ATTITUDES OF STUDENT TEACHERS BASED ON THEIR MAIDEN EXPOSURE TO MATHEMATICAL MODELLING

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ABSTRACT–This paper reports on the attitudes of mathematics student teachers, based on their maiden exposure to a mathematical modelling challenge. The Curriculum and Assessment Policy Statement (CAPS) determines that mathematics learners should develop the ability to identify, investigate and solve problems. The unpreparedness of mathematics teachers to solve and teach modelling activities is acknowledged worldwide. Modelling was thus included for the first time in the programme of a group of third year mathematics student teachers at a South African university.
Attitudes are behaviours, feelings or thinking that display someone's disposition or preferences. The students reported their attitudes towards modelling through an adapted version of the *Attitudes towards Mathematics Inventory* (ATMI). The nonparametric Mann Whitney test was used to compare the attitudes of the two gender groups, as well as of two groups of students, based on their performance in mathematics in Grade 12. Statistically significant differences were detected in respect of the overarching attitude towards modelling of both the gender and achievement groups, but all participants were remarkably positive towards modelling after their first exposure to it. The findings will be considered in the design of a strategy aimed at the effective integration of modelling into the programme of mathematics teachers.

Keywords: Mathematical modelling; Student attitudes towards modelling; Mathematics teacher education.

1. BACKGROUND CONTEXT AND PURPOSE

Mathematics teachers generally demonstrate remarkable diversity in their teaching approaches (Adler & Davis, 2006). To teach mathematics effectively a particular knowledge-in-action is required to unpack and expand mathematical ideas. A framework developed from Shulman's categories by Ball, Thames and Phelps (2008, p. 389) emphasises the expected knowledge components of effective mathematics teachers. The framework firstly incorporates mathematical content knowledge (MCK) and how mathematical topics are connected. Pedagogical content knowledge (PCK), which includes an understanding of how learners/students get a grasp on mathematical content, what skilful mathematics teaching means and what the mathematics curriculum entails is its second component. Although a profound understanding of MCK is essential, it is regarded as insufficient in effectively teaching mathematics (Turnuklu & Yesildere, 2007). That "…distinctive knowledge domain of teaching that differentiates the expert teacher in a subject area from the subject expert" (Kwong, Joseph, Eric & Khoh, 2007, p. 28) refers to mathematics teachers' PCK. Fennema and Franke (1992) argue that learning is constructed from the classroom environment and learner activities, and teachers' beliefs, knowledge, judgements and thoughts therefore impact on decision making in the classroom. Beliefs and principles are the primary watchdogs for mathematics teachers' professional classroom behaviour (Ernest, 1989). Teacher education programmes therefore have a huge role to play in steering and shaping prospective teacher beliefs and attitudes in an appropriate manner. It is not possible to teach mathematics effectively without the necessary subject knowledge. Teachers are expected to explain content in an 'already digested' manner, they have to inspire learners to discover mathematical relations and they also have to understand learners' reasoning and potential misconceptions (Turnuklu & Yesildere, 2007). The need for teacher education programmes in mathematical pedagogical content knowledge (MPCK) is outlined by Olanoff, Lo and Tobias (2014), who campaign for a stronger focus on regular and non-standard approaches to problem solving.

