

# Considering Pre-service Teacher Disposition towards Mathematics

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The push to ensure pre-service teachers are numerate, on face value, is appropriate. However, the way in which numeracy is described is of great importance as it will determine what is assessed and how it is assessed. The way numeracy is described will also impact on how teacher educators assist pre-service teachers to develop their numeracy. This paper proposes that numeracy incorporates mathematical skills and disposition towards mathematics. A discussion of what disposition towards mathematics is and how it may be measured is provided, together with the proposition that addressing pre-service teacher disposition towards mathematics may help pre-service teachers to develop their numeracy – numeracy that reflects willingness to actually use mathematics in the real world. Suggestions on how this may be achieved are outlined.

**Keywords:** pre-service teacher · teacher education · numeracy · disposition · assessment

## Introduction

Pre-service teacher numeracy is under examination. It is expected that pre-service teachers completing teacher training courses have numeracy levels commensurate with the top 30% of the population (Australian Government Department of Education and Training, 2013). In addition, the Australian Government, via the Australian Institute for Teaching and School Leadership (AITSL), will create tests that all pre-service teachers will have to take (Australian Government Department of Education, 2013). However, what numeracy is needs to be determined before it can be assessed.

There are several descriptions of numeracy that are available. Some, such as The Australian Core Skills Framework [ACSF] (Australian Government Department of Industry, n.d.), considers numeracy in terms of the application of mathematical skills. The ACSF focuses on using and applying, involving mathematics and mathematical skills, to:

make sense of the world ... [deal] with situations that involve the use and application of a range of mathematical skills and knowledge ... [draw] on knowledge of the context in deciding when to use mathematics ... [extract] mathematical information from the context ... [choose] appropriate mathematics to use ... [evaluate] the use of the mathematics, and ... to represent and communicate the mathematical results. (DET, n.p.)

The Australian Association of Mathematics Teachers [AAMT] (1997, p. 14) includes more than mathematical skills in their description of numeracy. Their description incorporates how the person feels about using mathematics, stating, “a person’s disposition to use mathematics is also critical in numeracy” (p. 14). This disposition to use mathematics is expanded by the clarification that it “includes personal confidence, comfort and willingness to ‘have-a-go’” (p. 14).



Disposition relating to mathematics has also been used by other authors. In his description of quantitative literacy, a USA term that corresponds to numeracy, Wilkins (2000) incorporated more than mathematical skills:

Quantitative literacy is defined in terms of mathematical content knowledge, mathematical reasoning, understanding of the social impact and utility of mathematics, understanding the nature and historical development of mathematics, and mathematical disposition. (p. 405)

The differences in the description between the ACSF and those provided by the AAMT (1997) and Wilkins (2000) could be seen to demonstrate different approaches to how mathematics and numeracy are related, and this difference could incorporate a crucial distinction. Dottin (2009) considered that having a skill does not mean that the skill is used – “having the ability to act (the knowledge and skills) does not guarantee the inclination to do so” (p. 84). Furthermore, there are claims that it is disposition that will encourage the decision to use and develop skills. Richardt (2002) asserted that it is disposition that makes the link between abilities and actions – from skills that are possessed to choosing to use them actively. Richardt referenced Dewey’s (as cited in Richardt, 2002) consideration of the desire to use knowledge as being part of the person’s disposition towards using that knowledge.

## What is Disposition?

Although Dottin (2009) stated there was lack of consensus on how disposition should be defined, descriptions and measures have been proposed. Katz and Raths (1985) viewed disposition as being descriptive and different from skills, attitudes, habits, and traits. Rather, they saw it as a criterion that incorporates a measure of competence of a skill that had been chosen to be used, not a measure of a skill that a person had but chose not to use. However, Katz and Raths clarified that it does not mean that the demonstration of a skill automatically indicates an appropriate disposition.

The fine distinction required to move from demonstrating a skill within mathematics to having a disposition towards mathematics can be explained by Maxwell (2001), who proposed that a positive learning disposition in mathematics could be described as “enjoyment”. It seems that a disposition towards mathematics would be the inclination to use mathematics borne out of desire, enthusiasm, confidence, and willingness, not out of necessity. In this way, it shares similarities with affect, particularly if McLeod’s (1992, as cited in Philipp, 2007) components are considered – beliefs, attitudes, and emotions; with beliefs and attitudes being more cognitive. As a result, disposition may also be more cognitive, which could result in disposition generating or leading to an emotional response rather than including emotions.

