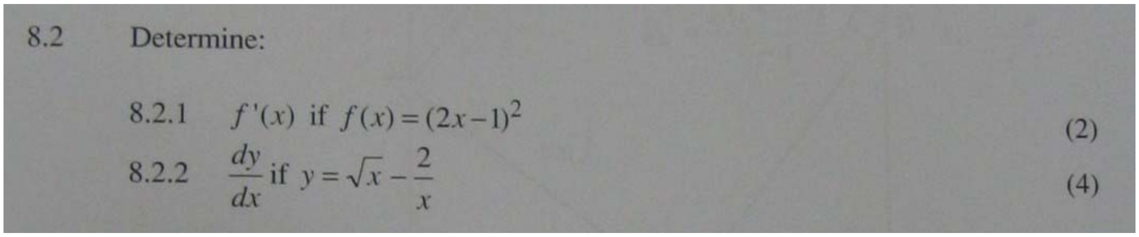


For each solution:

- Identify the error
- Identify the student's underlying difficulty? Do you know for sure? How?
- Where would you say this problem originates?
- What could you do about it?

D:

A student has produced solutions to the examination question. Study the solutions and then answer the questions.

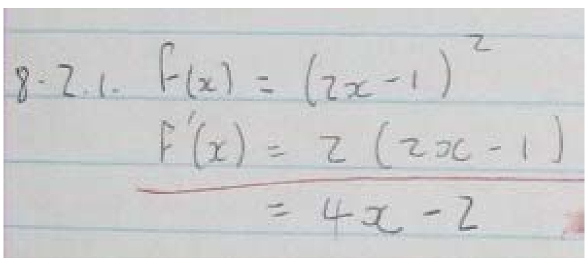


8.2 Determine:

8.2.1 $f'(x)$ if $f(x) = (2x-1)^2$ (2)

8.2.2 $\frac{dy}{dx}$ if $y = \sqrt{x} - \frac{2}{x}$ (4)

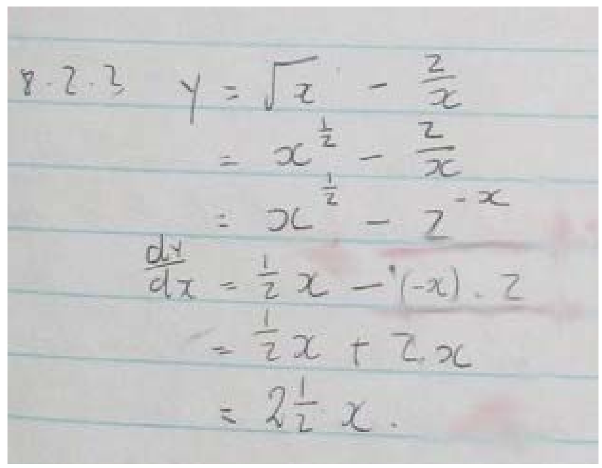
Solution



8.2.1. $f(x) = (2x-1)^2$

$f'(x) = 2(2x-1)$

$= 4x-2$



8.2.2 $y = \sqrt{x} - \frac{2}{x}$

$= x^{\frac{1}{2}} - \frac{2}{x}$

$= x^{\frac{1}{2}} - 2^{-x}$

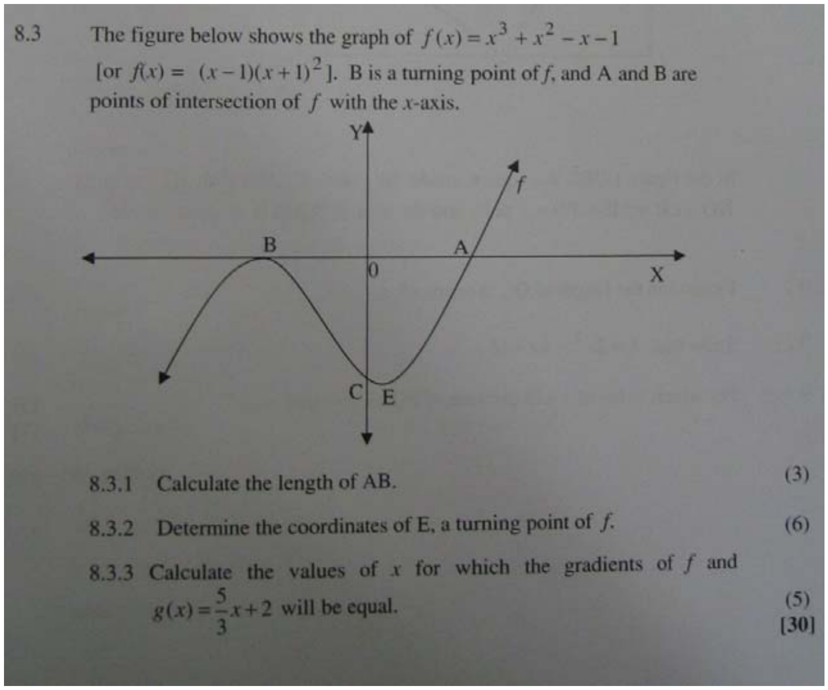
$\frac{dy}{dx} = \frac{1}{2}x - {}^{1}(-x).2$