Authentic problem solving is progressively used to great effect in enhancing learners' mathematical competencies and mathematics teachers' PCK and MCK (Buchholtz & Mesrogli, 2013). What is especially comforting is that the relationship between mathematical modelling (relatively recently incorporated into schools' mathematics curricula of several countries) and authentic learning has been proven (Kang & Noh, 2012). From a South African perspective, Adler and Davis (2006, p. 271-272) argue that the ways in which teachers interact with mathematics, when teaching, have significant implications for mathematics teacher education and raises the question "whether the mathematical education of teachers can and does provide opportunities to learn these ways of knowing and using mathematics". Their research emphasises two critical elements required for teaching mathematics (in contrast with the elements that mathematicians require), namely "unpacking" (an interpretation of mathematical results and processes) and "decompression" (an understanding and clarification as the learner engage with specific mathematical thinking and reasoning). Not only is the obligation of teacher education programmes to reshape the attitudes, beliefs and potential misconceptions of student teachers, but also to develop an in-depth understanding of their MCK and to expose them to mathematical knowledge-in-action. Ng (2013) and Ikeda (2013) caution against the unpreparedness of mathematics teachers in respect of the teaching of modelling. The open-endedness of modelling activities as well as the nurturing of a conducive climate towards modelling are relentless challenges. According to Soon and Cheng (2013) teachers may not be able to appreciate the benefits and importance of developing their learners' mathematical modelling competencies if they themselves were not adequately exposed to tasks and activities. The ideal is for prospective teachers to eventually model modelling in their classrooms.

Papageorgiou (2009, p. 7) reports that mathematics learners "separate their mathematical knowledge in formal school mathematics and informal 'everyday' mathematics, and are then unable to connect the two". Such learners are then regularly unable to solve problems, which demand both 'everyday' and school mathematics. Many mathematics learners also commonly believe that answers to problems are either right or wrong (Schoenfeld, 1989). The aforementioned fabricated perceptions make it difficult for learners to connect mathematics to everyday activities, which often causes higher levels of anxiety and worse performances than what would reflect their abilities. The link between learners' attitudes and achievement in mathematics has been proven many times. The connection works in both directions: firstly, higher achievers tend to have more positive attitudes toward mathematics than lower performers and secondly, learners' attitudes towards mathematics (or certain mathematical themes) determine their level of engagement and eventually also the quality of their learning (McLeod, 1992).

The *purpose* of this paper is to explore the attitudes of a group of third year mathematics student teachers at a South African university, based on their maiden exposure to a model-eliciting challenge. The two *research questions* are: (1) what is the nature of student teacher attitudes towards mathematical modelling and (2) are there differences between the attitudes of the two gender groups, as well as between higher and lower performing students? This inquiry forms part of a research project, which strives to deduce a set of guidelines aimed at the effective integration of mathematical modelling into the formal education of Grade 10-12 teachers.

2. LITERATURE PERSPECTIVES

2.1. Theoretical framework

The authors are of the opinion that the pre-service education of mathematics teachers, especially in the current South African school context, has a fundamental initial influence on their practices, beliefs, attitudes and early effectiveness. Aligned with the abovementioned assumption, the theoretical framework that *firstly* underlies this inquiry is the **Learning to Teach Secondary Mathematics (LTSM)** framework (Peressini, Borko, Romagnano, Knuth & Willis, 2004, p. 68), grounding its views on learning-to-teach activities and processes in mathematics by two statements viewed through a situative lens. 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, suggesting, 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" (Adler, 2000, p. 37).

The *second* theoretical framework that underlies this research, is the worldview of Schackow (2005) on **teacher beliefs and attitudes**. Schackow (2005, p. 12) defines teacher beliefs as the subjective ways in which teachers grasp their role(s) in a classroom, their learners, determinants of learning, the teaching environment, and the goals of education. Mathematics teachers conceptions about how mathematical themes should be taught are deeply rooted, usually relate to their own experiences as mathematics learners (also during their formal education) and are hard to change. Mathematics teachers' beliefs are primarily rational in nature, and they play an important role in the development of their (and their learners') attitudes. Mathematics teachers' beliefs and attitudes ominously influence how they interpret and implement mathematical modelling, while it will eventually also affect their learners' beliefs and attitudes towards modelling.

2.2. Theoretical (literature) perspectives on mathematical modelling

2.2.1. Model and 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. M*athematical 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).

2.2.2. 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).

