An Investigation of Pre-Service Teachers' Motivation and Self-Efficacy to Teach Numeracy

by

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Abstract

Teaching numeracy poses a significant challenge for many preservice teachers. More specifically, conceptual ambiguity regarding numeracy presents challenges for both teacher educators and future teachers. These difficulties are further compounded by significant and explicit attention given to numeracy in educational policy and national standards mandating the responsibility of all teachers to teach numeracy. In Australia, national policy has instituted a standardised literacy and numeracy test (LANTITE) for admission into teacher education programs. However, research indicates that personal competence does not necessarily translate to pedagogical competence. Furthermore, pedagogical competence does not necessarily equate to affective teacher beliefs such as motivation and self-efficacy. Previous research also reinforces that these affective variables exert significant influence on student learning outcomes. This highlights the need to combine content expertise with efforts to develop positive teacher beliefs within teacher education programs. At present, limited data has emerged regarding the motivation and self-efficacy of pre-service teachers when teaching numeracy across curriculum areas and including both primary and secondary year levels. Additional data is required to evaluate teacher educators' perspectives on the development of pre-service teachers' beliefs. An investigation of pre-service teachers' beliefs and their influences is therefore warranted and could contribute to improvements to initial teacher education programs involving numeracy curriculum and pedagogy.

The present research examines preservice teachers' levels of motivation and self-efficacy for teaching numeracy using a mixed methods design. Quantitative findings derived from a newly developed survey instrument demonstrated variability in levels of motivation and self-efficacy beliefs among 729 teacher candidates. Factor analysis indicated that both motivation and self-efficacy to teach numeracy represented valid and reliable factors reflective of Goos' rich interpretation of numeracy. Subsequent interviews with nine teacher educators yielded qualitative themes such as the significance of previous mathematical education and experience, and the role of teacher educators in fostering critical thinking of pre-service teachers. Integrating the quantitative and qualitative results highlights the need for sustained efforts to understand and improve teacher motivation and self-efficacy to teach numeracy within teacher education. Further research is needed to continue to improve the reliability and validity of the newly developed measure in conjunction with longitudinal and intervention studies. Overall, findings provide additional knowledge to inform ongoing program development and empirical inquiry regarding the field of numeracy teaching within initial teacher education.

Student Declaration

I, David Clements, declare that the PhD thesis entitled ‘Investigating Pre-Service Teacher Motivation and Self-Efficacy to Teach Numeracy’ is no more than 80,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work

I have conducted my research in alignment with the Australian Code for the Responsible Conduct of Research and Victoria University’s Higher Degree by Research Policy and Procedures.

All research procedures reported in the thesis were approved by the Victoria University Human Research Ethics Committee, application number HRE20-165.

Signature: *David Clements* Date: 11 March 2024

A Nataša

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ACARA	Australian Curriculum, Assessment and Reporting Authority
AITSL	Australian Institute for Teaching and School Leadership
CFA	Confirmatory Factor Analysis
EFA	Exploratory Factor Analysis
ITE	Initial Teacher Education
LANTITE	Literacy and Numeracy Test Initial Teacher Education
NAPLAN	National Assessment Program Literacy and Numeracy
PST	Pre-service Teacher
TE	Teacher Educator

Chapter one: Introduction

This thesis is driven by a commitment to enhancing numeracy teaching through initial teacher education by focusing on the motivation and self-efficacy of teachers. Motivation and self-efficacy are factors that influence a teacher's actions, reflecting their perceived desire, need, or belief in their capability to execute specific numeracy teaching tasks. Hattie et al. (2020, Section 1.4, para 1) highlight the central role that motivation and self-efficacy can play in educational success when writing that "motivating students…may be the greatest educational challenge of our times". Such an observation applies equally to educators. A key aspect of this educational challenge lies in the fact that motivation and self-efficacy share a reciprocal relationship whereby variations in one significantly affect the other (Bandura, 1997; Schunk & DiBenedetto, 2020). As such, it is difficult to identify the degree to which teachers' actions are attributed to one or both of these constructs. Furthermore, a large body of research indicates that motivation and self-efficacy vary regarding different sets of tasks, referred to as domain specificity (Bandura, 1997; Eccles & Wigfield, 2020; Pajares, 1996; Schunk & DiBenedetto, 2020; Smith & Fouad, 1999;;;). This domain specificity suggests that an individual teacher can feel motivated or self-efficacious to teach mathematics but not so in another domain such as physical education. Consequently, investigations into these constructs is best addressed from a domain perspective (Schunk et al., 2008).

Arguably one of the most important domains in education is numeracy as it underlies a vast range of educational, personal, social and occupational activities and outcomes (Parsons & Bynner, 2005). For example, research consistently attests to robust associations between numeracy and individual outcomes such as early mathematics proficiency (Mononen et al., 2015; Zhu & Chiu, 2019), and employment prospects including increased likelihood of high salary skilled occupations (Cumming, 2000). STEM careers (Yamashita et al., 2023) and choice of STEM subjects are similarly linked with higher levels of numeracy (Holmes et al., 2018; Jeffries et al., 2020). Additionally, research points to connections between numeracy and decision making capacities across financial and health domains (Peters & Shoots-Reinhard, 2022). Such investigations substantiate calls for better developing numerate citizens capable of navigating a private and public sphere saturated with quantitative information (Steen, 2001). Numeracy outcomes are also intertwined with broader economic ones. Investigations by the Organisation for Economic Co-operation and Development (OECD) link GDP and a country's wealth to its population's level of numeracy as measured by PISA (OECD, 2019). This relationship suggests that numeracy not only facilitates personal and social advancement but also propels innovation and efficiency across the labor market, particularly in mathematics-intensive sectors such as STEM, which are vital for national progress and global competitiveness (Productivity Commission, 2023).

This foundational role of numeracy in education, both within Australia and globally, has led to significant emphasis and investment in this area (Geiger et al., 2015). This focus is evident in the establishment of standardized testing initiatives such as Australia's National Assessment Program - Literacy and Numeracy (NAPLAN)(ACARA, 2023a), the Program for International Student Assessment (PISA), and the Trends in International Mathematics and Science Study (TIMSS), which underscore the prioritization of numeracy in discussions around educational outcomes (Liljedahl, 2015; Tsatsaroni & Evans, 2014). Policy developments parallel this emphasis on numeracy. For instance, the Australia Curriculum specifies numeracy as a core capability to be taught across all learning areas (ACARA, 2023b). On an international scale, UNESCO underscores the critical role of numeracy in education when it writes “Literacy and numeracy are indispensable not only to … the 10 related targets set out in the Education 2030 Framework for Action, but also to meeting the other 16 SDGs” (UNESCO, 2017, p. 1).

Given the significance of motivation, self-efficacy and numeracy, the development and assessment of these aspects in teachers have become key concerns for initial teacher education (ITE) (Garvis & Pendergast, 2016; Han & Yin, 2016). For example, the importance of fostering pre-service teachers’ (PST) self-efficacy in numeracy is underscored by studies that reveal their often inadequate mathematical skills, particularly in areas such as fractions and proportional reasoning (Lovin et al., 2018). This example points to how assessment within ITE can play a role in identifying pre-service teachers' educational needs, pathways for their growth, and the evaluation of such growth. Additionally, the development of measures of constructs such as motivation and self-efficacy to teach numeracy can promote a deeper understanding of its nature, influencing factors, and underlying mechanisms (Bandura, 1997). For instance, employing psychometric measures, Dweck (1999) has illuminated how fixed versus growth mindsets can impact effort, persistence, and resilience. An investigation into measuring levels of motivation and self-efficacy to teach numeracy in ITE could be equally illuminating for the goal of numeracy education.

The ability to assess and improve pre-service teachers’ motivation and self-efficacy to teach numeracy however is constrained by conceptual ambiguity and insufficient empirical data from robust measures. Firstly, conceptual ambiguity regarding what numeracy is and its distinction from mathematics exists throughout the literature, policy, and curricula (Askew, 2015; Frejd & Geiger, 2017; Geiger et al., 2015; Karaali et al., 2016; O'Sullivan, 2022; Vacher, 2019;). Such ambiguity has arguably inhibited efforts by schools and teachers tasked with teaching it (Goos & O'Sullivan, 2023). The conceptual difficulty is also compounded by a variety of synonymous or interrelated terms such as quantitative reasoning, quantitative literacy and mathematical literacy (Vacher, 2019). The absence of a clear concept of numeracy is likely to result in ineffective implementation of Australian national educational policies and teacher standards which explicitly make numeracy the responsibility of all teachers, across all subjects and year levels, including both primary and secondary (AITSL, 2017). Similar policies and standards also exist internationally, such as in Ireland (O'Sullivan, 2022). Parallel with difficulties faced by teachers are those specific to the field of initial teacher education. Reviews of ITE programs such as the recent Australian Teacher Education Expert Panel (TEEP) report, Strong Beginnings, have raised concerns over pre-service teacher graduates not feeling prepared to *teach* numeracy (TEEP, 2023). In addition to the definitional difficulties associated with the concept of numeracy, teacher educators in ITE programs are also faced with determining what it means to *teach* numeracy (Kortjass et al., 2021). Furthermore, questions can be raised regarding which teacher educators should be developing pre-service teachers' ability to teach numeracy and how it should be taught. Similar to teachers in schools, teacher educators are likely to vary in their understanding of what it means to teach numeracy (Kortjass et al., 2021). However, unlike in schools where all teachers teach numeracy, currently there is no requirement that all teacher educators should be responsible for developing pre-service teachers' ability to teach numeracy in Australia. Given the challenges outlined, further research into the conceptual definition of numeracy and numeracy teaching has potential to address some of these concerns.

There is also a need for further empirical work regarding pre-service teachers' numeracy teaching practices. In the Australian context, candidates to ITE courses must pass the Literacy and Numeracy Test (LANTITE) to a particular standard (Department of Education, 2024). Furthermore, ITE programs are required to demonstrate where their courses teach, practice, and assess each of the Australian Professional Standards for Teachers (APST) standards, of which 2.5 explicitly relates to literacy and numeracy teaching (AITSL 2017). However, the premise of ITE is clear that personal competence in knowledge or skills does not automatically translate to pedagogical expertise (Shulman, 1987). Therefore, ensuring that teacher candidates pass a numeracy test is only one aspect of being able to teach numeracy. Little empirical work has been conducted on whether implementing the LANTITE in Australia has had a positive effect on the quality of teaching numeracy. Furthermore, there is little research on whether ITE programs not only develop quality numeracy teachers but also to what extent teachers believe they are motivated and self-efficacious as teachers of numeracy. However, it is difficult to address these gaps without first determining the extent to which pre-service teachers are motivated and self-efficacious to teach numeracy.

This research addresses both the conceptual difficulties of defining numeracy teaching and the lack of empirical data on the extent to which pre-service teachers are motivated and self-efficacious to teach numeracy. Investigations into educational issues are arguably best informed by addressing at least the two necessary parts of any educational equation; the teacher and the student, or in this case, the teacher educator and pre-service teacher.

Research aim

The primary aim of this research is to investigate pre-service teachers' and teacher educators' perspectives of the key aspects of motivation and self-efficacy to teach numeracy. To achieve the aim, it is expected that an understanding of the current levels of motivation and self-efficacy, the dimensions of numeracy involved, and factors which influence these will be needed. As such, this research develops and validates a new psychometric measure to elicit a pre-service teacher perspective and compare the results with the perspectives of teacher educators. It seeks to complement previous research on the topic of numeracy (Geiger et al., 2015), the knowledge required for teaching numeracy (O'Sullivan, 2022) and numeracy teacher identity (Bennison, 2016) by complementing these efforts with work on the extent to which they are producing both motivated and self-efficacious teachers.

Thesis structure

The structure of this research is as follows. Chapter 2 reviews the existing literature on both the conceptual and empirical aspects relevant to pre-service teacher motivation and self-efficacy to teach numeracy. Conceptually, this includes examining how numeracy, motivation and self-efficacy are understood within the literature. The purpose here is to identify and make clear a foundation for using these terms throughout the research. Empirically, relevant studies on motivation and self-efficacy to teach measures are reviewed to determine what currently exists to serve as a basis for a new measure of numeracy teaching. Furthermore, studies on pre-service teachers' and teacher educators' perspectives provide an understanding of what is currently known and needs more research regarding the development of numeracy teaching practices in initial teacher education.

Chapter 3 then outlines how this research seeks to address the aims from two perspectives: that of pre-service teachers and teacher educators. While many studies typically focus on either students or teachers, the present research examines both considering them equally essential aspects of any educational equation. As an initial investigation into an under researched topic, a descriptive, cross sectional, mixed methods research design was adopted. This design is divided into three studies. The first two concern the development of a new measure of motivation and self-efficacy to teach numeracy using two independent samples of pre-service teachers. The third study then implements a series of interviews with a sample of teacher educators regarding their perspectives.

Chapter 4 presents the aims, methods, results and discussion of the first study. The study is designed to develop a new measure of motivation and self-efficacy to teach numeracy. This development requires the generation of questionnaire items to be administered with a sample of pre-service teachers studying a teacher education course for any level (primary, secondary or both) and with any set of specialisations (such as English, Maths, PE, etc.). As a new measure without any existing ones available to be adapted, exploratory factor analysis is used to assess its reliability and validity.

Chapter 5, study two, builds on the results of chapter 4 employing confirmatory factor analysis of the newly developed measure with an independent sample of pre-service teachers. The aim here is to both improve the measure's reliability and validity as well as then examine the influences of demographic variables on motivation and self-efficacy to teach numeracy.

Chapter 6 reports on the third study regarding the investigation of teacher educators' perspectives regarding pre-service teacher motivation and self-efficacy to teach numeracy using semi-structured interviews. Nine teacher educators teaching into a teacher education course at any level (primary, secondary, or both) and from both mathematics and non-mathematics backgrounds were purposively sampled. Thematic analysis was then used to generate results able to be compared with the first two studies.