$= \frac{1}{2}x + 2x$

$= 2\frac{1}{2}x.$

This student's solutions indicate an underlying problem. Describe the problem. What should be done to assist this student?

E: Two students provide answers to this question. Study their answers and then respond to the questions


8.3 The figure below shows the graph of $f(x) = x^3 + x^2 - x - 1$ [or $f(x) = (x-1)(x+1)^2$]. B is a turning point of f, and A and B are points of intersection of f with the x-axis.

8.3.1 Calculate the length of AB. (3)

8.3.2 Determine the coordinates of E, a turning point of f. (6)

8.3.3 Calculate the values of x for which the gradients of f and $g(x) = \frac{5}{3}x + 2$ will be equal. (5)

[30]

Two solution attempts for 8.3.3

Student 1

8.3.3 $fx = g(x)$

$x^3 + x^2 - x - 1 = \frac{5}{3}x + 2$

$x^3 + x^2 - 1\frac{5}{3}x - 3 = 0$

$x^3 + x^2 - \frac{8}{3}x - 3 = 0$

$(x - \frac{8}{3})(x+1)^2$

$x = \frac{8}{3}$ or $x = -1$

Student 2

8.3.3 $3x^2 + 2x - 1$

$\Delta = 0$

$3x^2 + 2x - 1 = 0$

$(3x-1)(x+1) = 0$

$3x = 1$ or $x = -1$

$x = \frac{1}{3}$ or $x = -1$

1. Look at each student's solution.
2. Identify the thinking that lead to each solution.
3. How would you assess each of solution? Give the mark and explain why this would be fair.

Appendix G. 4: Questions to guide interview # 3

Student interview # 3:

Welcome back again. Thank you for sticking with this process. How are you feeling about it? Has it been stressful at all? Discuss and help to relax if needed

We have previously talked a little about the curriculum documents and looked at some questions and answers. In the group interview we also talked a little about the various courses you have taken in your degree/diploma/ certificate and we have talked a little about what is in those courses. Now I want to focus a little more specifically on the mathematics and mathematics education courses you have done while studying to become a teacher.

1. In your Math Ed courses are there any particular theories (theory) that you have studied that you use to think about the teaching and learning of mathematics? Would you say there is a theoretical perspective that underlies the way in which your course (Math/ math ed) is taught … if so can you name it? How do you know?

(Probe: Is there specific research that you have drawn on? What did you use to think about the teaching and learning in mathematics – what were the resources? Journal articles? Books? Research that other people have done and reported on?.(NB do not mention anything particular - names or theories – rather try to elicit what they think about and those things they feel has had an influence on their consciousness - in terms of more than 'discussion with others to find out what works')

Once they have spoken about it give them a grid – have you though about any of these? AND IN RELATION TO EACH ONE /…. Some thing as a focus to elicit ….

2. Think back over your whole B.Ed? If I ask you to identify **the most important thing** you have learnt while studying towards your becoming a 'mathematics teacher' – what would that be? Explain.

3. In terms of actual mathematics courses – was there anything that you did that absolutely inspired you (not necessarily for teaching – but in relation to mathematics)? Explain.

4. In your mathematics education courses, was there anything that you did that absolutely inspired you? Explain.

5. What about while on Practice teaching – was there anything while on practice teaching that inspired you?

(Probe: Did you observe any teachers that you thought did a great job – if so explain what they did and why you think they were inspiring to you? Did you ever have a specialist tutor see you while out on practice teaching? Explain. Did you learn anything more about mathematics while on practice? Teaching mathematics? What did you learn? Did your tutors help with this – and how?).

6. In preparing to teach mathematics did you ever watch 'model lessons' (in reality or on video) as a group/ individually and discuss them? What did you do? How was the discussion structured/ controlled? Who did the teaching?