2.2.3. Contribution of mathematical modelling to mathematics teaching and learning

Modelling tasks have the proven ability to develop learners' reasoning, communication, problem solving and problem posing abilities (Kang & Noh, 2012; Ng, 2013). Such activities consequently improve decision-making capabilities as they link classroom mathematics to real life situations (Kang & Noh, 2012).

Research in Singapore (Ng, 2013) and South Africa (Julie, 2002) reveal that teachers' prior exposure to problem solving, their attitudes towards and beliefs about mathematics are factors that either enhance or limit their involvement in modelling activities. Their limited exposure to modelling tasks was identified as a cause in their lack of readiness to implement such tasks as most teachers perceive mathematics to be formula-based (Ng, 2013). As previously indicated (in section 1), teachers' appreciation of the contribution that mathematical modelling might make towards the teaching and learning of mathematics, will increase if they are familiar with mathematical modelling content (Soon and Cheng, 2013). Liljedahl et al. (2009), Kang and Noh (2012), Julie (2013) and Ng (2013) all acknowledge the vital dual role of teaching education programmes, with student teachers that should firstly be confronted with modelling as content and secondly with modelling as a pedagogical content knowledge (PCK) builder (Julie, 2002).

2.3. Theoretical (literature) perspectives on learner/student attitudes

2.3.1. Attitudes in general and more specifically towards mathematics

Attitudes form a central part of a person's identity. The affective domain of learning typically features three dimensions: *emotions*, *attitudes* and *beliefs (*Papageorgiou, 2009, p. 5). Attitudes are seen as "manners of acting, feeling, or thinking that show one's disposition or opinion. Attitudes change more slowly than emotions, but they change more quickly than beliefs. Attitudes, like emotions, may involve positive or negative feelings, and they are felt with less intensity than emotions. Attitudes are more cognitive than emotions but less cognitive than beliefs" (Philipp, 2007, p. 259). Many learners or students generally have a disposition towards mathematics, either positive or negative.

2.3.2. The effect of mathematics teaching on learner/student attitudes

It was confirmed (compare section 1) that the quality of mathematics teaching and the nature of teacher attitudes have a pertinent influence on learners' attitudes towards mathematics and eventually also on their achievement. Yara (2009) confirms that teachers with positive attitudes towards the subject likewise stimulate favourable attitudes in their learners. Henderson and Rodrigues (2008) and Quinn (1997) regard the main source of negative learner attitudes toward mathematics as inappropriate teaching practices and teacher attitudes. Ma and Wilkins (2002) finally put the vital role of teacher attitudes into perspective, by stating that learners who believe that teachers have high expectations of them tend to have a more positive attitude towards mathematics. This inquiry is based on the assumption that student teachers attitudes toward a mathematical theme like modelling are influenced by their experiences of the lecturer's approach and teaching.

3. RESEARCH DESIGN AND METHODOLOGY

3.1. Research paradigm and method

The research paradigm refers to a researcher's worldview, as reflected in a matrix of beliefs, perceptions and underlying assumptions (Foucault, 1972), which guides her/him in approaching the research problem. The main research paradigm underlying the nature of this enquiry relates to an attempt to measure participants' attitudes towards a mathematical modelling activity. The inquiry was thus conducted from a **post-positivist** stance (Heppner & Heppner, 2004). The post-positivist paradigm is a milder form of positivism, basically following the same principles, but allowing for more engagement between the researchers and the participants, by using a survey as data collection instrument. The authors assume that an external reality exists independently from this inquiry, and although this reality cannot be known fully, attempts at measuring it in an objective manner might be possible.

3.2. Participants

The participants are all enrolled for the third year of the B.Ed programme for Grade 10 to 12 mathematics educators at the University of Johannesburg in 2015. They study on a full-time basis and Table 1 below displays elements of their demographics. The majority are *male* (63%), *black* (almost 80%), *indigenous language* speaking (also almost 80%), *22 years or younger* (57%), and have scored *70% or more* in their Grade 12 year for mathematics (63%).

