

MATHEMATICS STUDENT TEACHERS' APPROACH TO, EXPERIENCE OF AND ATTITUDES TOWARDS MATHEMATICAL MODELLING

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Abstract—This paper interrogates the thinking and planning strategies of Mathematics student teachers, when faced with a mathematical modelling challenge for the very first time. Mathematical modelling is the process of generating mathematical representations in attempting to solve real life problems. Modelling has the proven ability to develop learners' reasoning, communication and problem solving competencies. Literature cautions against the unpreparedness of Mathematics teachers in teaching modelling to learners. The second aim of the Curriculum and Assessment Policy Statement (CAPS, 2011, p. 8) emphasises mathematical modelling as "...an important focal point of the curriculum. Real life problems should be incorporated into all sections whenever appropriate." A traditional textbook problem was converted into a modelling task and eight groups of third year mathematics student teachers at the University of Johannesburg were confronted with this challenge. The groups' strategies, nature of engagement and proposed solutions were monitored, while their attitudes towards the teaching of mathematical modelling were also researched. The aforementioned richly contributed to guidelines aimed at the effective integration of modelling into the new mathematics curriculum and into the formal education of mathematics teachers.

Keywords: Mathematical modelling; Problem solving; Attitudes towards mathematics; Mathematics teacher education.

1. BACKGROUND CONTEXT AND PURPOSE

Fennema and Franke (1992) accentuate four components of mathematics teachers' knowledge, namely knowledge of mathematics, of mathematical representations, of students and of teaching and decision making. The first two components, according to Shulman (1986), emphasise mathematical content knowledge (MCK) and the last two components pedagogical content knowledge (PCK). Although a profound understanding of MCK is essential, it is regarded as insufficient in effectively teaching mathematics (Turnuklu & Yesildere, 2007).

Mathematical concept formation and learning initially depend on the classroom environment and learner activities, with teachers' attitudes, knowledge, judgements and beliefs heavily impacting on this. "It has become an accepted view that it is the [mathematics] teacher's subjective school-related knowledge that determines for the most part what happens in the classroom", confirms Chappman (2002, p. 177). Teacher attitudes and beliefs about mathematics are a vital part of their subjective and pedagogical knowledge (Opt't Eynde, De Corte & Verschaffel, 2002). Teacher education programmes therefore have a huge role to play in steering and shaping prospective teacher beliefs and attitudes in an appropriate manner.

Authentic problem solving is increasingly used to great effect in enhancing learners' mathematical competencies and mathematics teachers' PCK and MCK (Buchholtz & Mesroglu, 2013). What's especially comforting is that the relationship between mathematical modelling and authentic learning has been proven (Kang & Noh, 2012). Modelling has been incorporated into schools' mathematics curricula of several countries, expecting mathematics teachers and learners to operate in a "culture of mathematising as a practice" (Bauersfeld (1993), in Stillman, Kaiser, Blum & Brown, 2013, p. 9). It is now also a theme of South Africa's Curriculum and Assessment Policy Statement (CAPS, 2011) for mathematics, geared at the Further Education and Training (FET) phase.

The second aim of the curriculum statement (CAPS, 2011, p. 8) specifies as follows: "Mathematical modelling is an important focal point of the curriculum. Real life problems should be incorporated

into all sections whenever appropriate. Contextual problems should include issues relating to health, social, economic, cultural, scientific, political and environmental issues whenever possible". Julie (2002) agrees that mathematical modelling let learners realise the relevance of mathematics as a subject.

Ng (2013) and Ikeda (2013) both caution against the unpreparedness of mathematics teachers in teaching modelling. They put forward pleas that mathematics student-teachers should be formally exposed to modelling tasks during their education. Not only should these prospective teachers eventually model modelling, but they should also be able to cultivate a climate conducive towards mathematical modelling in their classrooms.