Uses of the word disposition in literature often preface it with “positive” or “negative”. As an example of the former, Gresham (2008, p. 174) refers to their mathematics methods course as designed “to cultivate a positive disposition towards teaching mathematics”. Maxwell (2001, p. 33) refers to the term “negative disposition toward mathematics” when describing the impact prohibitive environments can have on students, and considers these negative dispositions toward mathematics being hard to change if they become “heavily entrenched”.

The AAMT (1997) uses the word disposition in relation to mathematics to describe the willingness to use mathematics. This implies a measure of the amount of willingness – with the tipping point being that it is sufficient for mathematics to be used. Wilkins (2000, p. 408) uses a similar interpretation – referring to the “willingness to engage”. In this paper, the use of the word disposition, and its application in terms of disposition towards mathematics, has neither a positive nor a negative connotation – it is considered as a continuum or a measure, much like the AAMT (1997) use of the word.

## Why a Focus on Pre-service Teacher Disposition towards Mathematics?

Pre-service teachers are educators of the future and will be teaching mathematics. This link to the future mathematics teaching is the impetus behind the focus on pre-service teacher disposition towards mathematics and the reason for investigating pre-service teachers' dispositions towards mathematics. First, Katz and Rath (1985) proposed that teachers' dispositions enable or disable their actions within classrooms. This is similar to how Pajares (1992) described the importance of investigating teacher and pre-service teacher beliefs—that these beliefs impact on teacher actions in the classroom. However, dispositions are more than beliefs and are the catalyst for setting behaviours into actions (Dottin, 2009). This creates an association more like that proposed by Skott (2009), where beliefs are not directly connected to the teacher's behaviours in the mathematics classroom but are mediated by the social aspects and context of the environment in the mathematics classroom. This places disposition towards mathematics as encompassing the beliefs of the teacher, beliefs that could be characterised as Beswick (2005) proposed to be "anything that an individual regards as true" (p. 39).

The second reason for studying teachers' dispositions is the need to examine the impact of teachers' actions regarding mathematics on the learning of their students. This occurs at three levels—how the teacher approaches mathematics; how the teacher sees the development of numeracy; and the classroom climate when mathematics is being used. The first level incorporates the approaches used when engaging in mathematics. Wilkins (2008) believed that teachers with a positive approach to mathematics will generate a more positive approach within their students. Maxwell (2001) connects student enjoyment of mathematics directly with the activities the teacher uses in the classroom. These activities have to motivate the students and "make mathematics worthwhile" (p. 35). Being motivated to complete mathematical tasks as they are seen as worthwhile can be connected to the development of numeracy.

The AAMT's (1997) description of numeracy incorporates the willingness and confidence to use mathematics and these concerns reflect Richardt's (2002) opinion that it is disposition that makes the jump from having mathematical abilities to actually choosing to use them. Numeracy needs to be seen as more than mathematical skills—it needs to incorporate the development of a willingness to engage in mathematics and a confidence to use mathematical skills. If teachers view numeracy as the development and application of mathematical skills, rather than also incorporating the desire to use it, then students may develop a negative outlook towards the completion of mathematical activities.

Ignacio, Blanco Nieto, and Barona (2006) described how students might develop a negative view of mathematics and how this could impact on their continuation with mathematics:

Many of them [students], even some of the most able, find mathematics to be just a tiresome chore. Indeed, many students, thinking that "they are not cut out for mathematics" end up by rejecting the subject, which they consider a sort of "millstone" that they have to get rid of as soon as they can (p. 17).

The final level of this reason involves the classroom climate when mathematics is being used. Teachers need to have a disposition towards mathematics that will enable them to "establish a classroom climate which cultivates positive dispositions in their students" (Maxwell, 2001, p. 37). Modelling and engaging in this disposition towards mathematics is necessary if teachers are to fulfil Lappan's (1999) request that they engender in their students a willingness to study mathematics, to persevere with mathematical problems, and to see themselves as able to learn mathematics. This needs to be modelled in teacher education as it is possible that pre-service teachers may not have experiences with mathematics that are positive (Beswick, 2006), making it essential that teacher education programs provide experiences that encourage a willingness to engage with mathematical activities.