Table 1. Demographic profile elements of participants

Profile variable		N	%
Gender (n=49)	Female	18	63.3
	Male	31	36.7
Ethnic group (n=48)	Asian, Indian , Coloured	4	8.3
	Black	39	81.3
	Don't want to indicate	2	4.2
	White	3	6.3
Home language (n=49)	Afrikaans	4	8.2
	English	6	12.2
	Indigenous	39	79.6
Age in years (n=47) (Mean = 22.4 yrs)	20 to 22 years	28	59.6
	23 to 25 years	15	31.9
	26 years or older	4	8.5
Math mark in Gr 12 (n=48) (Median = 70-79%)	49% or lower	2	4.2
	50 – 59%	4	8.3
	60 – 69%	11	22.9
	70 – 79%	23	47.9
	80% or higher	8	16.7

3.3. The data collection instrument and process

A self-designed questionnaire was used to collect information from the participants on the day after their exposure to the mathematical modelling activity (see section 3.6 below). Section A of the questionnaire contained demographical items including gender, ethnical group, home language, age in years and Grade 12 performance in mathematics. Collected demographical data were captured in a Microsoft Excel worksheet and then analysed via the frequencies, cross-tabulations and descriptive statistics options of the Statistical Package for the Social Sciences (SPSS, version 22).

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 focus of the original ATMI was adapted towards mathematical modelling (labelling it as the ATMMI), instead of mathematics, but the items and dimensions were kept intact. The ATMMI contains four dimensions, namely *value* (whether mathematical modelling knowledge and skills are worthwhile and necessary, 10 items), *enjoyment* (whether mathematical problem-solving and modelling challenges are enjoyable, 10 items), *self-confidence* (expectations about doing well in respect of mathematical modelling and how easily modelling is mastered, 15 items) and *motivation* (the desire to learn more about mathematical modelling and to teach it, 5 items). Each of the 40 items uses a Likert-type response scale, ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*). When reverse coding (which applies to approximately a third of the items) was done, all item responses in each of the four dimensions are added, yielding total scores for value and enjoyment (maximum 50 each), self-confidence (maximum 75) and motivation (maximum 25). Analysis of data, including normality testing, reliability measures and testing for attitudinal differences between groups of participants, were also performed via SPSS.

3.4. Ethical measures and participants' consent

After the goal of the research, the nature of the data collection instrument and their rights and responsibilities as respondents have been explained to them, individual written consent was obtained from all participants to safeguard the confidentiality of collected data and the anonymity of each participant.

3.5. Validity and reliability measures

The creators of the ATMI, Tapia and Marsh (2004, p. 18-19) report that the survey shows a high degree of internal consistency (its Cronbach's alpha was .88), while its factor structure "…covers the domain of attitudes towards mathematics, providing evidence of content validity". The authors conducted a pilot study (in May 2015) on the adapted (for modelling) ATMI, to determine and fine-tune its perceived sight validity. Cronbach's alpha coefficients were hence calculated in respect of each of the four dimensions (see 3.3 above), as well as in respect of the participants' total attitudinal scores. The coefficients are portrayed in Table 2 below, revealing high internal consistency (reliability) of participants' responses.

Table 2. Reliability of the Attitudes towards Mathematical Modelling Inventory (ATMMI)

ATMMI dimension	Cronbach's alpha
Enjoyment (10 items)	.891
Value (10 items)	.857
Self-confidence (15 items)	.925
Motivation (5 items)	.872
ATMMI total (40 items)	.893

3.6. The mathematical modelling activity

Participants were exposed to the mathematical modelling activity during the last week of the first semester of 2015. The activity was carefully planned, based on a similar study (conducted in May 2014 by the researchers) and the design guidelines of Kenyon, Davis and Hug (2011). The session lasted for approximately 110 minutes during a scheduled time table slot.

The participants have never been exposed to modelling or to its teaching before. They were divided into ten relatively comparable groups, each containing four to five 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 had at least a high(er), a moderate and a low(er) achiever.