Chapter 7 then compares and contrasts the similarities and differences between the first two studies (pre-service teacher perspective) and study three (teacher educator perspective) in relation to the aim of investigating the levels of motivation and self-efficacy to teach numeracy. Results from the measure, including the influence of demographic variables, can be compared with the thematic insights from teacher educators regarding, for example, what the structure of numeracy teaching is, and what the levels of motivation and self-efficacy are. This synthesis of both perspectives provides a potentially more robust and nuanced understanding that would otherwise be lacking.

Finally, chapter 8 presents a brief summary of the main results of the thesis in relation to the main aim and the key contributions to research. Recommendations for initial teacher education programs and future research projects are also given.

Chapter two: Literature Review

This chapter reviews the literature to examine the concepts of numeracy, motivation, and confidence and associated empirical measures within the field of initial teacher education. The reason for this review is to identify what is currently known in regard to this thesis' aim of investigating key aspects of pre-service teacher motivation and self-efficacy to teach numeracy. Establishing what is known is crucial for providing a rigorous basis for this investigation as well as identifying gaps that need to be addressed in doing so. A further reason stems from the fact that numeracy, motivation and self-efficacy are debated terms and empirical measures have been developed on the basis of differing interpretations of these terms. It is important therefore to provide a detailed analysis of these measures and their underlying constructs as follows. Firstly, this review explores the diverse conceptualizations of numeracy, which includes a variety of aspects such as basic arithmetic skills, mathematical literacy, cross-curricular emphases, contextually applied mathematical thinking, number sense, and social practices. Secondly, this review critically evaluates seminal and contemporary theories of motivation, including Self-Determination Theory, Social Cognitive Theory, Expectancy-Value Theory, Goal Achievement Theory, Attribution Theory, to identify a suitable approach to investigating levels of motivation to teach numeracy. Thirdly, it then examines the key distinctions regarding the definition and concept of confidence in educational contexts, by distinguishing between confidence as a general trait and a domain-specific concept, and the uses of the terms self-efficacy, self-concept, self-esteem, and locus of control as more specific notions of confidence. The analysis of the literature regarding these concepts of numeracy, motivation and confidence is then followed by a review of studies developing or using empirical measures of teaching relevant to initial teacher education. This section is divided into research from teacher educator and pre-service teacher perspectives seeking to determine the extent to which research has been conducted on motivation and confidence to teach numeracy and the key issues relating to the development of measures. Lastly, this review summarises the foundation for developing a novel measure to be used to meet this thesis' aim of investigating the key aspects of pre-service teachers' motivation and self-efficacy to teach numeracy. The conclusions drawn from this review will also then be used to further specify this aim into three sub-aims.

Numeracy concept

Defining numeracy within the educational literature is made difficult by a diversity of definitions and interpretations that have been offered, reflecting a significant level of ambiguity as seen from previous reviews (Frejd & Geiger, 2017; Geiger et al., 2015; Karaali et al., 2016; Sikko, 2023; Vacher, 2019). This variety of perspectives requires careful analysis, particularly in relation to one of the key premises of this research being the fact that in Australia and other parts of the world, numeracy is the responsibility of all teachers across all learning areas. Therefore, the aim of this section involves reviewing the different definitions of numeracy but also evaluating which is most appropriate as a basis for this current research. A brief survey reveals that a dominant view of numeracy is that it transcends basic arithmetic proficiency, capturing a broad array of competencies including mathematical reasoning, problem-solving capabilities, and the critical application of mathematical concepts across varied contexts (Geiger et al., 2015; O'Sullivan, 2022). However, the existence of other lenses through which numeracy is viewed by educators, policymakers, and researchers contribute to a heterogeneity in its conceptualization, operationalization, and the methodologies employed in its measurement (Frejd & Geiger, 2017; Pillai et al., 2017). This heterogeneity in understanding has implications for curriculum design, measures and assessments, and the preparation of pre-service teachers, influencing the pedagogical aspects involved in numeracy teaching (Goos & O'Sullivan, 2023). An analysis of these different views will be made clearer however with a brief outline of the history and background of the term numeracy.

The origin of the term 'numeracy' is relatively recent with seminal reports by Crowther (Ministry of Education, 1959) and Cockcroft (1982) frequently cited as pivotal in its conceptual evolution (Sikko, 2023). The Crowther Report is widely recognized for introducing the term 'numeracy,' in a passage that reads:

> In schools where the conditions we have described in the last paragraph prevail, little is done to make science specialists more "literate" than they were when they left the Fifth Form and nothing to make arts specialists more "numerate", if we may coin a word to represent the mirror image of literacy. (p. 269).

However, despite some claims to the recency of the not just the term, but the concept also (Geiger et al., 2015), historical analyses across various timelines, including the UK, US, and ancient Greece, suggest the concept of numeracy or its equivalent in societal functions dating back to antiquity (Cohen, 2016; Netz, 2002; Sing et al., 2022; Thomas, 1987). Such historical perspectives not only affirm numeracy's intrinsic value to societal development but also help track its trajectory in response to societal progress, perhaps also mirroring the evolution of mathematical thought. Interestingly, the Cockcroft Report articulates a notable shift in the interpretation of numeracy even over the two decades from its original conceptualization in the Crowther Report (Cockroft, 1982). It writes:

> In none of the submissions which we have received are the words 'numeracy' or 'numerate' used in the sense in which the Crowther Report defines them. Indeed,

> we are in no doubt that the words, as commonly used, have changed their meaning considerably in the last twenty years. (p. 11)

This observation is echoed by Craig (2018), who posits that the discourse on numeracy seeks to provide a middle path to traditional debates in mathematics education, particularly within the United States context. These brief historical details highlight the need for a comprehensive and detailed exploration of numeracy, to capture the variety of aspects of this construct.

In reviewing the diversity of views found within the literature on numeracy, six key aspects of thematic dimensions have been identified. However, this categorization of numeracy research into distinct viewpoints is primarily methodologically convenient. It does not fully capture the extent to which each aspect overlaps with other views in the academic discourse. Instead, the aim of this review is an attempt to identify and discuss the key features of numeracy relevant to this these which is to identify a conceptual framework that holistically addresses the various aspects of numeracy. This approach requires an analysis of each of these aspects, identifying the issues associated with each. Through this process, the review aims to provide a basis for defining numeracy that aligns with the research objectives and can inform the development of an effective measure for evaluating pre-service teachers' motivation and confidence to teach numeracy.

Basic arithmetic

A first conceptualisation of numeracy centres on viewing it as a set of basic arithmetic skills or essential mathematical operations such as addition, subtraction, multiplication, and division (Cohen, 2016; Ghazali et al., 2021; Karaali et al., 2016; Netz, 2002; Sing et al., 2022; Thomas, 1987). This view which could also be characterised as statistical, or computational proficiency as foundational to numeracy, predominantly finds expression outside educational discourse and within other disciplines such as health (Anderson & Schulkin, 2014), decision science (Cokely et al., 2014), history (Cohen, 2016), neuroscience (Carreiras et al., 2015), and psychology (Garcia-Retamero et al., 2019). Definitions emerging from this perspective, such as those by Kirsch (2001) and Adelswärd & Sachs (1996), highlight the application of arithmetic operations and the mastery of systems for quantification, measurement, and calculation as central to numeracy. For example, Kirsch et al., (1993) defines numeracy as:

> The knowledge and skills required to apply arithmetic operations, either alone or sequentially, to numbers embedded in printed materials, such as balancing a check-book, figuring out a tip, completing an order form, or determining the amount of interest on a loan from an advertisement. (p. 3)

However, this arithmetic-centric definition encounters several issues. Firstly, it overlooks other such dimensions which include mathematical reasoning, problem-solving, and the practical application of mathematics in real-world scenarios (Steen, 2001). Secondly, by confining numeracy to a narrow band of mathematical skills, such a definition fails to address broader societal applications (Sikko, 2023). Thirdly, this perspective may promote a fragmented approach to numeracy teaching, omitting elements such as the cross-curricular or interdisciplinary applications. Furthermore, in today's context which is increasingly being characterized by digitization, data and information, a focus on basic arithmetic skills may not be sufficient in equipping individuals with the necessary quantitative competencies to navigate modern society (Hobart & Schiffman, 2000). Overall, an emphasis on arithmetic proficiency seems to neglect these wider aspects of numeracy as a versatile skill necessary for engaging with mathematics across various personal, professional, and civic spheres.

Despite these challenges, a functional arithmetic view of numeracy is not without significance. Historical analyses, such as those by Cohen (2016) and Netz (2002), suggest that even a conception of numeracy limited to arithmetic skills can have profound implications for democracy and societal movements. Furthermore, ancient Greek notions of 'arithmos', despite their divergence from contemporary definitions of numeracy, have been also been regarded as foundational to the epistemology of knowledge (Sing et al., 2022). However, given the aim of this research, an arithmetic-centric view of numeracy appears inadequate for examining the motivation and self-efficacy of teachers across all learning areas. Instead, such a view arguably fits better with an emphasis on mathematics educators teaching arithmetic fluency within mathematics.

Mathematical literacy

An alternative perspective of numeracy emphasizes the notion of mathematical literacy, which itself is a term that also possesses a variety of interpretations (Ojose, 2011; Pillai et al., 2017). According to Sikko (2023), mathematical literacy can be construed in two key ways. Firstly, it could be employed interchangeably with numeracy, as evidenced by the definition provided by the Department of Education in South Africa, which describes mathematical literacy as the capacity to appreciate and comprehend the significance of mathematics in contemporary society. This conception is driven by an emphasis on life-related applications of mathematics, aiming to equip learners with the skills necessary to engage numerically and spatially in evaluating and addressing everyday contexts. This interpretation closely aligns with Geiger et al.'s definition of numeracy, which also highlights the ability to apply mathematical insights to non-mathematical contexts, exercise critical judgment, and solve real-world problems effectively (Geiger et al., 2015).

The second interpretation of mathematical literacy focuses on the idea of mathematical competence or proficiency, signifying the capability to interpret, analyze, and critically engage with mathematical content. This idea also moves beyond simple computation to encompass problem-solving and mathematical reasoning skills (Jain & Rogers, 2019; Karaali et al., 2015; Sikko, 2023; Vacher, 2019). However, Sikko explains how this suggestion focuses more on adopting a mathematician's approach to learning mathematics, characterized by the type of activities, inquiry, and experimentation of working mathematicians (Sikko, 2023). When numeracy is defined as mathematical literacy in these ways, it introduces several issues relevant to the aims of this current research. Firstly, this perspective tends to elevate abstract mathematical concepts and formal mathematical notation, while sidelining the practical and contextual applications pivotal in other conceptualizations of numeracy (Steen, 2001). Secondly, an overemphasis on the activities of working mathematicians may potentially marginalize the practical application of mathematical knowledge in everyday life (Geiger et al., 2015) and reflective of the Australian Institute for Teaching and School Leadership (AITSL, 2017) guidelines, which advocate for the integration of numeracy development across all learning areas. Thirdly, this definition might not adequately address the socio-cultural and contextual dimensions of numeracy (Rosa & Orey, 2015; Skovsmose, 2005). Therefore, conceptualizing numeracy as mathematical literacy could restrict the scope of developing an applicable measure for numeracy teaching in this research thesis. Such a limitation is significant, given the expectation for all teachers to develop their students’ numeracy skills, emphasizing practical problem-solving, informed decision-making, and critical quantitative reasoning within real-life contexts (ACARA, 2023b).

Contextual and applied mathematics

A further aspect of numeracy identified from the literature involves emphasizing its fundamentally contextual and applied nature. In this aspect, numeracy is compared against an abstract domain of mathematics, and seen as inherently linked to various daily life contexts and decision-making processes (Cockroft, 1982; Gal et al., 2020; Rosa & Orey, 2015; Steen, 2001). Steen (2001) articulates this distinction as follows:

> Mathematics is abstract and Platonic, offering absolute truths about relations among ideal objects. Numeracy is concrete and contextual, offering contingent solutions to problems about real situations. Whereas mathematics asks students to rise above context, quantitative literacy is anchored in the messy contexts of real life. (p. 11)

This picture suggests that while mathematics seeks to abstract from context, numeracy is inherent to the contexts and complexities of everyday situations. However, this emphasis of numeracy as contextual and applied introduces challenges that inversely mirror those associated with mathematical literacy described above. While practicality and real-world applicability of numeracy is aligns with the premises of this research, a concentration on its applied nature may lead to a marginalization of the essential mathematical knowledge and abilities that form the foundation of numeracy (Goos et al., 2019). This view potentially overlooks the question of a mathematical foundation for the comprehension and effective manipulation of quantitative data across varied and genuine contexts (Sellars, 2017). Furthermore, an overemphasis on the applied dimension of numeracy could motivate an educational strategy, in which the development of any theoretical mathematical content is minimised. If this were true, learners may demonstrate proficiency in particular practical tasks yet encounter difficulties when required to apply their knowledge to novel situations or adjust to new quantitative demands (Maclellan, 2012). Therefore, while the significance of contextual and applied numeracy can be recognised, adopting a more balanced understanding of numeracy that combines both foundational mathematical principles with their practical applications across contexts is required.

Cross curricular

From a cross-disciplinary understanding, numeracy is identified as a capability or orientation that spans across all learning areas (Goos et al., 2019). This perspective emphasizes the role that numeracy plays not only within mathematics but also across subjects such as science, economics, geography, among others (Geiger et al., 2015; Cockroft, 1982). For example, Goos et al. (2019), referring to the Quantitative Literacy Design Team (2001), explain the idea that, "for numeracy to be useful to students it must be learned in multiple contexts and in all school subjects." (p. 21). This articulation suggests that numeracy's utility is maximized when it is integrated and applied across a broad array of educational settings and subjects.