7. Did you ever read about particular lesson structures or any research articles about classroom practice? If so were these related to general classroom management? To specialist knowledge in relation to mathematics teaching practice? Something else? How have you used them in your own practice?

8. In your planning of lessons what do you do? What process do you use – explain. Please provide some examples of your BEST lesson plans and reflections on that if you have them. Will you be prepared to share with me the reports your tutors wrote for your practice teaching?

9. Do you have a particular structure for a lesson that you like to use? Please explain – show in diagram form. How did you come up with this? Why do you think you use it?

10. Is there anything that you think I didn't ask that you would have expected me to ask?

11. Where there any disturbing things that happened to you during your experiences of becoming a teacher that you would like to share?

12. Is there anything else you would like to add.

Thank you so much for participating in this project. I look forward to your presentation when we get together again as a group.

Please remember to select examples of your work that you would be willing to share with me.

Appendix G.5: Data tables for Sonny's Story

Table 11: Sonny's Story - data produced from working through all three interview transcripts.

Utterance	content of utterance												place utterances come from								
	PRF (discursive K field)				ORF (official K)				experience (local K)				projected identity - subject positioning - image of self						how self image is legitimated		
									school or university				within division of labour						type of data (psychic register)		
													learner								
chunk/episode	M	ME	MT	E	NSE	NCS	Old Curriculum	general policy	as M L in past	as learner T	everyday L	other	school M	teacher	teacher	mathematician	other	Individual Character	Concept (Symbolic)	Percept (Imaginary)	Affect (Real)
Focus 1 : Imagined Practices (tables exclude chunks focused on introductions/ housekeeping)																					
Int # 1.1 U# 5 to 9 (four NB aspects of good MT)	0	0	0	0	1	1	0	1	1	0	0	0	1	1	0	0	0	Self reflective	0	1	0
Int #1.1 U# 10 to 19 (four NB aspect of M)	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	critical, systematic thinker/ inventive	?	1	0
Int #1.1 U# 21 to 25 (image of self as T)	0	1	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	caring, sensitive, helpful, diligent, well prepared, makes a difference	?	1	0
Int #1.1 U# 26 to 28 (self in relation to other T)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	open, shares ideas, learns from others, humble	0	1	0

Int #1.1 U# 29 to 31 (a good M Learner)	0	1	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	listens, share ideas, respectful, diligent, argues convincingly	0	1	0
Int #1.1 U# 31-32 (the most NB to know about M Learning?)	0	1	0	1	0	0	0	1	0	0	0	0	0	1	1	0	0	shares ideas, listens and learns from others;	1	1	0
Int #1.1 U# 33 - 35 (what about assessment?)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	_	?	?	0
Total: 7 chunks (focus 1)	1	4	0	3	2	3	0	4	2	0	0	0	1	3	4	2	0		1 (3)	6 (7)	0
% **of 7 chunks focus 1 (to nearest whole)**	**14**	**57**	**0**	**43**	**29**	**43**	**0**	**57**	**29**	**0**	**0**	**0**	**14**	**43**	**57**	**29**	**0**		**14 (43)**	**86 (100)**	**0**
Focus 2: The school curriculum (NCSM)																					
Int # 1.2b. U# 36 to 37 (math as a subject)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	systematic worker	?	0	0
Int # 1.2b. U# 38 to 41(Learning math vs learning math teaching)	1	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	Someone who is selective and sensitive to context	0	1	0
Int # 1.2b U# 42 to 46 (math for critical citizenship)	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	Is inclusive	0	?	0

Int # 1.2b U# 47 to 50 (what is mathematical thinking?)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	-	0	1	0
Int # 1.2b U# 51 to 55 (what does it mean to invesigate?)	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	-	1	0	0
Int # 1.2c U# 56 to 65 (investigating the graphs of functions)	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	able to work things out	1	0	0
Int # 1.2c U# 66 to 67 (different representations of functions)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	-	1	0	0
Int # 1.2c U# 68 to 71 (investigating graphs of functions)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	Work systematically	1	0	0
Int # 1.2c U# 72 to 75 (algebraic manipulation)	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	Someone who thinks about what they are doing	1	0	0
Interview # 1 ends – focus 2c continues during Interview # 2																					
Int # 2.2c U# 5 to 15 (real/non-real numbers)	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	-	1	0	0