The *first goal* of this study is to identify and analyse the thinking and planning strategies of third year mathematics student-teachers, who are exposed to and involved in a mathematical modelling activity. The *second goal* is to explore these student-teachers' experiences of and attitudes towards the aforementioned. The authors intend to deduce a set of guidelines aimed at the effective integration of mathematical modelling into the pre-service education of Grade 10-12 mathematics teachers.

2. LITERATURE PERSPECTIVES: MATHEMATICAL MODELLING AND ITS DIVIDENDS

2.1. Theoretical framework

There continues to be much disagreement about the potential influence that teacher education has on teacher learning (compare Boaler, 2000; Lampert, 2001 and others). Some critics question whether teachers learn anything of value in their pre-service education programs, while others claim that the effects of these programs have been nullified once teachers enter more conventional school settings. The authors of this paper are of the opinion and assume that the pre-service education of mathematics teachers, especially in the current South African school context, has a fundamental influence on their practices, beliefs, attitudes and early effectiveness. It is of course not the only aspect that shapes their role as mathematics teachers, but it has a vital initial influence.

Aligned with the abovementioned assumption, the theoretical framework that underlies this inquiry relates to two complementary sets of literature perspectives. The first set of underlying perspectives is the Learning to Teach Secondary Mathematics (LTSM) framework (Peressini, Borko, Romagnano, Knuth and Willis, 2004, p. 68). This framework views learning-to-teach activities and processes in mathematics through a situative lens, based on two assertions. The first claim is that *how* a learner acquires a particular set of knowledge and skills and the specific teaching context (*situation*) in which it happens fundamentally influence what is eventually learned (Greeno, Collins and Resnick, 1996). The second claim is that teachers' knowledge, beliefs and attitudes interact with teaching-learning situations, implying, in the words of Adler (2000, p. 37) that mathematics teacher education is "...usefully understood as a process of increasing participation in the practice of teaching, and through this participation, a process of becoming knowledgeable in and about teaching".

The second set of underlying perspectives is underscored by the Vygotskian idea of the Zone of Proximal Development (ZPD), originally defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1986, p. 86). Chaiklin (2003, p. 40) summarises the core message of Vygotsky's ZPD with what learners are able to do via collaborative support today, they should be able to do independently tomorrow.

For the purpose of this paper, the three assumptions underlying ZPD particularly appeal to the authors, since they align well to the purpose and methods of this research on mathematical modelling. Chaiklin (2003, pp. 40-41) highlights them as the "generality assumption" (the ZPD is applicable to learning in all subject domains), the "assistance assumption" (learning is enhanced by the support of a more competent 'other'), and the "potential assumption" (learners usually display 'built-in' developmental properties and an 'automatic' readiness to learn).

The *Learning to Teach Secondary Mathematics* (LTSM) framework and the *Zone of Proximal Development* (ZPD), in their combination, serve as the theoretical lenses through which this specific study is viewed.

2.2. Conceptualising model, modelling and mathematical modelling

A model is a visualisation of something that cannot be directly observed via a description or a resemblance (Kang & Noh, 2012). Lesh and Doerr (2003) regard models as theoretical or conceptual systems that are used in an abstract form for a specific purpose. Models are social initiatives and should be reusable in different situations (Greer, 1997). Whereas the end-product is known as a *model*, the cognitive activities preceding it, which involve and require reasoning can be labelled as *modelling*.

Modelling is a cyclical process involving (1) the creation of a provisional model, which stems from (2) a series of interactive activities, which should be (3) continually tested and refined in order to improve or verify it (Kang & Noh, 2012). The modelling process can, at any stage, incorporate various forms of language, like computer programmes, sketches, drawings, tables, spreadsheets, and others.

Aligned to the abovementioned, *mathematical modelling* is the process of generating mathematical representations in attempting to solve real life problems (English, Fox & Watters, 2005; Greer 1997; Ikeda, 2013). A mathematical modelling process (cycle) consists of four sequential phases (Balakrishnan, Yen & Goh, 2010, p. 237-257), namely “mathematisation” (representing a real-world problem mathematically), “working with mathematics” (using appropriate mathematics to solve the problem), “interpretation” (making sense of the solution in terms of its relevance and appropriateness to the real-world situation) and “reflection” (examining the assumptions and subsequent limitations of the suggested solution). These representations are then validated, applied and continuously refined (Ang, 2010).