However, there are also certain challenges which arise as a result of emphasizing this aspect of numeracy. For instance, acknowledging the cross-disciplinary nature of numeracy may also inadvertently overlook the necessity for deep engagement with the mathematical content and skills that are foundational to a robust understanding of numeracy (Burkhardt, 2007; Madison, 2007). As such, this perspective may inadvertently prioritize the broad applicability of numeracy skills across different areas of study at the expense of a concentrated effort on developing a solid foundation in mathematical knowledge and conceptual understanding (Burkhardt, 2007; Madison, 2007). Burkhardt for example, writes the following "I was astonished to see the view that QL should not be taught by mathematics teachers as part of the mathematics curriculum, but become a cross-curriculum responsibility" (Burkhardt, 2007, p.147). A key reason is that “QL facilitates the learning of mathematics” (p. 147). Finally, an emphasis on cross-disciplinarity raises the difficulty of teachers' capacity to design and implement instructional strategies that are specifically designed to address the learning needs of students within varied disciplinary contexts (Madison, 2007; Murray, 2007). Although these challenges are evident, it is the cross-curricular notion of numeracy which has been taken up by the curriculum in Australia and forms the premise of AITSL standard 2.5 that all teachers are responsible for teaching numeracy. As such, this aspect of numeracy is crucial for the purposes of this research. After discussing several of the other elements of numeracy, the particular cross-curricular understanding of numeracy developed by Goos will be returned to in considering the approach to numeracy taken in this thesis.

Numeracy as social practice

In the literature on numeracy there are also scholars who highlight the socio-cultural characteristics of numeracy, arguing that its concept is not a homogenous one but varies significantly across different cultural landscapes and is shaped by specific social norms and practices (Barwell, 2004; Craig & Guzmán, 2018; Yasukawa et al., 2018). This approach acknowledges that the conception of numeracy is not a static or universal construct but is profoundly influenced by the cultural and societal milieu in which it is situated (Jablonka, 2015; Rosa & Orey, 2015; Skovsmose, 2005). For example, Rosa and Orey (2015, Introduction, para 7) argue that, "numeracy is related to the appropriation of concepts, features, and principles of mathematical knowledge associated with its sociocultural contexts." This view emphasises the notion that numeracy being intertwined with the socio-cultural nature of a community, derives its meaning from within this context.

Framing numeracy as a socio-cultural phenomenon raises several points relevant to the aim of this research. While it is essential to recognize the impact of cultural and societal influences on the development and understanding of numeracy, an extreme focus on these aspects may lead to an unhelpful relativism. In such a case, numeracy becomes contingent upon specific cultural contexts, denying the possibility of the development of numeracy skills that may be common across cultural and societal settings (Rowlands et al., 2001). Additionally, an exclusive focus on the socio-cultural dimensions of numeracy faces the difficulty of addressing philosophy of mathematics claims regarding its objective nature (Clarke-Doane, 2020). Furthermore, without a shared understanding of quantitative concepts, facilitating effective discussion and interpretation of quantitative information beyond the scope of one's immediate cultural or contextual sphere proves difficult (Rowlands et al., 2001). Therefore, while the socio-cultural aspects of numeracy warrant acknowledgment, it seems appropriate given the aims of this research to seek a holistic conceptualization of numeracy that also includes the development of core mathematical skills. This approach ensures that individuals are equipped with the required competencies to engage with quantitative challenges proficiently, irrespective of cultural or contextual disparities (OECD, 2023).

Development of number sense

Particularly in the fields of neuroscience and cognitive psychology, numeracy is often conceptualized as a developmental process, where individuals acquire and refine a sense of number, which forms the basis for the progression of more complex mathematical reasoning (Dehaene, 2011; Ghazali et al., 2021; Maclellan, 2012; Mix & Sandhofer, 2007). This perspective highlights the progressive nature of numeracy competencies, viewing their evolution through a lens that is frequently biological or evolutionary. Dehaene (2011), for instance, introduces the number sense hypothesis as, "the peculiar idea that we owe our mathematical intuitions to an inherited capacity that we share with other animals, namely, the rapid perception of approximate numbers of objects." This hypothesis suggests a foundational, innate ability that underlies our capacity for numerical understanding and further mathematical thought.

This focus on numeracy as inherently developmental and grounded in number sense may not however fully capture the complexity of other aspects of numeracy such as how socio-cultural contexts shape numeracy (Yasukawa et al., 2018). A further issues that arises with this view is that emphasizing a developmental trajectory might also neglect the varied routes through which individuals acquire numeracy skills, which can be influenced by a range of factors including prior experiences, pedagogical strategies, and personal attributes. Additionally, a key difficulty with this perspective is its close association of numeracy with mathematical skill acquisition, suggesting that numeracy's ultimate goal is the mastery of mathematics (Dehaene, 2011), rather than acknowledging its broader application across various contexts and disciplines (Connolly et al., 2021). Thus, while the development of number sense has much empirical support, a comprehensive understanding of numeracy must also include both the developmental aspects and the critical role of domain-specific demands throughout the educational curriculum at higher levels and in other learning areas (Coffey & Sharpe, 2023).

Approach taken for this research

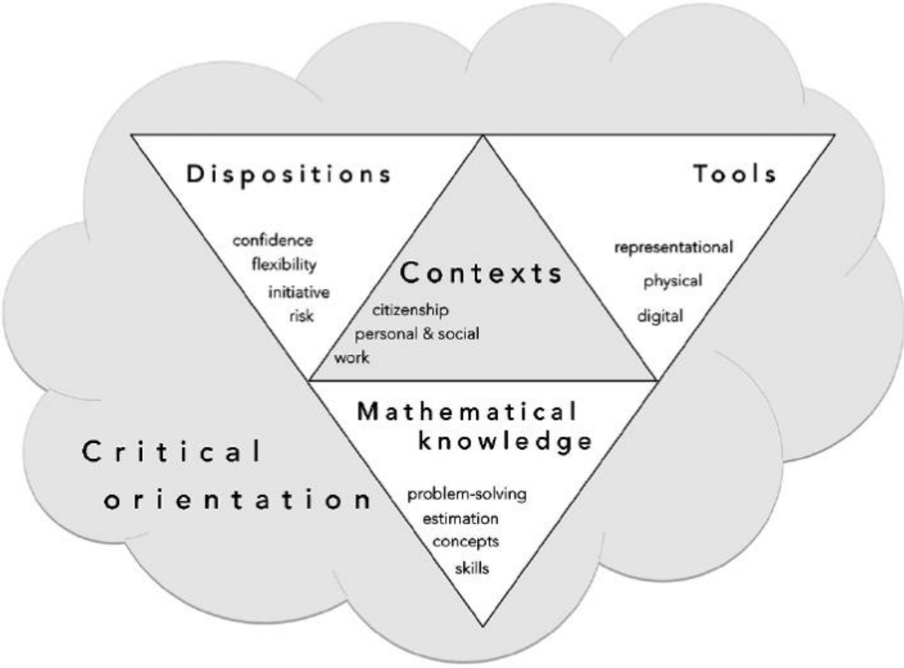
The above analysis of various aspects of and perspectives on numeracy illustrate the different interpretations of its definition and understanding. Some views emphasize the essential mathematical skills, while others highlight its practical applications, cultural significance, and cross curricular nature. Analysing this diversity of views was needed to identify a rigorous basis for the aims of this research thesis.

Despite the variance in perspectives, there is also a common thread to many of the views discussed: numeracy is fundamentally about engaging with numbers in a meaningful manner across various aspects of daily life. It can be argued that numeracy involves each of the aspects of the ability to process, analyze, and apply numerical and quantitative information through basic arithmetic, number sense, mathematical literacy, practical application, and within socio-cultural frameworks. At its core, numeracy represents the capacity to understand, use, and interpret numbers and data in diverse contexts, highlighting its critical role in decision-making, problem-solving, and engaging with the quantitative elements of life, education, and the broader society. While the specific emphases from the above discussions may differ, a consensus still emerges that numeracy is a key competency for effectively navigating the quantitative aspects of modern society.

It was noted that Goos advocated for a cross-curricular understanding of numeracy and that this therefore potentially aligned well with the aims of this thesis in investigating pre-service teachers' numeracy teaching across learning areas as expressed by AITSL 2.5. Here, Goos' framework is given further discussion and on the basis of the literature review of various views of numeracy, it is argued that Goos' framework best serves as a foundation for this thesis, inclusive of many of the aspects discussed above. Specifically, the selection of Goos' interpretation of numeracy as a foundation stems from the following reasons. Firstly, this framework presents a holistic view that resonates with many of the aspects expressed above. That is, it conceptualizes numeracy not merely as the ability to perform arithmetical procedures but as a construct that includes mathematical literacy, the practical use of mathematics in everyday life, and the critical analysis of quantitative data. As seen in figure 1, Goos' framework consists of five domains.

Figure 1

Goos' Model for Numeracy in the twenty-first century (Goos et al., 2019).



Briefly regarding each of the views of numeracy, Goos' framework includes attention to the socio-cultural and contextual dimensions of numeracy. This aspect of the framework is in line with contemporary views that advocate for an understanding of numeracy as a context-dependent skill. Additionally, the framework's utility extends across disciplinary boundaries, identifying numeracy as a capability across all learning areas. This cross-disciplinary recognition is crucial in an educational landscape that increasingly values the integration of skills across subject areas, highlighting numeracy's role as a fundamental competence in a wide array of academic and professional contexts. The developmental perspective offered by Goos' framework further strengthens its applicability. It acknowledges the progression of numeracy skills over time, addressing the educational requirements of learners at different stages of development. This perspective is essential for designing instructional strategies that are both age-appropriate and aligned with the learners' cognitive development stages.

Perhaps most importantly, Goos et al. (2019) initially articulated this framework with the explicit aim of aiding educators in teaching numeracy across the curriculum. This objective consolidates the framework's practical significance, offering a structured approach to integrating numeracy education throughout various subjects, thereby enhancing the coherence and relevance of numeracy teaching and learning and therefore provides a rigorous basis for the aims of this research. In summary, the depth and adaptability of Goos' framework render it as a highly appropriate model for conceptualizing numeracy. It accommodates a range of perspectives on numeracy, providing a solid foundation for both research and educational practice and therefore a comprehensive and inclusive approach to understanding and teaching numeracy.

Confidence concept

Just as with the definition and conceptualization of numeracy above, the primary challenge for the concept of confidence to teach lies in establishing a clear, empirically supported definition that distinguishes this construct from related concepts such as general confidence traits, self-efficacy and self-concepts. Addressing this effectively will involve a comprehensive review and synthesis of the literature on self-efficacy and confidence in the context of teaching. This will not only contribute a rigorous foundation for this current research but also enhance its applicability and relevance in pre-service teacher education.

In educational research, the conceptualization of confidence involves several definitions. Confidence has traditionally been viewed as a general belief in one's abilities, encompassing a wide range of activities and situations, similar to Bandura's (1977) concept of self-efficacy but more broadly and not confined to specific contexts. It has been defined both as a general sense of self-assurance in one's overall abilities (Bandura, 1997) and more narrowly as confidence in performing particular teaching tasks, such as the integration of technology into instruction (Ertmer & Ottenbreit-Leftwich, 2010) or teaching numeracy effectively (Beswick & Goos, 2012). Additionally, confidence has been tied to pedagogical content knowledge, with the premise that a teacher's confidence in their subject matter knowledge critically influences their instructional methods and student achievements (Swars et al., 2007). Importantly, some research understands the definition of confidence to include credence in one's judgment, investigating scenarios where participants are asked to answer questions and subsequently rate their confidence in the accuracy of those responses. This approach emphasizes the metacognitive aspect of confidence, highlighting its role in self-assessment and decision-making processes. The variety of interpretations of confidence therefore require some distinctions to be made so as to develop a clear basis for investigating pre-service teachers' numeracy teaching.

Metacognitive confidence

One conceptualization of confidence sees it as a metacognitive construct, whereby individuals assess the accuracy of their own responses. This view understands confidence in somewhat of a similar way to a belief in one's abilities, aligning with Bandura's (1977) definition of self-efficacy, but diverges by emphasizing the reflective assessment of one's knowledge or responses to specific tasks or questions. Metacognitive confidence, therefore, involves an evaluation of one's cognitive processes, including the judgments about the correctness of one's answers or decisions after having performed some action of behaviour. Crucially, however, Bandura's notion of self-efficacy, to be discussed further below, focuses on an individual's belief prior to undertaking an action, and not on an assessment of an already completed one. This perspective is critical when considering the development of a psychometrically valid and reliable measure for pre-service teacher motivation and confidence to teach numeracy, as it highlights the importance of distinguishing between the belief in one's capability to perform an action and the evaluation of one's actions. As will be seen in the review of empirical measures, the integration of metacognitive confidence into measures of teacher self-efficacy and confidence presents methodological challenges. Without a clear differentiation, the use of psychometric techniques such as factor analysis, while a robust tool for validation, can lead to poor solutions. Questions items need to be clearly formulated as assessing beliefs in capability or the reflective assessment of judgment accuracy.