The third reason is that there should be consideration given to what teacher education programs incorporate to ensure pre-service teachers will be able to teach mathematics to their future students. If we wish for children to develop enjoyment of mathematics and a willingness to engage in mathematics—that is, to develop numeracy rather than just mathematical skills and knowledge—then this is what should be developed in pre-service teachers (Dottin, 2009, p. 84). Katz and Raths (1985) ask that consideration of disposition towards mathematics be incorporated to reduce the “potential risks of the excessive emphasis on skill acquisition frequently associated with the performance- or competency-based approach to teacher education” (p. 304). They state that such a focus on mathematical skill acquisition could result in a negative disposition towards mathematics. If this is how teacher educators approach mathematics and numeracy, then there is the risk that this will be copied into the classroom, potentially impacting on the willingness of students to apply their skills and, therefore, on their development of numeracy.

Pre-service teachers are in the position of learning mathematics and developing numeracy as well as learning how to teach mathematics and to develop numeracy in their future students (Cooke & Sparrow, 2012). A consideration of disposition towards mathematics needs to be incorporated in pre-service teacher education due to what Maxwell (2001) describes as the essential role disposition plays when learning mathematics. It is also essential in terms of how the pre-service teachers will teach mathematics in their future classrooms (Wilkins, 2008) and how their future students will view mathematics (Lappin, 1999). These two final points lead directly into how the pre-service teachers’ future students will develop numeracy (AAMT, 1997).

### What Might Disposition towards Mathematics Involve?

Before exploring what disposition towards mathematics might involve, a way to describe it needs to be determined. Consideration of what is involved in disposition towards mathematics would benefit from being able to conceptualise it in terms of what it might comprise. These parts can be referred to as “components”, “elements”, or other such terms.

The use of components to explain disposition towards mathematics is similar to the approach used to investigate the impact of emotions on quantitative literacy results. In their investigation of emotions in mathematics classrooms, Op’t Eynde, De Corte, and Verschaffel (2006) saw the use of constituent components as enabling an investigation of the interplay of these components within the context of the mathematics classroom. Donn and Taylor (as cited in Wilkins, 2000) created a framework of components of quantitative literacy, and Wilkins (2000) used this to frame his examination of quantitative literacy using the Third International Mathematics and Science Study [TIMSS] data. The use of components also addresses the difficulties that can be present when assessing disposition, as Jung, Rhodes, and Vogt (2006) found in their investigation of technology disposition in pre-service teachers. If disposition towards mathematics is to be considered in terms of elements or components, what might they be?

This paper proposes that there are four elements that can be considered as measurable components of disposition towards mathematics. The first element considered is attitudes. Ernest (1989) saw attitudes as being applicable to mathematics and to mathematics teaching, with attitudes involving the degree of liking, enjoyment, interest, and enthusiasm for mathematics. Several of these terms have been used in descriptions of the type of disposition needed towards mathematics (for example, Maxwell, 2001). Attitudes were also one of the six indicators Atallah, Bryant, and Dada (2010) proposed for dispositions of mathematics. All six of their indicators involved descriptions the respondent had to report against and were focused on three areas—attitudes towards mathematics; perceptions of the value of mathematics and what it will help them achieve; and learning (a self-assessment of their own ability as a learner, their learning approaches, and proof of their learning of mathematics).

The second element considered as a measurable component of disposition towards mathematics is mathematics anxiety. This element is different from the other three elements as it has a negative perspective. Mathematics anxiety is included as it can act as a dampener on disposition towards mathematics, creating “the presence of a negative disposition” (Fuentes Rivera & Gomez-Chacon, 2013). McLeod (1992, as cited in Philipp, 2007) considered mathematics anxiety as a factor that could impact on the use of mathematics. Research on mathematics anxiety has found that people with mathematics anxiety may avoid mathematics (Isiksal, Curran, Koc, & Askum, 2009), an action that is not commensurate with developing a positive disposition towards mathematics. Gresham (2008) found that pre-service teachers with mathematics anxiety may have a more negative belief regarding their skills and abilities as a teacher than pre-service teachers without mathematics anxiety. That is, high levels of mathematics anxiety would be likely to impact negatively on disposition towards mathematics—in terms of Maxwell’s (2001) consideration of enjoyment of mathematics, Katz and Rath’s (1985) willingness to engage in mathematics, and Ernest’s (1989) liking and enthusiasm for mathematics.