2.3. Three levels of modelling tasks

The International Community for the Teaching of Mathematical Modelling and Applications (ICTMA, in Stillman, Gailbrath, Brown & Edwards, 2007, p. 689), fittingly distinguishes mathematics applications from modelling. Applications attempt to link mathematics to reality: “*Where can I use this particular piece of mathematical knowledge?*”. Mathematical modelling tasks focus on the antithesis, linking reality to mathematics: “*Where can I find some mathematics to help me with this problem?*”

Galbraith and Clatworthy (1990), later supported by Kang & Noh (2012), acknowledge three different levels of mathematical modelling tasks. Traditional problem solving fits the description of a so-called level 1-problem. Such problems are already carefully defined, no additional data is required to formulate a model and the problems require specific mathematical procedures. Problems at level 2 have a slight vagueness as insufficient information needed to successfully complete the task is given. Level 3-problems are the most authentic and open-ended type, characterised by unstructuredness and a challenging level of complexity (Ng, 2013).

2.4 The dividends and necessity of mathematical modelling exposure

It was rationalised and deduced (in Section 1 above) that:

Teacher education programs play an important role in steering and shaping prospective teacher beliefs and attitudes in an appropriate manner.

Authentic problem solving can be used to great effect to enhance learners’ mathematical competencies and teachers’ PCK and MCK.

A strong positive relationship exists between mathematical modelling and authentic learning.

Mathematics teachers (worldwide) are generally underprepared to teach modelling and student-teachers should be exposed to the topic during their education.

Modelling is since 2011 a prescribed theme in the CAPS document. According to the National Curriculum and Assessment Policy Statement Grades R-12 (2012, p. 6), two essential abilities that mathematics learners should gradually develop are to “identify and solve problems and make decisions using critical and creative thinking”, and “to demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation”. Suitable modelling tasks are exactly the kind of exposure that learners nowadays require to empower them in striving to attain the two aforementioned CAPS ideals.

Research in Singapore (Ng, 2013) and South Africa (Julie, 2002) reveal that teachers’ lack of prior experience in problem solving and their (sometimes too conventional) beliefs about mathematics are major obstacles, when they are exposed to modelling activities. “The teachers generally perceive mathematics to be formula-based involving linear track solutions”, remarks Ng (2013, p. 346), implying that they are mostly severely challenged by the open-endedness of modelling.

In this regard teacher education programmes have a prominent responsibility to fulfil. Julie (2002, p. 7), supported earlier by Kang & Noh (2012), phrases it in the following manner:

There is no doubt that this realisation can only be effected through mathematics teacher education programmes which, in addition to developing mathematical modelling pedagogical content knowledge, aim at developing mathematical modelling as content. After all, it is during the engagement with mathematical modelling as content that windows of opportunities are opened for dealing with relevance relevantly.

3. RESEARCH DESIGN AND DATA COLLECTION

3.1 Research paradigms and methods

The research paradigm refers to the researchers’ worldviews, as reflected in a matrix of beliefs, perceptions and underlying assumptions (Foucault, 1972), which guided them in approaching the research problem. The paradigm influenced the researchers’ decisions regarding the data collection instruments, selection of participants and methods of analyses, among others. Alongside the positivist, post-positivist, critical theory and pragmatist worldviews, the constructivist-interpretivist approach (Giacobbi, Poczwadowski & Hager, 2005; Onwuegbuzie & Leech, 2005) was chosen as primary research paradigm underlying this study.