Int # 2.2c U# 16 to 27 (exponents and logs)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	?	Someone who needs to be taught	1	0	1
Int # 2.2c U# 28 to 42 (functions)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	?	-	1	1	0
Int # 2.2c U# 43 to 54 (the derivative)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	Is unfortunate (a victim of apartheid ed)	1	0	1
Int # 2.2c U#: 55 to 59 (the integral)	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	unfortunate (lacks opportunity)	1	0	1
Int # 2.2c U# 60 to 64 (geometric definitions and their significance)	0	0	0	0	0	0	0	0	1	0	1	0	0	0	?	0	1	Is knowledgeable	0	1	0
Int # 2.2c U#: 65 to 67 (similarity and trig ratios)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	_	1	0	0
Total 15 Chunks (Focus 2)	12	1	1	0	0	1	0	1	5	1	1	0	1	3	2 (3)	9 (11)	1 (3)		11 (12)	4 (5)	3
% of 15 chunks : focus 2 (to the nearest whole)	**80**	**7**	**7**	**0**	**0**	**7**	**0**	**7**	**33**	**7**	**7**	**0**	**7**	**20**	**13 (20)**	**60 (73)**	**7 (20)**		**73 (80)**	**27 (33)**	**20**

Focus 3: Imagined and actual learner productions																					
Int #2.3a U# 72 to 77 (imagining learner errors in an assessment item - quadratic equation)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	listens to learners	1	1	0
Int #2.3a U# 78 to 82 (thinking about learner errors in solving inequalities and division by zero)	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	Argues convincingly	1	1	0
Int #2.3b U# 83 to 86 (analysing student productions to matric calculus problem)	1	1	(?)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	understands learners thinking but evaluates thinking mathematically	1	0	0
Int #2 ends. Focus 3 continues into int # 3																					
Int #3.3b U# 1 to 14 (student productions while working with exponents)	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	Practicing exercises is important	0	1	0
Total 4 Chunks (Focus 3)	3	2	(1)	0	0	0	0	0	2	0	0	0	1	0	4	0	0		3	3	0

% of 4 chunks focus 3 (to the nearest whole)	**75**	**50**	**(25)**	**0**	**0**	**0**	**0**	**0**	**50**	**0**	**0**	**0**	**25**	**0**	**100**	**0**	**0**		**75**	**75**	**0**
Focus 4: Reflections on University career																					
Int# 3.4 U# 33 to 44 (a theory of math education?)	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0		?	1	0
Int# 3.4 U# 44 to 59 (a study group)	0	0	0	0	0	0	0	0	0	1	?	0	0	1	0	0	1	share ideas; help one another	0	?	0
Int# 3.4 U# 60 to 64 (what was most important in studies of math)	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	Someone interested in aspects relevant to everyday life	0	1	0
Int# 3.4 U# 65 to 68 (what was most iimportant from studies in math ed/ math method)	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	Someone interested in aspects relevant to everyday life	0	1	0
Int# 3.4 U# 60 to 85 (mathematics teaching practice)	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	_	0	1	0
Int# 3.4 U# 86 to 104 (lesson planing for mathematics teaching)	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	Someone who is well prepared	0	1	0

Int# 3.4 U# 105 to 109 (typical pattern for a lesson)	0	0	?	0	0	0	0	0	0	1	0	0	0	0	1	0	0	time conscious; checks learners work; manages the class well	0	1	0
Int# 3.4 U# 108 - 119 (irrelevant discussion - interlude)																					
Int# 3.4 U# 120 to 138 (classroom management) -	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	has difficulty managing the class- uses the **threat** of assessment as a management tool	0	1	0
Total 8 Chunks (Focus 4)	1	2	2 (3)	1	0	0	0	0	1	5	(1)	0	0	7	1	0	2		(1)	7(8)	0
% of 8 chunks focus 4 (to the nearest whole)	**13**	**25**	**25 (38)**	**13**	**0**	**0**	**0**	**0**	**13**	**63**	**(13)**	**0**	**0**	**88**	**13**	**0**	**25**		**(13)**	**88 (100)**	**0**
Totals for all (34 chunks - excludes houskeeping)	17	9	3 (5)	4	2	4	0	5	10	6	1 (2)	0	3	13	11 (12)	11 (13)	3 (5)		15 (19)	20 (23)	3
% of totals 34 chunks (excluding housekeeping)	**50**	**26**	**9 (15)**	**12**	**6**	**12**	**0**	**15**	**29**	**18**	**3 (6)**	**0**	**9**	**38**	**32 (35)**	**32 (38)**	**9 (15)**		**44 (56)**	**59 (68)**	**9**

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