Related constructs: general, self-concept

General confidence trait

In contrast to the metacognitive aspect of confidence, another approach is to conceptualise it as a general human trait, which relates to an individual's belief in their own abilities to succeed across a broad variety of tasks and settings. On this view, confidence is seen as a personality equivalent to the general intelligence factor g. This broad understanding of confidence is therefore distinct from the specificity of self-efficacy, as proposed by Bandura (1977) which is considered to be domain specific. Confidence as a general trait is rather understood as shaping one's approach to challenges in general, or resilience in the face of adversity, and overall performance in diverse areas of life, including education. Stankov (2012) posits that confidence, when viewed as a trait, overlaps significantly with constructs of self-esteem and generalized self-efficacy, yet maintains distinct qualities that influence decision-making and risk-taking behaviors. Confidence, in this broad sense, is not merely task-specific but reflects a global self-assessment of capability that affects one's engagement with the world (Stankov et al., 2017). Research by Chemers, Hu, and Garcia (2001) has suggested the importance of this type of confidence in academic settings, demonstrating its correlation with higher motivation, better performance, and increased persistence among students. These findings suggest that confidence, as a general trait, can play a crucial role in educational success, not only for students but also for educators. Teachers with high levels of confidence are more likely to implement innovative teaching strategies, maintain positive classroom environments, and foster a culture of learning that supports student achievement (Tschannen-Moran & Hoy, 2007). The measurement of confidence as a general trait often involves psychometric instruments that assess self-perceived abilities across a wide range of contexts. The General Self-Efficacy Scale (GSES) by Schwarzer and Jerusalem (1995) is a prominent example, designed to evaluate individuals' beliefs in their capacity to cope with a variety of difficult demands in life. Although not exclusively focused on confidence, the GSES reflects the broader conceptualization of belief in one's abilities that underlies the construct of confidence. In the realm of teacher education, Caprara et al. (2006) emphasize the role of teachers' personal beliefs in their effectiveness and satisfaction with their profession. Teachers who perceive themselves as competent and confident are more likely to experience job satisfaction and less likely to suffer from burnout, highlighting the significance of confidence in sustaining a healthy and productive teaching career. Furthermore, the relationship between confidence and other psychological traits, such as optimism and resilience, suggests that enhancing confidence could have far-reaching benefits for teachers' personal and professional well-being. Carmona-Halty, Schaufeli, and Salanova (2019) found that optimistic teachers exhibit higher levels of work engagement and resilience, indicating that interventions aimed at boosting confidence could also foster a positive outlook and resilience in the face of challenges.

Self-concept

Self-concept relates to an individuals' perception and evaluation of themselves, including their abilities, characteristics, and value. This broad understanding of self-concept overlaps with the notion of confidence, particularly when confidence is construed as a belief in one's general capabilities. Shavelson et al. (1976) provided a foundational model of self-concept, distinguishing between academic and non-academic self-concepts, with the former further divided into subject-specific evaluations. This model underscores the complexity of self-concept, suggesting that confidence, when viewed as part of self-concept, varies across different domains of an individual's life. Marsh and Martin (2011) extended this understanding, emphasizing the hierarchical and multidimensional nature of self-concept and its impact on academic achievement and motivation. In the context of education, self-concept influences not only students' learning outcomes but also teachers' efficacy and instructional strategies. Teachers with a positive self-concept are more confident in their teaching abilities, which translates into more effective teaching practices and a positive classroom environment (Tschannen-Moran & Hoy, 2001; Tschannen-Moran & Hoy, 2007). This relationship highlights the role of self-concept as a form of confidence that can enhance educational experiences for both teachers and students. Recent research has further explored the dynamic between self-concept and confidence. Orth et al. (2012) found that a positive self-concept is associated with higher levels of confidence, well-being, and resilience, indicating that interventions aimed at enhancing self-concept could bolster confidence across various domains.

The relationship between self-concept and confidence has significant implications for teacher education and professional development. Betoret and Artiga (2011) argue that enhancing teachers' self-concept can lead to increased job satisfaction and reduced burnout, underscoring the importance of confidence-building measures in teacher education programs. Similarly, Guo et al. (2010) demonstrate that early childhood educators' self-concept is closely linked to their teaching behaviors and interactions with students, further highlighting the critical role of confidence in effective teaching. In summary, self-concept is to be understood as a comprehensive evaluation of one's abilities and worth which can play a crucial role in shaping confidence in educational contexts.

Bandura’s self-efficacy

In contrast to both the general, metacognitive aspects and construct of self-concept, Albert Bandura's concept of self-efficacy, introduced in 1977, explicitly refers to an individual's belief in their capability to execute behaviors necessary to produce specific performance attainments (Bandura, 1977). Bandura’s seminal work, "Self-efficacy: Toward a unifying theory of behavioral change," argues that self-efficacy beliefs significantly determine how people feel, think, motivate themselves, and behave (Bandura, 1977). Bandura (1997) further elaborated on the concept in "Self-efficacy: The exercise of control," explaining that these beliefs influence the choices individuals make, the effort they put into tasks, their persistence in the face of challenges, and their resilience to adversity. The significance of self-efficacy in education stems from its predictive power regarding students' learning outcomes and teachers' instructional effectiveness. For instance, Tschannen-Moran and Hoy (2001) linked teacher self-efficacy to higher levels of planning, organization, and enthusiasm in teaching, demonstrating its impact on educational practices. Recent studies continue to validate Bandura's theory. For example, Klassen and Tze (2014) found that teacher self-efficacy significantly predicts teachers' willingness to implement technology in their teaching. Additionally, research by Zee and Koomen (2016) supports the idea that teachers’ self-efficacy beliefs are crucial for fostering a positive classroom climate and student engagement.

The development of self-efficacy beliefs, as outlined by Bandura (1977, 1997), occurs through four main sources: mastery experiences, vicarious experiences, verbal persuasion, and physiological and emotional states. Mastery experiences, or successes, reinforce self-efficacy, while failures may undermine it, particularly if failures occur before a sense of efficacy is firmly established. Vicarious experiences, such as observing peers succeed, can strengthen self-efficacy, especially when observers see themselves as similar to the models (Bandura, 1997). Verbal persuasion, including encouragement from others, can enhance self-efficacy beliefs, although its effects are often less lasting than those derived from mastery experiences. Lastly, positive physiological and emotional states can enhance self-efficacy beliefs, whereas negative emotions can diminish them. Measurement of self-efficacy has evolved to include various scales tailored to specific contexts, reflecting Bandura's assertion that self-efficacy is a task-specific construct. The development of reliable and valid instruments, such as the Teacher Self-Efficacy Scale (TSES) by Tschannen-Moran and Hoy (2001), demonstrates efforts to operationalize self-efficacy for empirical study.

Approach taken for this research

With several different understandings of what is meant by confidence, it is necessary to adopt a clear basis for this research. This section outlines the rationale for adopting Bandura's self-efficacy as the most appropriate foundation for developing a new measure of levels of confidence to teach numeracy, addressing the limitations associated with broader conceptualizations of confidence. Firstly, understanding confidence as a metacognitive construct involves assessing one's judgments about the correctness of their answers or decisions (Koriat, 2012). While metacognitive confidence is crucial for self-regulated learning, it emphasizes accuracy of judgment rather than belief in capability to perform tasks. This distinction is critical in the context of teaching numeracy, where the focus is on the teacher's belief in their ability to effectively teach numeracy rather than on accuracy of their judgement. Bandura's self-efficacy framework, with its emphasis on task-specific beliefs in capability, aligns more closely with the demands of teaching numeracy, as it accounts for the teacher's belief in their ability to engage students, convey complex mathematical concepts, and foster a positive learning environment for numeracy. This specificity ensures that measures of self-efficacy directly reflect the teacher's perceived competence in teaching numeracy, rather than their metacognitive assessment.

Secondly, conceptualizing confidence as a generalized trait suggests a stable, personality-like characteristic that influences behavior across various domains (Stankov, 2017). This broad conceptualization, while useful for understanding overarching patterns of behavior, lacks the context sensitivity required to accurately assess teaching competencies in specific subject areas such as numeracy. Generalized confidence measures may not capture the nuances of teaching numeracy, including the unique challenges and skills required for effective numeracy instruction. In contrast, Bandura's self-efficacy theory offers a task- and situation-specific framework that can more readily capture the unique aspects of teaching numeracy, thereby providing a more accurate and relevant assessment of teachers' confidence in their numeracy teaching abilities.

Thirdly, while self-concept encompasses an individual's overall perception of themselves, including their capabilities (Shavelson et al., 1976), it does not necessarily predict specific behaviors in particular contexts as effectively as self-efficacy (Marsh & Martin, 2011). Self-concept might influence a teacher's general sense of competence and worth, but it is Bandura's concept of self-efficacy that more directly impacts their motivation, persistence, and strategies in teaching numeracy. Self-efficacy beliefs are specifically related to how teachers plan, organize, and execute numeracy teaching tasks, affecting their instructional practices and student engagement in numeracy learning. Lastly, Bandura's self-efficacy theory also provides a clear methodology for measuring and enhancing self-efficacy through its identification of four primary sources: mastery experiences, vicarious experiences, verbal persuasion, and physiological and emotional states (Bandura, 1977; Bandura, 1997). This framework not only facilitates the development of targeted interventions to boost teachers' self-efficacy in numeracy but also enables the creation of measurement tools that can accurately assess changes in self-efficacy levels over time.

Given these reasons, Bandura's concept of self-efficacy offers a precise, performance-oriented framework for measuring and understanding confidence in teaching numeracy. It addresses the limitations of broader conceptualizations of confidence by focusing on task-specific beliefs in capability, directly linking these beliefs to performance in teaching numeracy. Adopting Bandura's self-efficacy as the theoretical foundation for a new measure of levels of confidence to teach numeracy ensures that the measure is contextually relevant, accurately assesses the specific competencies required for numeracy teaching, and provides a basis for effective intervention strategies to enhance teaching practices. Using Bandura’s concept also means that the more specific term of self-efficacy will be used as opposed to the term confidence for the remainder of the thesis.

Motivation concept

The concept of motivation within educational literature is characterized by a rich variety of definitions, theories and models, each positing different origins, mechanisms, and outcomes of motivational processes. Despite this diversity, there appears to be a fundamental agreement on motivation's role in directing behavior towards goals and sustaining engagement and effort over time (Schunk & DiBenedetto, 2020). However, the field also grapples with the challenge of integrating these diverse perspectives into a coherent understanding that accommodates the complex nature of motivational phenomena. Theories such as Self-Determination Theory (SDT) emphasize the importance of autonomy, competence, and relatedness as intrinsic motivators (Ryan & Deci, 2020), while Expectancy-Value Theory (EVT) focuses on how individuals' expectations of success and the value they attach to tasks drive motivation (Eccles & Wigfield, 2020). Additionally, the situated expectancy-value theory extends EVT by considering the influence of context and culture on motivation, highlighting the dynamic interplay between individuals and their environments (Turner & Patrick, 2008). Despite these advancements, some scholars call for a more integrated approach that bridges various theories, suggesting a need for continued research to achieve greater clarity and consensus on the underlying dimensions of motivation (Anderman, 2020; Nolen, 2020). Given this diverse range of views, and the vast amount of literature on motivation, it is not only necessary to review existing definitions and theories of motivation, but to also be selective in such a review. As such, five of the most dominant perspectives within the field of education and educational psychology have been analysed in order to determine a sufficient basis for this current research beginning with Self-determination theory.

Self-Determination Theory

Self-determination theory (SDT) posits that motivation is a phenomenon that varies in quality and intensity, depending on the degree to which it is self-determined or controlled by external forces (Ryan & Deci, 2017). The theory distinguishes between intrinsic motivation, which arises from within an individual due to the inherent satisfaction of an activity, and extrinsic motivation, which is driven by external incentives or pressures (Ryan & Deci, 2000). This distinction is crucial for understanding the depth and breadth of human motivation, as it acknowledges that the reasons behind our actions significantly impact our behavior, engagement, and well-being (Ryan & Deci, 2000).

One of the key contributions of SDT to the concept of motivation is its focus on basic psychological needs of autonomy, competence, and relatedness (Ryan & Deci, 2017). According to SDT, these needs are universal and essential for psychological growth, integrity, and well-being. When these needs are satisfied, individuals are more likely to experience intrinsic motivation and engage in activities with a sense of volition and passion (Deci & Ryan, 2000). The emphasis on basic psychological needs highlights the importance of the quality of motivation, suggesting that not all forms of motivation are equally beneficial for an individual's psychological health and performance (Deci & Ryan, 2000).

SDT also addresses the continuum of motivation, ranging from amotivation, or a lack of motivation, through various forms of extrinsic motivation, to intrinsic motivation, thereby offering a comprehensive framework for understanding the complexity of human motivation (Deci & Ryan, 2000). This continuum allows researchers and practitioners to assess not just the presence or absence of motivation but also its quality, providing insights into how to foster more self-determined forms of motivation in various domains, such as education, work, and health (Ryan & Deci, 2017).

Despite its contributions, SDT faces several difficulties. One challenge is the operationalization and measurement of the theoretical constructs of autonomy, competence, and relatedness, as well as the different types of motivation along the continuum (Deci & Ryan, 2020). While scales have been developed to measure these constructs, capturing the experiences of autonomy, competence, and relatedness in diverse cultural and situational contexts remains complex (Chirkov et al., 2003). This complexity can limit the applicability of SDT-based measures across different populations and settings, potentially restricting the theory's universality (Chirkov et al., 2003).

Another difficulty is the integration of SDT with other motivational theories and frameworks. While SDT provides a robust framework for understanding motivation, it does not fully account for the influence of unconscious motives, emotional processes, and the dynamic interplay between individual differences and situational factors on motivation. This limitation suggests that SDT might not capture the entire landscape of human motivation, requiring integration with other theoretical perspectives to provide a more comprehensive understanding of motivational processes (Ryan & Deci, 2017). Considering the focus of this thesis is on developing a measure of levels of motivation rather than the type of motivation, SDT's concept of motivation offers some assistance by emphasizing the importance of assessing the quality of motivation. However, this focus has meant that the development of measures typically go beyond quantifying motivation to understanding its sources (Ryan & Deci, 2017). Furthermore, SDT's framework may be inadequate as the sole basis for this new research project due to its emphasis on self-determination and intrinsic motivation, potentially overlooking other significant motivational factors such as emotional, unconscious, and situational influences (Deci & Ryan, 2000). Additionally, the complexity of measuring the psychological needs posited by SDT and their satisfaction across diverse contexts may limit the utility and generalizability of a new measure (Chirkov et al., 2003). Thus, while SDT provides a rich theoretical background for understanding the factors that influence motivation, it is primarily oriented towards explaining why people act in certain ways, not how much motivation they have. For the purposes of this research project however, a theoretical approach that explicitly addresses motivational intensity and can be adapted to measure changes in motivation over time or in response to specific interventions is needed. While SDT contributes valuable insights into the qualitative aspects of motivation, its focus on the types of motivation and the fulfillment of psychological needs makes it less suitable therefore, for this current research.