The inquiry aims to understand participants’ experiences of, attitudes towards and perspectives on the personal and group dynamics that are forged during their exposure to and involvement in a mathematical modelling activity. The chosen paradigm enabled the researchers to collect data on the lived experiences of the participants, via their individual and/or shared exposure to and involvement in problem-solving activities (Charmaz & Mitchell, 1996; Cresswell, 2009).

Besides the qualitative constructivist/interpretive approach, the inquiry also incorporates a quantitative dimension. This dimension relates to an attempt to measure participants’ attitudes towards the mathematical modelling activity, as well as towards the subject mathematics. It was conducted from a post-positivist stance (Heppner & Heppner, 2004), which presumes that an external reality exists independent from the researchers, and although this reality cannot be known fully, attempts at measuring it would be possible.

3.2 The mathematical modelling experiment

In striving to realise the goals an in-class experiment was conducted during the last week of the first semester of 2014. The experiment was carefully planned and modelled on a similar pilot study, involving 48 mathematics teachers and 57 mathematics student teachers, conducted just more than a decade ago in 2003 at the Nanyang Technological University in Singapore (Ng, 2013, pp. 339-349). Thirty-eight (38) third year Mathematics student-teachers, in more or less even sized-groups, were exposed to a mathematical modelling activity, during which their own views of their group’s problem-solving strategies were collected. Afterwards, data in respect of their lived experiences and attitudes towards mathematics and mathematical modelling were also gained. The experiment was

conducted in a one hour 50 minutes contact session during the scheduled Mathematics time slot on the timetable.

The participants had little formal mathematics teaching experience - approximately five weeks of school practice in total through the two and a half years of their studies so far. They have also never been exposed to modelling tasks before, and neither to the teaching of such tasks. Care was taken to divide them into eight relatively comparable groups, each containing four to six members, based on their performance in the 3rd year Mathematics course. Proportional stratified sampling was employed to randomly assign them to the groups, in such a way that each group at least had a high(er), a moderate and a low(er) achiever.

The session kicked off with a 20 minute presentation (by one of the researchers) on the goal and nature of the research and experiment. The inclusion of mathematical modelling in CAPS, what modelling entails, phases of a typical modelling cycle (as outlined in section 2.2 above) and the ethical measures taken to safeguard the confidentiality of collected data and the anonymity of each participant, were the main components of the presentation. Individual written participant consent was obtained, also in respect of their feedback, the day after the experiment.

The selected modelling task on "Traffic flow" (Stewart, Redlin & Watson, 2012, p. 661) was an adaption of one of their textbook problems. The task can be categorised as a level three challenge (compare section 2.3), typified as open-ended and incomplete. It involves data collected by a city's Traffic Department on traffic flow in a busy section of the city's street network. Participants were requested to recommend the best location for a Day Care Centre for toddlers to the Department of Town and Regional Planning, based on the traffic flow data provided.

Taking into account the complexity of the task, the inexperience of the student teachers (as modellers) and the relatively limited interaction time, groups were not expected to come up with well-defined solutions to this real-world problem, nor to provide their views on the representativity, validity and applicability of their 'answers'. Groups were merely required to report on the strategies and methods that they employed. The experiment and group interactions were carefully monitored by the researchers and each group recorded their strategies, processes and suggested solutions on a pre-designed worksheet.

The researchers initially also planned that each group should critique their suggested solutions, based on three generally accepted criteria of Ng (2013, p. 342), namely *representation* (how well their suggested solutions solve the problem), *validity* (suggestions on how to improve their solutions) and *applicability* (whether their solutions can be used in other contexts). As the experiment unfolded, it was realised that the aforementioned was definitely a bridge too far.

3.3 Collection and analysis of data on participants' demographics, experiences and attitudes

The day after the experiment (described in section 3.2 above), during the last contact session of the first semester, individual participant feedback was collected. A self-designed questionnaire was used for this purpose.