The third element considered as a measurable component of disposition towards mathematics is confidence. Maxwell (2001) saw teacher confidence in mathematics as an essential aspect of generating student enjoyment of mathematics. Atallah et al. (2010) considered self-assessment of mathematics ability as an aspect of disposition, and this can be related to Ernest’s (1989) incorporation of confidence in mathematics teaching ability. Both include a perception of ability rather than the actual ability, though Atallah et al. (2010) did incorporate the provision of evidence to prove mathematics learning. The use of proof to support claims of ability can be seen as providing a measure of confidence in the ability that is being justified, an element of “I can do this”. Confidence is also an element of the AAMT (1997) description of numeracy provided above.

The fourth element considered as a measurable component of disposition towards mathematics involves how mathematics is conceptualised. Beliefs about mathematics can be connected to attitudes to mathematics (McLeod, 1994); and as a result, would also be related to disposition towards mathematics. Ernest (1989) considered beliefs to be part of teacher’s dispositions. He viewed teachers’ disposition towards mathematics as focusing on a “system of beliefs, conceptions, values and ideology” (p. 20). The conception of mathematics could combine features of the three philosophies of mathematics—mathematics as a revisable, problem solving field; mathematics as a static interconnecting set of truths; or mathematics as a collection of unrelated facts and skills (Ernest, 1989). Hannula (2002) also considered mathematics in terms of beliefs that were organised within a “framework of emotions, associations, expectations, and values” (p. 42).

## How Will the Components of Disposition towards Mathematics be Measured?

Dottin (2009) stated that it is important that disposition in pre-service teachers be measured. However, Katz and Rath (1985) do not believe that dispositions can be measured solely through scales, as “the actions are not actually observed” (p. 302). However, Jung et al. (2006) used Likert-style scales for their instruments, based on the two components identified for assessing technology disposition.

Likewise, Albee and Piveral (2003) used an instrument with Likert-style questions as a tool for pre-service teacher self-administration, mentor teacher, and lecturer assessment regarding dispositions for teaching. Albee and Piveral used the tool as a means for pre-service teachers to reflect and identify areas where they needed development. They stated that the tool also provided a way to monitor pre-service teacher disposition and, where necessary, to enable educators to



intervene. Thus their components of disposition towards mathematics were beneficial during pre-service teacher education.

### *Attitudes towards Mathematics*

Zan and Di Martino (2007) believe instruments designed to measure attitudes towards mathematics needed to take account of “particular problems in mathematics” (p. 158). Beswick, Ashman, Callingham, and McBain (2011) created a questionnaire that contained instruments addressing attitudes to mathematics. Three situations were investigated—attitudes regarding mathematics in everyday life; attitudes regarding mathematics in the classroom; and attitudes regarding mathematics in teacher education. Each situation used a separate instrument, with the first two instruments containing 15 items to investigate everyday life and the classroom, and the third instrument investigating teacher education containing 16 items (Beswick et al., 2011). The Beswick et al. instruments were modified by Cooke and Hurst (2013) to reduce the responses to the Likert-style questions to four—strongly disagree, disagree, agree, and strongly agree (see Cooke & Hurst, 2013, for further discussion on the use of these instruments).

### *Mathematics Anxiety*

Cavanagh and Sparrow (2010a) considered mathematics anxiety as situational, proposing that measuring each situation would generate precise data. The instruments within the questionnaire developed by Cavanagh and Sparrow (2010b) incorporated questions within three domains—attitudinal; cognitive; and somatic. These instruments were modified by Cooke, Cavanagh, Hurst, and Sparrow (2011) to enable their use with pre-service teachers. A domain of mathematical knowledge was created, and three instruments were developed to address three different situations for which pre-service teachers were asked to consider their anxiety—when thinking about working on mathematics in a group situation; when thinking about working on mathematics in a test situation; and when thinking about teaching mathematics. Each instrument used the same 22 items applied to the three situations, with responses on 4-point Likert-style scales using categories of strongly disagree, disagree, agree, and strongly agree. Further information about this questionnaire and the three instruments is available in Cooke et al. (2011).