Social Cognitive Theory

Social Cognitive Theory (SCT), as articulated by Albert Bandura, offers a comprehensive framework that integrates cognitive, behavioral, personal, and environmental factors to understand human motivation (Bandura, 1986). A key aspect of SCT is the concept of reciprocal determinism, which posits that behavior, cognitive and other personal factors, and environmental influences all operate as interacting determinants of each other (Bandura, 1986). This interplay highlights the complexity of human motivation, acknowledging that it cannot be fully understood by examining only individual or environmental factors in isolation.

Another significant contribution of SCT to the understanding of motivation is the concept of self-efficacy, as discussed above, defined as individuals' beliefs in their capabilities to organize and execute the courses of action required to manage prospective situations (Bandura, 1997). Self-efficacy is central to SCT's explanation of motivation, as it influences the choices people make, the effort they put into these endeavors, their persistence in the face of obstacles, and the resilience they show to failures (Bandura, 1997). This emphasis on self-efficacy underscores the role of cognitive processes in motivation, suggesting that individuals' perceptions of their abilities significantly impact their motivational states.

However, SCT faces difficulties in accounting for the intrinsic aspects of motivation. While SCT acknowledges the role of intrinsic factors, its primary focus on external and cognitive influences sometimes underrepresents the intrinsic motivation that is pursued for its own sake, independent of external rewards or recognition (Deci & Ryan, 2000). This gap points to the complexity of human motivation, which includes activities engaged in for the inherent satisfaction they provide, beyond cognitive evaluations of capability or outcome expectations. Additionally, SCT's broad applicability across different domains and cultures raises questions about its sensitivity to cultural diversity in motivational processes. Although SCT posits that human motivation is shaped by a common set of cognitive mechanisms, the influence of cultural context on these mechanisms and their interplay with motivation can vary significantly (Markus & Kitayama, 2013). This variation suggests that SCT might not fully capture the cultural nuances that shape motivational processes, limiting its generalizability across diverse populations.

In the context of this research’s aim of developing a new measure of levels of motivation rather than types of motivation, SCT's concept of motivation provides valuable insights by emphasizing the importance of self-efficacy and the interplay between personal, behavioral, and environmental factors. These insights can inform the development of measures that account for the nature of motivation, including cognitive beliefs about self-efficacy and the influence of environmental factors. However, the intrinsic motivation to engage in activities for the inherent pleasure and satisfaction they provide, and the cultural context that shapes motivational processes, are critical components of motivation that SCT does not fully encompass (Markus & Kitayama, 2013).

Goal Achievement Theory

Goal Achievement Theory, also known as Goal-Setting Theory, conceptualizes motivation as largely driven by the process of setting and striving towards personal goals. This theory, primarily associated with the work of Locke and Latham (1990), posits that specific and challenging goals lead to higher performance than easy, non-specific, or no goals at all. One of the key aspects it contributes to the concept of motivation is the emphasis on goal specificity and difficulty as central determinants of task performance, suggesting that clear, challenging goals motivate individuals to exert effort, develop strategies, and persist in the face of obstacles (Locke & Latham, 2002).

Another significant contribution is the identification of high self-efficacy and commitment to goals as critical factors that enhance the goal-performance relationship. Individuals who believe in their capabilities (self-efficacy) and are committed to their goals are more likely to embrace challenging objectives, exert sustained effort, and achieve higher performance (Bandura, 1997; Locke & Latham, 1990). Similar to social cognitive theory, this focus on self-efficacy and commitment underscores the interplay between cognitive factors and motivation, highlighting how beliefs and attitudes towards goals can significantly impact motivational states and outcomes (Locke & Latham, 2002).

However, as with SCT, Goal Achievement Theory faces difficulties in accounting for the intrinsic value of activities and the role of intrinsic motivation in sustaining engagement and satisfaction. While the theory acknowledges the motivational power of goals, it primarily focuses on extrinsic outcomes and performance metrics, potentially underestimating the importance of intrinsic motivation

- engaging in activities for the sheer enjoyment and satisfaction they provide, independent of external rewards or outcomes (Ryan & Deci, 2000). Furthermore, the theory's emphasis on goal specificity and challenge may not fully capture the complexity of motivational processes in contexts where goals are ambiguous, fluid, or collaboratively determined. In such situations, the rigid application of specific and challenging goals might not be appropriate or effective, suggesting a limitation in the theory's applicability across diverse settings and tasks (Latham & Locke, 2007). Given the aims of this current research, Goal Achievement Theory's concept of motivation provides some assistance by highlighting the importance of goal specificity, difficulty, self-efficacy, and commitment. These factors can inform the development of measures that assess the motivational impact of goal characteristics and individual beliefs about goal attainment. However, the theory's focus on extrinsic goal achievement may be inadequate for such a research project because it does not fully address the multidimensional nature of motivation, including intrinsic motivation and the satisfaction of basic psychological needs (Ryan & Deci, 2000).

Attribution theory

Attribution theory, pioneered by Heider (1958) and further developed by Weiner (2012), focuses on how individuals interpret and ascribe causes to their own and others' behavior. This theory suggests that understanding how people explain their successes and failures is crucial to comprehending their motivation (Kelley, 1973). A fundamental aspect of attribution theory is its emphasis on the locus of control, distinguishing between internal attributions (causes within a person, such as ability or effort) and external attributions (causes outside a person, such as luck or task difficulty) (Weiner, 2012). This differentiation is vital for understanding motivation because it affects individuals' emotions, expectations, and future behaviors (Weiner, 2012). Attribution theory also focusses on stability and controllability. Weiner (2012) proposed that attributions along these dimensions influence individuals' expectancy of future success and their emotional reactions to success or failure. For example, attributing failure to a stable and uncontrollable factor like ability can lead to feelings of helplessness and decreased motivation, while attributing failure to unstable and controllable factors like effort can motivate individuals to try harder in the future (Weiner, 2012).

However, attribution theory also faces challenges in capturing the full complexity of motivational processes. One difficulty is the variability in attributional styles among individuals and across cultures, which can influence the generalizability of the theory's predictions (Markus & Kitayama, 2013). Moreover, the theory primarily addresses reactions to past events and may not fully account for proactive motivation or the role of future goals and aspirations in driving behavior (Dweck, 1999). Again, considering the aims of this current research, developing a new measure of levels of motivation rather than types of motivation, attribution theory's concept of motivation would suggest highlighting the importance of causal attributions in influencing motivational states. Understanding how individuals attribute their successes and failures can provide insights into their motivational orientations and potential barriers to motivation. However, the theory's focus on these post-hoc explanations of behavior may be inadequate for such a research project because it does not directly address the dynamic, forward-looking aspects of motivation that drive individuals toward future goals (Dweck, 1999). Furthermore, the emphasis on cognitive processes in attribution theory might not fully capture the emotional, social, and intrinsic aspects of motivation that are crucial for understanding and measuring motivation levels (Ryan & Deci, 2000).

Expectancy value

Expectancy-Value Theory (EVT) offers a nuanced understanding of motivation by combining individuals' expectations of success with the value they place on achieving certain outcomes (Wigfield & Eccles, 2000). This theory posits that motivation is influenced by the belief in one's capability to succeed (expectancy) and the perceived importance, interest, or utility of the task (value), suggesting that both these factors are critical for predicting engagement and performance in various domains (Eccles & Wigfield, 2002). Crucial to EVT is its emphasis on subjective perceptions and evaluations, recognizing that individuals' beliefs about their abilities and the significance of tasks play a central role in motivating behavior (Wigfield & Eccles, 2000). This perspective highlights the cognitive processes underlying motivation, offering insights into how expectations and values shape individuals' decisions to engage in, persist at, and perform tasks. EVT also differentiates between different types of values, such as attainment value, intrinsic value, utility value, and cost, providing a comprehensive framework for understanding the multifaceted nature of motivational constructs (Eccles & Wigfield, 2002). This differentiation allows for a more detailed analysis of how various aspects of value contribute to motivation, enabling targeted interventions to enhance motivation by addressing specific value components.

EVT struggles, however, in accounting for non-cognitive factors influencing motivation, such as emotional and social influences. While the theory acknowledges the role of such factors to some extent, its primary focus on cognitive evaluations may not fully capture the complexity of motivational processes (Ryan & Deci, 2017). Additionally, EVT's emphasis on individual perceptions and evaluations might overlook broader contextual and cultural factors that shape motivation, limiting its applicability across diverse settings and populations (Markus & Kitayama, 2013). EVT's concept of motivation provides valuable insights by emphasizing the importance of expectancy and value in motivating behavior. This focus can inform the development of measures that assess the cognitive determinants of motivation, potentially leading to more precise predictions of motivational outcomes. However, the theory's primary focus on cognitive evaluations may be inadequate for this current research project because it does not fully address the dynamic and complex nature of motivation that includes emotional, social, and intrinsic factors (Ryan & Deci, 2000). Moreover, the emphasis on individual perceptions and evaluations might not capture the full spectrum of motivational states.

Approach taken for this research

Having briefly reviewed several of the most prominent theories of motivation, it is necessary to justify the approach to be taken for this thesis. The central argument here is that a pragmatic approach to understanding and measuring motivation, particularly in the context of teaching numeracy, provides a more inclusive and flexible framework that can mitigate some of limitations inherent in adopting a singular theoretical perspective such as Self-Determination Theory (SDT). This approach acknowledges the debated nature of motivation, recognizing that each theory contributes to an understanding of individuals' motivational states as influenced by a variety of factors, both intrinsic and extrinsic, and that these factors may vary significantly across different contexts, cultures, and individuals (Turner & Patrick, 2008). The specific approach adopted for this research therefore is to focus on individuals' self-reported levels of motivation, rather than their types of sources of motivation. This more pragmatic approach leverages the subjective experience of motivation as a direct and accessible indicator of motivational states, thus offering a straightforward and adaptable method for measuring motivation levels in educational settings (Brehm & Self, 1989). One of the primary advantages of this approach is its inclusivity and flexibility. It does not restrict the understanding of motivation to a single theoretical framework but rather allows for the integration of insights from various theories, including but not limited to SDT, expectancy-value theory, and achievement goal theory (Dweck, 1986; Eccles & Wigfield, 2002; Elliot & McGregor, 2001). This approach is particularly advantageous in educational psychology and teacher education, where the diversity of student backgrounds, learning environments, and educational objectives necessitates a versatile and comprehensive approach to motivation (Wigfield & Eccles, 2000). This approach also has precedent, particularly as demonstrated by Brehm's theory of motivation intensity, which suggests that individuals' effort investment is directly related to the subjective value of the goal and the perceived probability of achieving it (Brehm et al., 1983). By asking individuals directly about their motivation levels, educators and researchers can identify insights into the subjective value students place on teaching numeracy and their beliefs about their ability to succeed, thereby addressing the core components of motivation intensity (Wright & Brehm, 1989). This method also circumvents some of the difficulties associated with operationalizing and measuring constructs defined by theories like SDT. For example, while SDT emphasizes the importance of autonomy, competence, and relatedness in fostering intrinsic motivation, these constructs can be challenging to quantify and measure directly, particularly in a way that is sensitive to the nuances of individual experience and cultural context (Ryan & Deci, 2017). A pragmatic approach, by relying on self-report measures of levels of motivation, can more easily accommodate this, providing a more individualized and context-sensitive assessment of motivation (Pintrich, 2003).

To conclude, a pragmatic approach to measuring motivation levels in the context of teaching numeracy represents a flexible, inclusive, and practical strategy that leverages the strengths of various motivational theories while avoiding their limitations.

By focusing on individuals' self-reported levels of motivation, this approach provides a direct, adaptable, and context-sensitive means of assessing motivation that can inform effective teaching strategies and support positive educational outcomes.

Research on Initial teacher education

Up to this point, the literature review has focused on the conceptual side of numeracy, motivation and confidence. This section now seeks to review the research and empirical studies relating to motivation and confidence to teach numeracy within the context of initial teacher education. Before doing so, some brief background on research in ITE in general will help highlight how research regarding pre-service teachers' and teacher educators' perspectives are largely separated with few studies attending to their comparison.

Initial teacher education (ITE) serves as a foundational phase in preparing pre-service teachers to enter the profession with the requisite knowledge, skills, and dispositions necessary for effective teaching. The complexity of ITE stems from the need to bridge theoretical knowledge with practical teaching skills, a challenge that involves both teacher educators and pre-service teachers. From the perspective of teacher educators, the challenge lies in designing curricula that are both academically rigorous and practically relevant, ensuring that pre-service teachers are equipped to face the diverse challenges of contemporary classrooms (Darling-Hammond, 2006). This involves a commitment to evidence-based teaching practices and the integration of pedagogical theory with subject-specific knowledge, particularly in areas such as numeracy, where confidence and competence are crucial (Ball et al., 2008).

Pre-service teachers, on the other hand, face the challenge of developing a professional identity and self-efficacy, particularly in relation to teaching subjects such as numeracy. Self-efficacy, or the belief in one's ability to execute behaviors necessary to produce specific performance attainments (Bandura, 1977), has been shown to play a critical role in shaping pre-service teachers' motivation, persistence, and resilience in the face of challenges. Research has shown that pre-service teachers often enter ITE programs with varying levels of self-efficacy, which can significantly impact their engagement with the curriculum and their development as teachers (Tschannen-Moran et al., 1998). Furthermore, the confidence to teach numeracy is not merely a function of mathematical competence but also of pedagogical content knowledge, the ability to convey mathematical concepts in ways that are understandable and engaging for students (Shulman, 1986).