3.3.1 Demographical data

Section A of the questionnaire's contains a number of demographical items (gender, ethnical group, home language, age and Gr 12 performance in Mathematics), enabling the researchers to construct a participant profile. The last two items of the section gained information on participants' exposure to mathematics in their Gr 12 year and the main reason(s) underlying their decision to study towards becoming mathematics teachers. Collected data were captured in a Microsoft Excel worksheet and then analysed via the frequencies and descriptive statistics options of the Statistical Package for the Social Sciences (SPSS, version 22).

3.3.2 Participants' attitudes towards mathematics as subject

The Attitudes Towards Mathematics Inventory (ATMI, Tapia & Marsh, 2004) is an internationally recognised instrument, used for gaining learner attitudes towards Mathematics as subject.

Schackow (2005) tailored the ATMI towards mathematics student- and practising teachers, making it appropriate for this study. The ATMI has four underlying dimensions, namely *value* (whether mathematical skills are worthwhile and necessary), *enjoyment* (whether mathematical problem-solving and challenges are enjoyable), *self-confidence* (expectations about doing well and how easily mathematics is mastered, or not) and *motivation* (the desire to learn more about mathematics and to teach it). Only two ATMI dimensions, enjoyment (ten items) and self-confidence (15 items), were incorporated into the questionnaire (Section B). Each of the 25 items uses a Likert-type response scale, ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*). All item responses in each dimension are added, yielding total scores for the enjoyment (maximum 50) and self-confidence (maximum 75) dimensions. Analysis of ATMI data, including validity and reliability measures, were also performed via the Statistical Package for the Social Sciences (SPSS, version 22).

3.3.3 Participants' perceptions of mathematical modelling

Section C of the questionnaire focusses on participants experiences of and current attitudes towards mathematical modelling. All four questions were open-ended. The final question collected concrete suggestions from participants on how they might be supported during their education in becoming more effective modellers and teachers of modelling.

Individual feedback per question was consolidated into a worksheet and hence analysed via the constant comparative method (Jacobs and Du Toit, 2006:305-306), as a directed form of content analysis (Hsieh and Shannon, 2005:1281). Appropriate participant views per category, by quoting their direct words, are integrated in the findings.

3.3.4 Trustworthiness, validity and reliability

Strategies to maintain the *trustworthiness* of the experiment included selected credibility, transferability, dependability and confirmability measures, originally prescribed by Lincoln and Guba (1985). A thorough description of the experiment, its planning and implementation, the properties of the participants and the data collection instrument and methods enhances transferability. A dense description of the methodology employed in the constant comparative and directed content analysis methods promotes dependability and rigour. The credibility of the research is augmented through a proper interrogation and triangulation of the findings by both researchers, while the original records were maintained for follow-up purposes.

The creators of the Attitudes Towards Mathematics Inventory (ATMI), Tapia and Marsh (2004, p. 18-19) report that the survey shows a high degree of internal consistency (Cronbach's alpha was in the region of .88), while its factor structure "...covers the domain of attitudes towards mathematics, providing evidence of content validity". The researchers conducted a pilot study (involving three third year mathematics students, who weren't participants) on the questionnaire, confirming its perceived *validity*. Three Cronbach's alpha coefficients were hence calculated in respect of the two ATMI dimensions, Enjoyment and Self-confidence, and the participants' total ATMI score (the sum of the two dimensions). The coefficients are portrayed in Table 1 below and confirm that the quantitative items of the questionnaire have high internal consistency (*reliability*).

Table 1: Reliability of the Attitudes Towards Mathematics Inventory (ATMI)

ATMI dimension	Cronbach's alpha
Enjoyment (7 items ^❶)	.745
Self-confidence (15 items)	.922
ATMI total (25 items)	.917

❶ The original Cronbach's alpha value was .718 for all ten items in the Enjoyment dimension, but after the removal of items 1, 2 and 10, the alpha value for the remaining seven items increased to .745

4. EMPIRICAL FINDINGS

4.1 Demographic profile of the participants

Table 2 (on the next page) displays elements of the demographics of the participants. The majority can be characterised as *male* (63%), *black* (76%), *indigenous language* speaking (74%), *23 years or younger* (61%), and having scored *60% or more* for Mathematics in matric (79%).