A 20 minute presentation on the purpose and nature of the research, what modelling entails, phases of a typical modelling cycle (see section 2.2.1 above) and the ethical measures taken to safeguard confidentiality and anonymity, served as introduction. The modelling activity, labelled "World Cup Rugby 2015" (adapted from Stewart, 2013) is based on the content of the course curriculum. It entails a level three challenge (see section 2.2.2), being open-ended and incomplete. Participants were expected to make recommendations to the South African Rugby Union on the maximum number of official rugby balls that can be transported via a crate in a plane to England for the World Rugby Tournament of 2015.

The ten groups were required to report on the strategies and methods that they employed, and to come up with possible solutions and to critique their suggested solutions. The experiment and group interactions were carefully monitored by the researchers and each group recorded their strategies, processes and suggested solutions on a predesigned worksheet.

4. EMPIRICAL FINDINGS

4.1. Participants' ATMMI scores, reflecting their attitudes towards mathematical modelling

Sweeting (2011, p. 53-54) categorises teacher attitudes towards mathematics as subject 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 *value* dimension (maximum 50) would also be 41 or more. Scores on the *self-confidence* dimension (maximum 75) would be 61 or more and scores on the *motivation* dimension (maximum 25) would be 21 or more. A strongly positive *ATMMI total* (incorporating all four dimensions – maximum 200) would be 161 or above.

The researchers expected the overwhelming majority of the participants (all of them studying to become mathematics teachers), to portray relatively positive attitudes towards modelling, but the complexity of modelling as an activity, and because they have been introduced to it for the very first time, might have had an influence on the number of highly positive attitudes. Table 3 provides a breakdown of the scores. About 60% of the group displayed strongly positive attitudes in respect of the enjoyment they got from the modelling task, while the corresponding percentages in respect of the other three dimensions (value, self-confidence and motivation) were 53%, 30% and 31% respectively. Just less than half of the participants (47%) exhibited a strongly positive overarching attitude towards modelling. The majority of participants were positive (although not necessarily highly positive, confident or motivated to experience more) about their modelling exposure. The built-in complexity of a modelling challenge and the novice status of participants surely played a role here.

Table 3. Distribution and descriptive statistics of ATMMI scores

ATMMI dimensions	Scoring intervals	N=	%
ENJOYMENT [N=48] [M = 42.10; SD = 6.33]	40 or lower	19	39.6
	41–50	29	60.1
VALUE [N=38] [M=39.63; SD=6.73]	40 or lower	18	47.4
	41-50	20	52.6
SELF-CONFIDENCE [N=44] [M=51.32; SD=11.79]	50 or lower	19	43.2
	51-60	12	27.3
	61-75	13	29.5
MOTIVATION [N=49] [M=17.61; SD=4.82]	15 or lower	11	22.4
	16-20	23	46.9
	21-25	15	30.7

TOTAL ATMMI SCORE [N=36] [M=152.25; SD=24.27]	140 or lower	11	30.6
	141–160	8	22.2
	161 or higher	17	47.2

4.2. Testing for significant differences between groups of participants

The Mann-Whitney U test, as non-parametric statistical technique was used to analyse differences between the medians of the responses of participants in the two gender groups and in two performance groups (based on their achievement in mathematics in Grade 12). The Mann-Whitney test is considered appropriate, because the participants' responses aren't normally distributed, are measurable on an ordinal scale, are comparable in size and independent (responses from one subgroup don't affect the responses of another subgroup) (Milencović, 2011, p. 74).