### *Confidence with Mathematics*

The questionnaire created by Beswick et al. (2011), containing the attitudes to mathematics instruments discussed in the above section, also included an instrument designed to address pre-service teachers’ confidence to teach mathematics. The 21 questions were designed specifically to address aspects of the content strands and proficiency strands of the *Australian Curriculum: Mathematics* (ACARA, 2013). This instrument was modified for use by reducing the responses to the Likert-style questions to four categories ranging from strongly disagree, to disagree, to agree, and to strongly agree. This instrument was used with pre-service teachers, as reported by Cooke and Hurst (2013).

### *Conceptualisation of Mathematics*

Atallah et al. (2010) considered six indicators within the conception of mathematics, incorporating five verbal descriptions and a drawing of a mental image. The verbal descriptions addressed ideas, requirements for learning outside the classroom, types of activities completed within the classroom, the purpose of learning, and the thoughts that indicate understanding. However, these rely on the actions of mathematics as a way to frame what mathematics is. An alternative

consideration of the conceptualisation of mathematics would be to describe the understanding required, rather than the activities to be completed or the thoughts that are created. This interpretation of how mathematics is conceptualised would be more likely to reflect features of the three philosophies of mathematics outlined by Ernest (1989).

To address this component, an instrument was created by the author. Questions from the instrument are provided in Table 1, below, to indicate the mathematics philosophies outlined by Ernest (1989).

Table 1  
*How the Questions from the Conceptualisation of Mathematics Instrument Relate to the Mathematics Philosophies Outlined by Ernest (1989)*

Only relates to Mathematics as a revisable problem solving field
3. Maths learned in the classroom is widely used outside the classroom. 4. I can see how maths is related to games. 5. Maths problems and questions can often have more than one correct answer. 19. Maths is creative.
Relates to both Mathematics as a revisable, problem solving field and Mathematics as a static interconnecting set of truths
2. Maths is about more than just numbers. 6. Maths can be used in many subjects at school. 10. . I can see how maths connects to the world. 11. Maths involves much more than following rules and procedures. 13. Maths involves many ideas that are easily and clearly connected to other ideas. 14. . I use maths in everyday conversations. 16. . I view maths as something I can use to explain the world. 17. . I use maths to successfully play games. 18. Using maths to find out about other things is enjoyable. 20. The maths I have learned in the classroom links and connects to what I do in the real world.
Relates to Mathematics as a revisable problem solving field, Mathematics as a static interconnecting set of truths, and Mathematics as a collection of unrelated facts and skills
1. I often use the maths I learnt at school. 7. The maths I did at school has been very useful to me. 8. I see maths as useful in life. 9. It is important to know why mathematical rules and procedures work. 12. Maths can be used when describing nature. 15. I try to understand maths I have to use.

Four questions are considered to be connected to only one philosophical perspective—mathematics as a revisable problem solving field (questions 3, 4, 5, and 19) with half of the questions (questions 2, 6, 10, 11, 13, 14, 16, 17, 18, 20) connected to mathematics as a revisable, problem solving field and mathematics as a static interconnecting set of truths.

The final six questions connected to all three philosophical perspectives—mathematics as a revisable, problem solving field; mathematics as a static interconnecting set of truths; and mathematics as a collection of unrelated facts and skills (7, 8, 9, 10, 12, and 15).

As with the other instruments, all questions are Likert-style with response ranging from strongly disagree, to disagree, to agree, and to strongly agree. The instrument will be validated during the first semester of 2014.

## Going Forward After Looking Back

In 2010, research was initiated to investigate pre-service teacher situational mathematics anxiety at a large metropolitan university in Australia (for example, see Cooke et al., 2011). In 2012, the instruments on attitude and confidence that were modified from Beswick et al. (2011) were incorporated into the research (Cooke & Hurst, 2013).

This research culminated in the creation of a new first year unit at the university. The new unit was designed for pre-service teachers from both the primary and early childhood cohorts enrolled in a Bachelor of Education. The focus of the unit was on developing pre-service teacher numeracy—in terms of mathematics skills and attitudes, anxiety, and confidence towards mathematics.