Participants' motivation to become mathematics teachers

Their responses to the question: '*What is the main reason(s) underlying your decision to become a mathematics teacher?*' indicate participants' intentions in sustaining their relationship with the subject mathematics. Main feedback categories are their interest in mathematics and the resulting curiosity and challenges it generates; the opportunity to make a difference to learners in disadvantaged communities, who lack good mathematics education; and to positively contribute to South Africa's' educational challenges.

4.2 Participants' attitudes towards mathematics as a subject

Sweeting (2011, p. 53-54) categorises teacher attitudes towards mathematics as subject (represented by their total ATMI score out of 200) on five levels, which she respectively labels as "strongly negative, negative, neutral, positive and strongly positive". Using her categorisation in this study, positive scores on the enjoyment dimension (maximum 50) would be *41 or more*. Likewise, corresponding scores on the self-confidence (maximum 75) dimension would be *61 or more*. A positive ATMI total (incorporating just the two dimensions – maximum 125) would be minimum *100*.

Table 3 (on the next page) provides a breakdown of the participants' ATMI scores. The researchers expected the majority of the participants (all of them studying to become mathematics teachers), to portray a positive disposition towards mathematics. Thirty-two of the 38 participants (84.2%) have a positive to strongly positive attitude in respect of their *enjoyment* of mathematics as a subject, while 28 (75.6%) disclosed a corresponding attitude in respect of their mathematics *self-confidence*.

Their *total* ATMI scores (on the two dimensions) unveiled a similar pattern, with the mean score of 109 (out of 125) sufficient reason to describe the group's attitude towards mathematics as positive to strongly positive. Although the ATMI is a self-rating survey (which is definitely a limiting factor), the strong relationship between a positive attitude towards and achievement in mathematics has been well documented in many studies (compare Brown, McNamara, Hanley & Jones, 1999; Dowker, Ashcraft & Krinzinger, 2012; Durandt & Jacobs (2013); Ismail & Anwang, 2009; Khatoon & Mahmood, 2010; Sweeting, 2011, and several others).

Table 2: Demographic profile elements of participants (n=38)

Profile variable		N	%
Gender	Female	13	34.2
	Male	24	63.2
	No response	1	2.6
Ethnic Group	Asian, incl. Indian	2	5.3
	Black	29	76.3
	Coloured	1	2.6
	White	6	15.8
Home Language	Afrikaans	3	7.9
	English	6	15.8
	Indigenous	28	73.7
	European	1	2.6
Age in years (Avg= 23.3 yrs)	Up to 21 years	10	26.3
	22 or 23 years	13	34.2
	24 to 26 years	11	28.9
	27 years and older	3	7.9
	No response	1	2.6
Math mark in Gr 12 (Median = 60-69%)	50 – 59%	7	18.4
	60 – 69%	12	31.6
	70 – 79%	8	21.1
	80% +	10	26.3
	No response	1	2.6

Table 3: Distributions of ATMI enjoyment, self-confidence and total scores

ATMI dimension		N	%
Enjoyment (Mean = 44.7)	46–50	13	34.2
	41–45	19	50.0
	36–40	6	15.8
Self-confidence (Mean = 64.3)	68–75	12	32.4
	61–67	16	43.2
	53–60	6	16.2
	52 and lower	3	8.1
Total ATMI score (Mean = 109.0)	113–125	13	35.1
	100–112	18	48.6
	87–99	5	13.5
	75–86	1	2.7

Group strategies and proposed solutions to the modelling challenge

4.4.1 Solution styles and complications

All eight groups succeeded in representing the real-world problem mathematically. Five groups used more than one style to present the data in a mathematical context. All eight groups made use of graphical illustrations, one group adding a histogram, two groups a double bar graph and three groups a two-way table.