Teacher educators are tasked with the dual responsibility of enhancing pre-service teachers' content knowledge and their pedagogical content knowledge, fostering an environment where pre-service teachers can develop the confidence and skills needed to teach numeracy effectively. This requires a focus on innovative teaching methodologies that promote active learning and reflection, as well as the provision of meaningful practicum experiences that allow pre-service teachers to apply their knowledge in real classroom settings (Zeichner, 2010). Moreover, the assessment of pre-service teachers' competencies must be aligned with these educational goals, utilizing both formative and summative assessments to gauge their development over time (Darling-Hammond, 2010).

The interplay between teacher educator responsibilities and pre-service teacher development highlights the complex nature of ITE. Addressing the key issues within ITE necessitates a comprehensive approach that considers the cognitive, motivational, and emotional aspects of learning to teach. This includes understanding the impact of self-efficacy on pre-service teachers' learning processes and outcomes, and the importance of creating supportive learning environments that foster both competence and confidence in teaching numeracy (Bandura, 1997). As such, ITE programs must be designed with an awareness of these dynamics, ensuring that both teacher educators and pre-service teachers are equipped to meet the challenges of modern education. From this brief review of the background of key aspects of ITE research, little research explicitly addressing both the perspectives of pre-service teachers and their teacher educators was found. The following sections therefore go into more detail regarding each perspective separately.

Teacher educators' perspectives

Research on teacher educators within Initial Teacher Education (ITE) has revealed critical insights into their roles, challenges, and the competencies they need to effectively prepare pre-service teachers, but with minimal focus on the topic of numeracy teaching. A significant finding is that teacher educators play a pivotal role in shaping the beliefs, knowledge, and practices of pre-service teachers, emphasizing the need for a deep understanding of pedagogical theories and practices as well as subject matter expertise (Loughran, 2014; Lunenberg, Dengerink, & Korthagen, 2014). This dual competence is particularly crucial in the context of teaching numeracy, where teacher educators must possess both mathematical knowledge and the ability to teach this content effectively to pre-service teachers (Sullivan, 2011).

Another key finding is the importance of teacher educators' own professional identities and how these identities influence their teaching and interactions with pre-service teachers. The development of a professional identity as a teacher educator involves a complex process of integrating personal beliefs about teaching and learning with professional knowledge and practices (Beauchamp & Thomas, 2009). This identity influences their motivation and confidence in their ability to teach and mentor pre-service teachers, which in turn affects the learning experiences of these pre-service teachers (Swennen et al., 2010). Additionally, research has highlighted the challenges teacher educators face, including the need to stay current in educational research and policy changes, the pressure to incorporate technology and innovative teaching methods into their teaching, and the expectation to contribute to the academic community through research and scholarship (Murray & Male, 2005). These challenges reinforce the necessity for ongoing professional development and support for teacher educators, ensuring they have the resources and skills needed to meet the demands of their roles (Cochran-Smith, 2005). Lastly, the impact of teacher educators on pre-service teachers' confidence and motivation, in teaching different learning areas, has been a focus of some recent studies. For example, teacher educators' beliefs and teaching practices have been found to significantly influence pre-service teachers' self-efficacy beliefs and their attitudes towards teaching mathematics, highlighting the need for teacher educators to model effective teaching practices and to provide supportive and constructive feedback (Swars et al., 2007). Overall, however, minimal research has attended to the question of numeracy teaching from the perspective of teacher educators.

Pre-service teachers and motivation to teach

General overview

In contrast to the literature on teacher educators and numeracy, far more research exists regarding pre-service teachers and the question of motivation to teach. However, no empirical measures of motivation or confidence to teach numeracy were identified in the literature. As such, this section first outlines some of the key findings from research on motivation of pre-service teachers in general before looking more specifically at motivation to teach measures. These measures have been selected because of their prominence of use, and measures that are cross curricular in nature have also been analysed due to their analogous relationship to the teaching of numeracy as a cross curricular endeavor.

Research into pre-service teachers' motivation to teach has identified several key factors. A central finding is the significant role of intrinsic motivation, which is driven by an inherent interest in teaching and a desire to make a positive impact on students' lives. Studies have shown that pre-service teachers with high levels of intrinsic motivation are more likely to be engaged in their teacher education programs and committed to pursuing a career in teaching (Watt & Richardson, 2007). This intrinsic motivation is often linked to personal teaching efficacy beliefs, where pre-service teachers feel confident in their ability to teach effectively and manage classroom challenges (Tschannen-Moran & Hoy, 2001). Another critical aspect of pre-service teachers' motivation is the influence of extrinsic factors, such as the perceived status of the teaching profession, salary prospects, and job security. While these factors are not the primary motivators for many pre-service teachers, they can impact their decision to enter and remain in the profession (Roness, 2011). The role of prior experiences, including positive interactions with teachers and successful teaching or tutoring experiences, has also been highlighted as a significant contributor to pre-service teachers' motivation to teach. These experiences can reinforce pre-service teachers' beliefs in their teaching abilities and their commitment to the profession (Klassen et al., 2011). Furthermore, the support and encouragement from teacher education programs, including mentoring relationships with faculty and opportunities for practical teaching experiences, are crucial for sustaining pre-service teachers' motivation. Engaging in reflective practice and receiving constructive feedback during practicum experiences can enhance their self-efficacy and commitment to teaching (Darling-Hammond, 2006).

Measures of motivation to teach

The exploration of pre-service teachers' motivation to teach has led to the development and validation of several psychometric scales, designed to measure various facets of motivational constructs in the educational context. Among these, the Factors Influencing Teaching Choice (FIT-Choice) scale by Watt and Richardson (2007) and the Teacher Beliefs and Motivations for Teaching Scale by Richardson et al. (2014) stand out for their comprehensive approach and widespread application in research.

The FIT-Choice scale, developed by Watt and Richardson (2007), is designed to assess the motivations behind individuals' decisions to pursue teaching as a career. This scale includes factors such as intrinsic value, perceived teaching ability, and social utility values, among others. It has been validated across different cultural contexts and is notable for its ability to capture a wide range of motivational factors. The scale demonstrates strong psychometric properties, including high reliability and validity, making it a valuable tool for understanding the complexity of pre-service teachers' motivation (Watt et al., 2014). Richardson et al. (2014) Teacher Beliefs and Motivations for Teaching Scale focuses on the beliefs about teaching and self-regulatory mechanisms that influence teachers' motivations. This scale emphasizes the role of self-efficacy, outcome expectancy, and task value in shaping motivation, providing insights into how pre-service teachers perceive their future profession. Like the FIT-Choice scale, it has been subject to rigorous psychometric testing, confirming its reliability and validity in measuring motivational constructs. While these scales have contributed significantly to the understanding of pre-service teachers' motivation, they are not without limitations. One critique of the FIT-Choice scale is that while the scale has been validated in various cultural contexts, the extent to which cultural differences influence motivation to teach is an area requiring further exploration. Also, the Teacher Beliefs and Motivations for Teaching Scale, while comprehensive, has been critiqued for its focus on the cognitive aspects of motivation, potentially overlooking the emotional and social dimensions that also play a crucial role in motivating individuals to pursue and remain in the teaching profession (Klassen & Chiu, 2011).

Within the SDT framework, scales developed to measure the motivation to teach based on SDT principles have aimed to capture the extent to which these needs are fulfilled in the teaching profession. One notable scale is the Work Tasks Motivation Scale for Teachers (WTMST), adapted by Fernet et al. (2008) from the original Work Tasks Motivation Scale. This scale assesses teachers' motivation towards various aspects of their work, including those tasks specific to teaching, through the lens of SDT. It evaluates intrinsic motivation, extrinsic motivation (identified, introjected, external), and amotivation towards teaching tasks. The WTMST has demonstrated good psychometric properties, including reliability and construct validity, in various studies. However, it has been critiqued for its focus on in-service teachers, with adaptations required to fully capture the pre-service teacher experience (Fernet et al., 2008). Another important contribution to measuring motivation in education through SDT is the Teacher Motivation and Self-Determination in the Classroom Scale developed by Pelletier et al. (2002). This scale is designed to assess teachers' self-determination for teaching, examining the extent to which their motivation aligns with SDT's intrinsic and extrinsic motivational orientations. While this scale provides valuable insights into teachers' motivation, its application to pre-service teachers necessitates further validation to ensure it accurately reflects the motivations of those entering the profession. Critiques of these SDT-based measures often revolve around the complexity of translating SDT's theoretical constructs into practical measurement tools that can accurately reflect the nuanced experiences of pre-service teachers. Additionally, the cross-cultural applicability of these scales raises questions about their universal relevance, given that cultural contexts can significantly influence motivational constructs (Chirkov & Ryan, 2001).

The Orientations to Teach Survey developed by Ferrell and Daniel (1993) represents a seminal contribution to the field of educational psychology, specifically in measuring the motivational orientations of individuals entering the teaching profession. This instrument was designed to categorize pre-service teachers according to their primary motivations for choosing teaching as a career, including altruistic, intrinsic, extrinsic, and lifestyle factors. The survey has been a pivotal tool for researchers aiming to understand the complex motivations behind choosing teaching as a career and how these motivations might impact future teaching effectiveness and retention in the profession. Subsequent research utilizing the Orientations to Teach Survey has provided valuable insights into the motivational profiles of pre-service teachers. Studies have demonstrated that those with a predominantly altruistic or intrinsic orientation tend to show higher levels of commitment and satisfaction once they enter the teaching profession (Richardson & Watt, 2006). These findings highlight the importance of fostering and supporting these motivations during teacher education programs to enhance teacher retention and effectiveness. Some critiques of the Orientations to Teach Survey, however, have emerged. One critique focuses on its static categorization of motivational orientations, which may not fully capture the dynamic and evolving nature of motivation as pre-service teachers progress through their training and into their professional careers (Watt & Richardson, 2007). Another limitation is the survey's emphasis on pre-entry motivations, potentially overlooking how motivations change in response to experiences within teacher education programs and early professional experiences. Longitudinal research is required to track these motivational changes and understand their implications for teacher development and retention (Eren & Tezel, 2010).

Lastly, another influential scale is The Academic Motivation Scale (AMS), developed by Vallerand et al. (1992). It is a well-established instrument designed to assess the motivation of students in academic settings and is also based on Self-Determination Theory (SDT). The AMS categorizes motivation into different types: intrinsic motivation (to know, to accomplish things, and to experience stimulation), extrinsic motivation (external, introjected, and identified regulations), and amotivation, providing a comprehensive framework for understanding students' motivational drives in educational contexts.

Pre-service teachers and Confidence to teach

General overview

Research into pre-service teachers' confidence and self-efficacy to teach has consistently emphasised the critical role these constructs play in educators' professional development and instructional effectiveness. Seminal work by Tschannen-Moran et al. (1998) established the Teacher Sense of Efficacy Scale, providing a foundational tool for measuring teacher self-efficacy across various domains, including classroom management, instructional strategies, and student engagement. Their research demonstrated that higher levels of self-efficacy among pre-service teachers are associated with more effective teaching practices and a greater willingness to implement innovative instructional methods. Subsequent studies have built upon these findings, exploring the factors that contribute to the development of self-efficacy and confidence in pre-service teachers. For instance, Klassen and Chiu (2010) found that pre-service teachers' self-efficacy beliefs are significantly influenced by their experiences during teacher education programs, including practicum experiences and the quality of mentorship received. These experiences contribute to their confidence in their ability to manage classrooms and deliver effective instruction. More research by Swars et al. (2007) emphasized the importance of subject-specific self-efficacy, particularly in mathematics education. They discovered that pre-service teachers' confidence in their mathematical abilities directly impacts their enthusiasm for teaching the subject and their persistence in overcoming teaching challenges. This highlights the need for teacher education programs to specifically address subject-matter confidence and provide targeted support to enhance self-efficacy in areas where pre-service teachers may feel less confident. Furthermore, the role of psychological well-being in developing teacher self-efficacy has gained attention in the literature. Caprara et al. (2006) illustrated that pre-service teachers' emotional states, including stress levels and job satisfaction, are closely linked to their self-efficacy beliefs. This suggests that fostering a supportive, positive learning environment within teacher education programs can significantly benefit pre-service teachers' confidence and self-efficacy.

Measures of confidence to teach

As with motivation to teach discussed above, several foundational scales have been developed and validated to measure pre-service teachers' confidence or self-efficacy to teach and then adapted further to particular scales.

The Teacher Sense of Efficacy Scale (TSES), developed by Tschannen-Moran and Hoy (2001), has been an influential instrument for measuring teacher self-efficacy. The TSES is grounded in Bandura's theory of self-efficacy (Bandura, 1977), and it is designed to assess teachers' beliefs in their ability to influence student engagement, classroom management, and instructional strategies. This scale has been extensively psychometrically validated and serves as a foundation for numerous subsequent measures of teacher confidence and self-efficacy. Tschannen-Moran and Hoy's (2001) development of the TSES involved a comprehensive process to ensure its validity and reliability. The scale includes items that reflect a wide range of teaching tasks and scenarios, making it a robust tool for assessing teacher self-efficacy across different contexts. The TSES has demonstrated strong internal consistency, with Cronbach's alpha coefficients regularly exceeding .90, indicating a high level of reliability (Tschannen-Moran & Hoy, 2001). Subsequent research has adapted the TSES to explore specific dimensions of teaching self-efficacy or to apply it within particular educational contexts. For example, Swars et al. (2007) modified the TSES to assess elementary teachers' self-efficacy in teaching mathematics. Their adapted scale, while maintaining the integrity of the original TSES structure, highlighted the importance of subject-specific self-efficacy in influencing teaching practices and student outcomes in mathematics. This adaptation reinforces the TSES's flexibility and applicability to various teaching domains. Another significant adaptation is the Science Teaching Efficacy Belief Instruments (STEBI), which measures science teaching self-efficacy. Originally developed by Riggs and Enochs (1990) and later aligned more closely with the TSES framework, the STEBI has been instrumental in assessing and enhancing science teachers' self-efficacy beliefs. Research using the STEBI has demonstrated its predictive validity concerning teachers' instructional practices in science education (Bleicher, 2004). Despite its widespread use and adaptation, there are critiques of the TSES and its derivatives. While the TSES provides a general measure of teaching self-efficacy, it may not capture the full complexity of teacher beliefs and their impact on specific teaching behaviors and student learning outcomes (Wheatley, 2005).