The unit uses the instruments on attitudes to mathematics, mathematics anxiety, and confidence with mathematics to enable the pre-service teachers to be aware of their own attitudes, anxiety, and confidence regarding mathematics. The unit was conducted for the first time in 2013 and initial results from the three administrations of all of the instruments indicate success in both identifying areas that pre-service teachers can focus on to address and for showing changes in these areas over the length of the unit. The next iteration of the unit will also include the instrument on conceptualising mathematics. It is anticipated that the results of the next version of the unit will also reflect Wilkins and Brand's (2004) and Beswick's (2006) findings—that mathematics education units and their education course can positively influence and change pre-service teachers' beliefs and attitudes about mathematics.

The incorporation of disposition towards mathematics in teacher education courses can be helpful in establishing baseline data (Jung et al., 2006) as well as a measure of the impact of the teacher education course. It will also provide pre-service teachers with the opportunity to incorporate reflection and an element of what could be termed meta-disposition, where their access to measures of the components of their disposition towards mathematics enables them to address areas they identify as needing to change. This meta- approach reflects Lin, Schwartz, and Hatano's (2005) consideration of the impact of metacognition on pre-service teachers, specifically the monitoring aspect that enables performance at a higher level.

In this paper, disposition towards mathematics does not include a component addressing competence. The exclusion of competence as a component to be incorporated in the measure of disposition towards mathematics reflects a view of numeracy as comprising two branches—the mathematics skills and their use as one branch, and the willingness and confidence to use them as the other. Ananiadou and Claro (2009) saw competence as involving the application of skills, which sits well with the first of the two branches described above. However, they also considered that attitudes could impact on competence—which would be problematical if both competence and attitudes were measured as components of disposition towards mathematics. Keeping competence separate from disposition towards mathematics enables a cleaner and clearer view of each of these branches and tightens the links to numeracy. However, this separation should not be seen as artificial or imposed, it is a recognition of the AAMT (1997) description of numeracy—that both exist together to create numeracy.



There is no doubt that pre-service teachers need to be numerate. The doubt is in how numeracy will be described and how it will be assessed. In their development of a test of numeracy for pre-service teachers, the Australian Government Department of Education and Training (2013) needs to consider whether there will be a focus exclusively on mathematics skills or whether the disposition towards mathematics of the pre-service teacher will also be investigated.

If disposition towards mathematics is included—particularly what the AAMT (1997, p. 14) refers to as “personal confidence, comfort and willingness to ‘have-a-go’”—a more robust indication of pre-service teacher numeracy may be revealed. As Katz and Rath (1985) stated, including disposition towards mathematics reduces:

... potential risks of the excessive emphasis on skill acquisition frequently associated with the performance- or competency-based approach to teacher education. The most disconcerting risk (probably applicable to education at every level) is that excessive focus on skill learning, drill, and practice may damage the disposition to use the skills (p. 304).

Wilkins (2008) reiterates the concerns of Katz and Rath (1985) and underlines the importance of considering the potential for pre-service teachers’ dispositions towards mathematics to enrich pre-service teacher education. These points in no way advocate *not* developing mathematics skills—the aim is to consider both the mathematical skills and the disposition towards mathematics to ensure the development of true numeracy. That is, in Katz and Rath’s (1985) terms, consider both the skills and the disposition, not one or the other: “It is not a matter of emphasizing skills or dispositions; it is our view that the acquisition of skills and the dispositions to use them must be mutually inclusive goals” (p. 304).

With the potential of pre-service teacher education courses to change pre-service teachers’ attitudes and beliefs regarding mathematics (Leder & Grootenboer, 2005), it seems that pre-service teacher education courses are the best place to address issues of pre-service teacher numeracy, particularly the willingness and confidence to use mathematics.

## Conclusion

That pre-service teachers have mathematical skills is only part of the requirement to be numerate. It is willingness to use their mathematical skills and confidence in their use—their disposition towards mathematics—that also needs to be addressed in the development of numeracy. The overarching theme from this paper is that pre-service teacher disposition towards mathematics needs to be integrated into their mathematics education. Ways that disposition towards mathematics can be incorporated into pre-service teacher education is undergoing investigation and research. However, the first step should be to make pre-service teachers aware of their disposition towards mathematics and of the impact it can have on their own numeracy as well as how they will address the development of numeracy in their future students.

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