Tables 4 and 5 below present the test statistics and ranks in respect of students' overarching attitudes, as presented by their total ATMMI scores, with *gender* and *mathematics achievement in Grade 12* as grouping variables. The Mann-Whitney test findings firstly indicate that female mathematics student teachers in this study (*Mdn* =135) have a significantly lower (at the 95% confidence level) overarching attitude towards mathematical modelling than their male counterparts (*Mdn* = 168.5), *U* = 82.50, *p* = .020. Cohen's effect size (r = .39) is in the medium to high interval (Milencović, 2011, p. 77), which implies that the finding has moderate (to high) practical significance. The Mann-Whitney test findings secondly indicate that mathematics student teachers in this study, who have scored 69% or less for mathematics in their Grade 12 year (*Mdn* =141.0) have a significantly lower (at the 95% confidence level) overarching attitude towards mathematical modelling than their counterparts, who have scored 70% or more for mathematics in Grade 12 (*Mdn* = 168.5), *U* = 93.0, *p* = .038. Cohen's effect size (r = .393) is also in the medium to high interval (Milencović, 2011, p. 77), which implies that this finding also has moderate (to high) practical significance.

Table 4. Test statistics [a] for student teachers' overarching ATMMI scores

	Gender [b]	Achievement in mathematics in Gr 12 [c]
Mann-Whitney U	82.500	93.000
Wilcoxon W	187.500	198.000
Z	-2.322	-1.981
Asymp. Sig. (2-tailed)	.020 [d]	.048 [d]
Exact Sig. (1-tailed)	.019 [d]	.049 [d]

a Grouping variables: *Gender* and *Achievement in mathematics in Grade 12*

b *Female* participants are compared to *male* participants

c Participants, who scored *69% or less* in mathematics in Gr 12 are compared to participants, who scored *70% or more* for mathematics in Gr 12

d Significant at the 95% level of confidence

Table 5. Ranks in respect of total ATMMI scores

Demographic attributes	Groups	N=	Mean Rank	Sum of Ranks
Gender [N=36]	Female	14	13.39	187.50
	Male	22	21.75	478.50
Achievement in mathematics in Gr 12 [N=36]	69% or less	14	14.14	198.00
	70% or more	22	21.27	468.00

5. CONCLUSION

The relationship between mathematical modelling, which has been incorporated into the secondary schools' mathematics curricula of several countries (including that of South Africa) and authentic

learning has been proven. Another strong relationship between positive attitudes towards and achievement in mathematics has also been well documented (compare Brown, McNamara, Hanley & Jones, 1999; Dowker, Ashcraft & Krinzinger, 2012; Durandt & Jacobs, 2013; Ismail & Anwang, 2009; Khatoon & Mahmood, 2010; Sweeting, 2011, and others).
The research questions that this study attempted to find answers to were two-fold, namely:

(1) what is the nature of student teachers' attitudes towards mathematical modelling and
(2) are there differences between the attitudes of the two gender groups, as well as between higher and lower performing student teachers?

The group of almost 50 third year mathematics student teachers was exposed to a mathematical modelling activity (as part of their formal curriculum) for the very first time. An interrogation of their attitudes towards modelling revealed that they enjoyed and valued the activity, but that they lack substantial confidence in performing modelling, while they are not necessarily motivated (yet) to further their modelling knowledge and skills. A further analysis indicated that female student teachers, as well as student teachers who have scored below 70% in mathematics in Grade 12, displayed less conducive attitudes towards mathematical modelling, than their male or higher achieving counterparts.

The theoretical framework on which the inquiry is based, Learning to Teach Secondary Mathematics (Peressini, et al, 2004), *firstly* asserts that how a learner acquires a particular set of knowledge and skills and the specific teaching context in which it happens fundamentally influence what they eventually learn. It *secondly* stipulates that mathematics teachers' knowledge, but especially their beliefs and attitudes, are shaped through increased participation in the practice of teaching itself. The challenge seems clear: mathematics student-teachers need to acquire modelling knowledge and skills during their formal education. It can be effected through a formal programme, which, in addition to developing their mathematical modelling pedagogical knowledge, also strives to develop their mathematical modelling content knowledge. Such a programme should ideally be based on a well-considered set of guidelines for implementation that take cognisance of and gradually build student teachers attitudes.

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