The Teacher Efficacy Scale (TES), originally developed by Gibson and Dembo (1984), has also played a foundational role in educational research, offering an approach to measuring teachers' beliefs in their ability to influence student engagement and learning outcomes. The TES is also based on the theoretical framework of self-efficacy as proposed by Bandura (1977), focusing specifically on the domain of teaching efficacy. This scale assesses two primary components of teacher efficacy: personal teaching efficacy and general teaching efficacy. Personal teaching efficacy relates to teachers' beliefs in their own abilities to bring about desired outcomes, while general teaching efficacy refers to teachers' beliefs in the ability of teachers collectively to influence student learning, regardless of external constraints (Gibson & Dembo, 1984). Research has both validated and critiqued the TES, leading to the development of refined scales and measures. The TES has demonstrated significant predictive validity, correlating with various positive educational outcomes, including teachers' instructional strategies, classroom management, and student achievement (Ross, 1992). Its psychometric properties have been extensively evaluated, with studies confirming its reliability and factor structure (Soodak & Podell, 1996). However, critiques of the TES have centered on its conceptual and methodological limitations. One critique involves the scale's dichotomous structure, which some argue oversimplifies the nature of teaching efficacy (Tschannen-Moran & Hoy, 2001). This critique led to the development of the Teachers' Sense of Efficacy Scale (TSES), which provides a more nuanced assessment of teacher efficacy across multiple dimensions, including instructional strategies, classroom management, and student engagement (Tschannen-Moran & Hoy, 2001). Further, research has questioned the stability of the TES's factor structure across different teaching contexts and populations. Some studies have found variations in the scale's factor loadings when applied to teachers working in diverse educational settings or teaching subjects (Wheatley, 2005). These findings suggest the need for scales that can accommodate the diverse realities of teaching practice. In response to these critiques, adaptations of the TES have been developed to address specific teaching domains or to enhance the scale's applicability across different educational contexts. For instance, the Science Teaching Efficacy Belief Instruments (STEBI) adapted the TES framework to measure science teaching efficacy specifically, demonstrating its utility in subject-specific teacher education research (Enochs & Riggs, 1990).

Although different from numeracy, a number of scales have been developed regarding the related learning area of mathematics. The Mathematics Teaching Efficacy Beliefs Instrument (MTEBI), an adaptation of the Science Teaching Efficacy Belief Instrument (STEBI) developed by Enochs and Riggs (1990), represents a significant advancement in this area. The MTEBI is designed to assess mathematics teachers' self-efficacy beliefs regarding their ability to teach mathematics effectively and influence student learning outcomes (Enochs et al., 2000). The MTEBI comprises two subscales: Personal Mathematics Teaching Efficacy (PMTE) and Mathematics Teaching Outcome Expectancy (MTOE). PMTE addresses teachers' beliefs in their capabilities to teach mathematics effectively, while MTOE relates to teachers' beliefs about the extent to which their teaching can influence student learning in mathematics (Enochs et al., 2000). Studies employing the MTEBI have demonstrated its strong psychometric properties, including high reliability and construct validity (Charalambous & Philippou, 2010). Research utilizing the MTEBI has provided valuable insights into factors influencing mathematics teaching efficacy. For instance, Swars et a. (2007) found that pre-service teachers' mathematics teaching efficacy beliefs were significantly related to their mathematics content knowledge and attitudes towards mathematics. This finding underscores the importance of both content knowledge and affective factors in the development of teaching self-efficacy.

In the area of classroom management, the Teachers' Sense of Efficacy Scale (TSES) includes a subscale specifically designed to assess teachers' beliefs in their abilities to manage classroom behavior effectively (Tschannen-Moran & Hoy, 2001). This subscale has been instrumental in linking teachers' self-efficacy beliefs to classroom management strategies, student behavior, and learning environments (Martin et al., 2006). Studies using the TSES have demonstrated that higher levels of self-efficacy in classroom management are associated with more positive classroom climates and better student outcomes (Emmer & Stough, 2001).

Regarding inclusivity, the Inclusive Teaching Strategies Inventory (ITSI), developed by Sharma et al. (2012), measures teachers' self-efficacy in implementing inclusive practices in their classrooms. The ITSI scale addresses various aspects of inclusive education, including differentiation, collaboration, and classroom management in diverse classrooms. Research employing the ITSI has shown that teachers' self-efficacy in inclusivity is critical for the successful inclusion of students with diverse needs and backgrounds (Malinen et al., 2012).

Pre-service teachers and Numeracy

Although no measures of motivation or confidence to teach numeracy were identified in the literature, some studies have addressed pre-service teachers and the issue of numeracy. This research comprises two distinct yet interrelated domains. On one hand, studies have investigated pre-service teachers' own personal numeracy, examining their mathematical skills, understanding, and attitudes towards numeracy as individuals. This line of inquiry assesses the foundational numeracy competencies that pre-service teachers bring to their professional education, highlighting areas of strength and identifying potential gaps that could impact their future teaching. On the other hand, a separate and growing body of research focuses on pre-service teachers' ability to teach numeracy, exploring how well they can transfer their personal numeracy understanding into effective teaching practices. This research evaluates the preparedness of pre-service teachers to design and deliver numeracy education across various curriculum areas, aiming to understand the impact of teacher education programs on building their pedagogical content knowledge and teaching self-efficacy in numeracy. Together, these two domains provide an overview of the challenges and opportunities in preparing pre-service teachers to support numeracy learning in schools and will be discussed sequentially.

Personal numeracy

Pre-service teachers' conceptualization of numeracy varies significantly, with a considerable proportion equating it directly with mathematical knowledge, such as counting and using mathematical figures (Forgasz et al., 2017). This perception demonstrates a foundational understanding but also reveals a narrower view of numeracy that might limit the application in diverse contexts. Forgasz et al., found that only a fraction of respondents view numeracy in terms of critical thinking processes like problem-solving and decision-making, which are crucial for real-life applications (Forgasz et al., 2017). This disparity in understanding necessitates ITE programs to foster a broader conceptualization of numeracy, emphasizing its applicability beyond traditional mathematical exercises to real-world problem-solving and decision-making contexts.

The apprehension about personal numeracy abilities among pre-service teachers emerges as a significant challenge, potentially impacting their engagement with numeracy in ITE courses (Forgasz et al., 2017). This apprehension is further compounded by the lack of recognition of the need for all teachers, irrespective of their specialization, to develop students’ numeracy capabilities. The introduction of compulsory numeracy courses, as reported by Forgasz and Hall (2019), aimed to address this by improving pre-service teachers' understanding of numeracy and confidence in integrating it across the curriculum. They developed courses which drew on comprehensive numeracy models to equip pre-service teachers with the skills to plan and implement numeracy-enriched tasks across various learning areas (Forgasz et al., 2017). Furthermore, the implementation of numeracy standards for graduate teachers has heightened the focus on numeracy within ITE programs, prompting a shift towards embedding numeracy across the curriculum. This shift is vital for preparing pre-service teachers to meet contemporary educational demands, emphasizing the application of numeracy in diverse academic disciplines and real-life settings (Forgasz et al., 2017).

Another key study in this area is by Hall and Forgasz (2017), which explored pre-service teachers' views on and capabilities in numeracy. This study, part of a larger project, aimed to understand how pre-service teachers perceive numeracy and their confidence in their numeracy skills before and after completing a numeracy unit in their Master of Teaching program at an Australian university. The majority of pre-service teachers recognized a difference between mathematics and numeracy, indicating an awareness that numeracy encompasses a broader set of skills beyond traditional mathematical knowledge. However, the study noted variations in how deeply pre-service teachers understood this distinction and its implications for teaching across the curriculum. Confidence in numeracy varied significantly among pre-service teachers, with those specializing in STEM subjects generally displaying higher confidence and capability in numeracy than their non-STEM counterparts. This finding underscores the influence of academic background on numeracy self-perception and highlights the need for targeted support within ITE programs for those from non-STEM fields. A substantial majority of pre-service teachers acknowledged the importance of being proficient in numeracy for effective teaching, reflecting an understanding of numeracy as a foundational skill across various educational contexts. Despite this acknowledgment, there was a noted gap between recognizing importance and feeling prepared to integrate numeracy into teaching practices effectively. The study suggested that engagement with the numeracy unit positively affected pre-service teachers' confidence and capabilities in numeracy. This finding points to the effectiveness of focused numeracy education within ITE programs in enhancing pre-service teachers' readiness to teach numeracy across the curriculum.

A study by Sellings et al., (2018) focused on enhancing pre-service teachers' literacy and numeracy skills through the implementation of the Developing, Embedding, Extending, Reflecting (DEER) framework within initial teacher education (ITE) programs. This framework was introduced to address the varying literacy and numeracy needs of a diverse student population and to ensure that pre-service teachers meet the literacy and numeracy standards required by policy and cultural expectations (Sellings et al., 2018). The DEER framework aimed to support all learners by recognizing the diversity of literacy and numeracy skill levels, the multimodal nature of literacy, the need for critical thinking and reflection skills, and the importance of highlighting literacy and numeracy in all courses (Sellings et al., 2018). The implementation of this framework was evaluated through the comparison of pre-service teachers' literacy and numeracy test results before and after the intervention. The study found significant improvements in both literacy and numeracy skills among pre-service teachers, with effect sizes calculated at 0.99 for numeracy and 0.75 for literacy, indicating a substantial impact of the DEER framework on enhancing these skills (Sellings et al., 2018). The success of the DEER framework is attributed to its comprehensive approach, which includes ensuring that pre-service teachers understand their own skill levels, targeted responses from lecturers, additional support programs, and a reflective approach to learning (Sellings et al., 2018). The framework's approach led to changes in the core curriculum and the implementation of small group or individual activities, enabling pre-service teachers to develop a deeper understanding of literacy and numeracy concepts. The researchers also observed that pre-service teachers not only improved their conceptual understandings but also grew in confidence to teach literacy and numeracy as a result of participating in activities introduced through the DEER framework (Sellings et al., 2018). One limitation of the study was the absence of a control group, which was avoided to ensure equity in educational opportunities for all pre-service teachers (Sellings et al., 2018). The study concluded that the DEER framework's impact extends beyond a regional Australian context and has implications for ITE programs in other universities, both regional and metropolitan.

Teaching numeracy

In addition to research on pre-service teachers' personal numeracy, previous research has examined, although not in great depth, the issue of pre-service teachers' capacity, motivation or confidence to teach numeracy. A study by Muir and Edmondson focused on an innovative curriculum module designed for pre-service teachers at the University of Tasmania, and aimed at exploring numeracy opportunities across the curriculum. Through this module, pre-service teachers were required to design, trial, and evaluate math trails with school-aged students, thereby developing their understanding of how numeracy can be incorporated into cross-curricular, transdisciplinary teaching (Muir & Edmondson, 2007). The study's dual aims were to describe the module's design and teaching aspects and to document the reflective practices engaged by pre-service teachers throughout the process (Muir & Edmondson, 2007). A key finding of the study was the identification of challenges pre-service teachers face when integrating numeracy into their lesson planning. Many found it difficult to identify numeracy opportunities within designed tasks or to consider the numeracy demands these tasks placed on learners. The module sought to address this by providing pre-service teachers with practical experiences in incorporating numeracy through the design and trial of math trails in outdoor settings (Muir & Edmondson, 2007). Math trails were selected as the vehicle for this outdoor learning experience due to their potential to motivate students and apply mathematical skills in diverse contexts outside the traditional classroom setting. This approach aligns with contemporary views on numeracy, which encompass the ability to use mathematical concepts and critical thinking to navigate everyday life and the broader world (Muir & Edmondson, 2007). The qualitative feedback from pre-service teachers indicated that the module was successful in enhancing their confidence and competence in addressing numeracy across the curriculum. Participants reported a deeper appreciation for the role of numeracy in various learning areas and recognized the value of creating rich mathematical learning environments that promote problem-solving and critical thinking (Muir & Edmondson, 2007). Furthermore, the study highlighted the importance of reflection in the learning process. Pre-service teachers engaged in reflective practices that allowed them to assess the effectiveness of their math trails, consider student learning outcomes, and evaluate their own instructional strategies. This reflective process was instrumental in bridging the gap between theoretical knowledge and practical teaching skills, enabling pre-service teachers to become more critically reflective practitioners (Muir & Edmondson, 2007).

Another study Rohl and Greaves (2005) investigated how pre-service teachers in Australia are prepared to teach literacy and numeracy to a diverse range of students. This study evaluated the effectiveness of pre-service teacher education courses in equipping beginning teachers with the necessary skills to address the literacy and numeracy needs of students with diverse learning requirements. The research focused particularly on how well beginning teachers felt prepared to teach students who present the most significant challenges in literacy and numeracy learning. The findings from this study revealed that a substantial percentage of teachers did not feel adequately prepared to teach students with diverse learning needs. This lack of preparedness was particularly noted in the areas of phonics and spelling. One of the highly regarded models for pre-service teacher education identified in the study was a placement in a clinical setting where individual assessments and programs were written and implemented for students. This study highlighted several key issues within pre-service teacher education in Australia. Firstly, it brought to light the gap between the expectations of teacher education programs and the reality of teaching students with diverse needs, especially in literacy and numeracy. Many beginning teachers felt ill-equipped to address the specific challenges faced by students struggling in these critical areas. Secondly, the study underscored the potential benefits of practical, hands-on experience in teacher preparation. The model of placing pre-service teachers in clinical settings for direct assessment and program implementation was viewed positively, suggesting that such experiences could significantly enhance teachers' readiness to meet their students' diverse needs.