Most groups experienced difficulty in introducing variables and in matching them to unknown quantities. Initially, the majority of groups introduced two variables, one for the number of cars entering and another for the number of cars leaving the city's street network. They later realised that the number of cars entering an intersection (from various directions) must equal the number of

cars leaving that intersection. In setting up their mathematical models, four variables (for example x , y , w and z) were required. The variables represent the number of cars (from all four directions) traveling along a specific street. Most groups felt unfamiliar working with four variables.

The researchers had to intervene and guide most groups in setting up a first and even a second mathematical equation. Thereafter, all groups could formulate the third and fourth equation. Four of the groups attempted to solve the system of linear equations. Only one group eventually provided a probable solution, while another group introduced a more sophisticated mathematical strategy, involving matrices.

4.4.2 Task interpretations

An interrogation of their submitted worksheets revealed that half of the groups made a recommendation as to the most appropriate location of the Day Care Centre. One group argued in favour of the intersection with the highest traffic flow (being more convenient for working parents), while two groups supported exactly the opposite (an intersection with the lowest traffic volume). Another group juxtapositioned convenience (for parents) versus safety (for toddlers) and thus recommended a medium busy intersection. Only three groups found time to critique their solutions (models) and also made suggestions to improve their own models. In the researchers' opinion, the open-ended nature of the modelling task was perhaps the biggest challenge to the participants.

Participants' experiences and suggestions to enhance their modelling skills

The participants provided feedback on their lived experiences of the modelling experiment and also made suggestions that could enhance their abilities to implement mathematical modelling tasks.

Their experiences were dominated by the overwhelming open-ended nature of the modelling problem and its consequential challenges. Participants reported that group members struggled to agree on an idea and to get everyone's point of view across. As a result the groups found it extremely difficult to construct mathematical equations to represent task contains. Even after formulating and attempting to solve the equations (as reported in 4.4.1), the interpretation of their findings was confusing as some participants were not convinced about their validity. Participants' feelings and attitudes toward mathematical modelling fluctuate from extremely negative to tremendously positive. Besides the challenging nature of the task, participants acknowledged the opportunity to experience mathematics in the real-world.

A number of suggestions to assist pre-service mathematics teachers in becoming good modellers and effective modelling teachers were made. The crux of their suggestions revolves around the provision of guidelines on how to approach mathematical modelling problems, more frequent exposure to modelling activities (and to examples with their solutions), more group work opportunities, more time on tasks and the challenge to present a lesson on mathematical modelling.

5. CONCLUSION

The literature is filled with references to the positive relationship between mathematical modelling and authentic learning. The theme of modelling is since 2011 a theme in South Africa's Curriculum and Assessment Policy Statement for the Further Education and Training phase.

The underpreparedness of mathematics teachers to teach, but also to grasp modelling is a global phenomenon. Several calls for the exposure of mathematics student-teachers to modelling tasks during their education are made. Not only are prospective mathematics teachers expected to model mathematical modelling, but they should also be able to cultivate a climate conducive towards modelling in their classrooms.

In this inquiry, a group of third year Mathematics student-teachers was exposed to a mathematical modelling activity, thereafter their experiences were explored. The study revealed that it was not only a very challenging ordeal for the participants, but that it was indeed very difficult for them to link the 'world out there' (reality) to the mathematics of the classroom. The question, '*Where can I find appropriate mathematics to help me solve this problem?*' encapsulates their predicament.

However, although this first ‘taste’ of modelling might have been extremely perplexing, it was also thought-provoking, inspiring and motivational for them. Their feedback suggests that they ‘want more’, although they realise that ‘it won’t come easy’.

In preparing prospective mathematics teachers more optimally to grasp and also to teach modelling, several suggestions were made by the participants. The researchers have no doubt in their minds that (based upon the study’s theoretical framework) mathematics student-teachers should formally acquire modelling knowledge and skills during their education. This should ideally happen in teaching contexts (situations), which let them experience for themselves that mathematics teaching isn’t a formula-dependent, linear-track endeavour, but indeed much more authentic, open-ended and even thrilling.

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