Further work has been conducted by Bennison whose study focused on integrating numeracy across the curriculum within initial teacher education (ITE) programs. This research aimed to address the limited research base available for designing ITE courses that develop strategies for embedding numeracy across various subjects. The study reported on the impact of a course aimed at this goal by examining pre-service teachers' (PSTs) responses to two course tasks completed at the beginning and end of the course. The findings suggested that PSTs' confidence in addressing numeracy may have increased after studying the course. The course, typically taken in the final year of a four-year dual degree ITE program, aims to build PSTs' capacity to embed numeracy into their teaching subjects in ways that develop students' numeracy capabilities and enhance subject learning. The theoretical framework for the study included Goos' 21st Century Numeracy Model, which assists teachers in embedding numeracy across the curriculum. This model, with dimensions such as mathematical knowledge, context, dispositions, tools, and a critical orientation, informed the design of learning activities in the numeracy component of the course and was utilized to code qualitative data. The preliminary findings of this small pilot study indicated an increase in PSTs' confidence in various aspects of addressing numeracy in the subjects they will teach, highlighting the potential impact of the course. However, the study also emphasized the challenges of evaluating the impact of courses with small cohorts and the broader issue of obtaining feedback from PSTs. This study begins to address the lack of research on ITE courses designed to prepare PSTs to address numeracy in their teaching subjects, pointing to the need for further research in this area.

Finally, O'Sullivan and Goos (2022) conducted a study examining pre-service secondary teachers' preparedness to teach numeracy across the curriculum in Ireland. They focused on how initial teacher education (ITE) standards and curriculum requirements align with the development of numeracy teaching strategies. The study utilized questionnaire and interview data from participants across three universities to explore their understanding and experiences related to teaching numeracy within their subject specialisms. The research found that pre-service teachers generally had a superficial understanding of how to integrate numeracy into their teaching areas. Many reported varied opportunities within their ITE programs to learn about numeracy pedagogy, indicating inconsistencies in the emphasis placed on numeracy across different institutions. This highlights a significant gap between the expectations set by educational standards and the actual preparation of pre-service teachers regarding numeracy education. Another critical finding was the identification of three distinct themes in pre-service teachers' descriptions of numeracy: mathematical knowledge, application of mathematical knowledge in various contexts, and numeracy as thinking processes such as problem-solving and logical reasoning. However, the majority viewed numeracy primarily in terms of mathematical knowledge, suggesting a limited appreciation for the broader concept of numeracy as a cross-curricular competence. The study also examined pre-service teachers' ideas for incorporating numeracy into lessons. Many responses indicated a lack of curricular awareness, with suggestions often unrelated to the numeracy demands of their teaching subjects. This lack of awareness was further evidenced by trivial examples of numeracy integration, such as writing dates on the board, which do not substantially contribute to students' numeracy development. Interviews revealed that pre-service teachers from universities with specific courses on numeracy felt more prepared and had a broader understanding of numeracy's role in teaching. In contrast, those with minimal exposure to numeracy pedagogy felt less confident in their ability to teach numeracy. This suggests that dedicated numeracy courses within ITE programs can significantly enhance pre-service teachers' understanding and preparedness to integrate numeracy across the curriculum.

Summary and Implications for the Aim and Sub-aims of this Research

This chapter has provided an extensive review of numeracy, motivation, and confidence within educational research, particularly focusing on initial teacher education. It highlights the complexity of defining and measuring these constructs, emphasizing the importance of a considered and pragmatic approach that incorporates various theoretical perspectives. The review identified significant research gaps, including a lack of unified definitions and measures for assessing pre-service teachers' motivation and confidence to teach numeracy. These gaps justify the need for investigating pre-service teachers' numeracy teaching abilities and developing a psychometrically validated and reliable measure of their motivation and confidence levels. This investigation is crucial for enhancing educational strategies and interventions aimed at improving pre-service teachers' readiness and efficacy in numeracy education.

Returning to the primary aim of this research to investigate pre-service teachers' and teacher educators' perspectives on the key aspects of motivation and self-efficacy to teach numeracy, it is now possible to formulate three more specific sub-aims. These sub-aims are consequences of the conclusions drawn from the literature to address the identified gaps. Specifically, these Sub-aims are as follows:

Sub-aim one: To describe pre-service teachers' current levels of motivation and self-efficacy to teach numeracy.

Sub-aim two: To analyse the dimensions of motivation and self-efficacy to teach numeracy.

Sub-aim three: To identify the personal and background factors influencing motivation and self-efficacy to teach numeracy.

Sub-aim one addresses the need for a clear understanding of the baseline levels of motivation and self-efficacy among pre-service teachers for which there is minimal empirical data in the existing literature. Sub-aim two focuses on more explicitly determining what the various components of numeracy teaching are since in previous studies, the dominant focus has been on determining those of numeracy rather than the teaching of numeracy. Lastly, sub-aim three explores external and intrinsic factors that impact pre-service teachers' motivation and self-efficacy to teach numeracy, again addressing a lack of empirical data on this issue, as well as facilitating the creation of more effective educational interventions for Initial Teacher Education programs.

Chapter Three: Methodology

This chapter sets out the methodology adopted for this research thesis. Detail within this chapter aims to provide a thorough understanding of the methodological framework by synthesizing and integrating insights from a diverse range of educational paradigms. An overview of the question of paradigms is presented first, drawing from an analysis of the dominant positions, before arguing for a scientific realist position. A description of the rationale for selecting the research design then follows, which includes provision of the necessary methodological detail to support the subsequent chapters' presentations of methods, results and discussions.

Research Paradigms

The purpose of research paradigms within educational research is to provide a structured framework for understanding the philosophical and methodological choices that shape the nature of research. Paradigms in educational research articulate distinct ontological, epistemological and axiological positions, which influence the research design, strategies for data collection, and analysis techniques (Bryman, 2006; Cohen et al., 2017; Guba & Lincoln, 1994). The following critical engagement with each of the dominant paradigms not only helps to clarify the researcher's stance towards these issues but to also further understanding of the interaction between the researcher and the subject matter (Denzin, 2010; Guba & Lincoln, 1994).

Paradigms are claimed to serve as a lens through which researchers view the world, guiding them in the formulation of research questions, the selection of appropriate methodologies, and the interpretation of data. They are considered essential in framing the research process, from the conceptualization of ideas to the dissemination of findings. By explicitly acknowledging their paradigmatic positions, researchers contribute to the transparency and rigor of their work, enabling peers to critically assess the validity and reliability of the research (Johnson & Onwuegbuzie, 2004; Sale et al., 2002).

The discussion of paradigms in educational research is therefore not merely theoretical but has practical implications for how research is conducted and understood. Paradigms such as positivism, constructivism, critical theory, and pragmatism each offer different perspectives on reality, knowledge, and the role of values in research. These paradigms may influence the choice of research methods, ranging from quantitative approaches that seek to measure and predict phenomena to qualitative methods that aim to understand the complexity and depth of educational experiences (Tashakkori & Teddlie, 2021). Furthermore, critically engaging with research paradigms encourages a researcher's deeper exploration of the philosophical foundations of educational inquiry. It prompts critical examination of assumptions about the nature of reality, the possibility of gaining knowledge, and the ethical implications of research practices. This critical reflection in turn contributes to the educational research discourse, progressing further understanding of the complexities inherent in educational phenomena and enhancing the robustness and relevance of research outcomes (Biesta et al., 2011; Hammersley, 1995). This understanding is achieved in two key ways. First, it enables researchers to situate their work within broader intellectual traditions. Secondly, it provides a common language for discussing methodological choices and interpreting findings, thereby contributing to the cumulative development of knowledge within a particular field of education.

It is important to note, however, that the question of educational paradigms is subject to debate regarding whether they are prior to or equivalent with methodological decisions (Hammersley, 2013). If paradigms require the establishing of beliefs about the world and how it can be understood, prior to research, then they are a fundamental step in the research process, and one that requires careful consideration and justification. Researchers must then be aware of the implications of their paradigmatic choices for the design, conduct, and interpretation of their studies. On the other hand, if paradigms are shorthand classification for a set of methods, techniques for analysis, and rules of interpretation, then appealing to a paradigm for the justification of research design is essentially tautological. This point was already made clear by Kuhn, “When paradigms enter, as they must, into a debate about paradigm choice, their role is necessarily circular. Each group uses its own paradigm to argue in that paradigm’s defense” (Kuhn, 1962, p. 93). The inclusion of an analysis of research paradigms for this research thesis is therefore essential for determining to what extent such paradigms influence research design. Reviewing and analyzing paradigms is a critical preliminary step to ensure that the research is grounded in a thoughtful and well-articulated conceptual foundation.

Positivism

Positivism, is typically taken to be rooted in empirical observation and quantification, emphasizing objectivity and the verification of hypotheses (Sale et al., 2002). For example, Scott argues that for a positivist method “facts can be identified, free of the values and personal concerns of the observer. Thus, any assertions or statements made about this world are about observable measurable phenomena” (Scott, 2017, Epistemology section, para 3). The arguments against the positivist research paradigm are then usually described as follows. Firstly, a primary concern lies in an aim to oversimplify complex phenomena by reducing them to quantifiable variables, potentially overlooking nuances and context-specific factors that are integral to educational research (Manicas, 2006). An emphasis on objectivity may lead to a distancing from the lived experiences and subjectivity of participants, potentially diminishing the depth of understanding in educational contexts where human experiences play a significant role (MacLure, 2003). Furthermore, positivist research is claimed to prioritize empirical data over qualitative insights, ignoring the inherently political or value-laden nature of data (Selwyn, 2016). Finally, the reliance on deductive reasoning and hypothesis testing may not always align with the intricate and dynamic nature of educational phenomena or social science more broadly, potentially resulting in findings that are less relevant or applicable to real-world educational settings. The conclusion of these set of arguments against positivism is that it equates to a diminishment of a more holistic approach educational research. As a counter to these perspectives, a set of positive responses exist. Firstly, typical presentations of positivism are such that there are possibly no adherents of such a view (Johnson & Gray, 2010). For example, Gorard (2004, p. 6) writes "given that no one is suggesting that we have direct experience of an objective reality, we should be more concerned with finding better ways of describing what we do experience". This can also be seen by those who do in fact advocate for a positivist view, such as Gomm who writes, "Though the term 'positivism' once implied that it was possible to attain a 'foundation' of 'positive' or certain knowledge, it is uncertainty rather than certainty which characterizes modern positivism" (Gomm, 2017, Section 2). Secondly, the views of those associated with label positivism are far more nuanced, varied, and sophisticated than is typically given credit (Phillips, 2004). Although often simplistically grouped together, thinkers such as Descartes, Comte, Carnap, and Popper hold substantially different views (Phillips, 2004). Thirdly, and applicable to the discussions of the other paradigms below, discussions of positivism are unhelpfully tied to methods rather than on the substantive issues of epistemology or ontology (Phillips, 2004). This is patently false as it is possible to hold different views about reality while using a particular method (Gorard, 2013; Guba, 1994). For example, a researcher's decision to use a ruler or an interview says nothing about whether that researcher epistemologically holds to relativism, radical constructivism, or epistemicism, or ontologically holds to materialism, dualism, or idealism. The widespread assertion that methods dictate particular paradigms or vice versa is perhaps a key reason for significant confusion and the unhelpful nature of discussions around research paradigms in educational research (Gorard, 2013). Finally, a more accurate reading of positivism would suggest that its original concern lay in clearly demarcating between science and metaphysics. In this sense therefore, positivism is not to be necessarily equated with a commitment to objective reality, nor necessarily as being concerned with what is true, only with what is demonstrable or verifiable. In fact, a number of scholars have argued for this type of positivism to be considered precisely an anti-realist position. In a broad sense then, what positivism got wrong was the attempt to develop criteria capable of delineating between science and metaphysics and its emphasis on justifying scientific statements through demonstration or verification. As will be outlined later in this chapter, neither of these attempts are necessary for a broad understanding of scientific realism and both are arguably rejected by the majority of philosophers of science today.

Constructivism

Constructivism, as an educational research paradigm, emphasizes the interpretative processes of participants, primarily utilizing qualitative methods to derive contextually rich understandings of phenomena (Guba & Lincoln, 1994). As such, this paradigm significantly overlaps with or is often treated as synonymous with interpretivism (Creswell, 2003). Specifically, concerns regarding constructivism include the potential for subjectivity and researcher bias during data interpretation, which might restrict the generalizability of findings (Maxwell, 2017). Moreover, the qualitative focus inherent in constructivism often leads to smaller sample sizes, possibly diminishing the statistical power and broader applicability of the research outcomes (Sale et al., 2002). The intensive nature of qualitative data collection and analysis poses practical challenges, particularly in educational research environments constrained by resources or stringent timelines (Biesta et al., 2011). Additionally, the paradigm's commitment to understanding phenomena through participants' perspectives could result in an undue emphasis on micro-level analysis, potentially overlooking significant systemic or structural dimensions within educational contexts (Hammersley, 1995). Lastly, some forms of constructivism are claimed to lead to a denial of any standard of evaluating the truth of knowledge claims whatsoever (Danermark, 2019).

However, as with the case of positivism above, portrayals of constructivism such as this obscure the wide variety of views, the substantive issues involved in such views and again associates particular methods as inherent to the paradigm. There are of course several distinctions that have been made regarding constructivism, social constructivism, radical constructivism (Spivey, 1997; Von Glasersfeld, 1984) and social constructionism (Berger & Luckmann, 1966). Furthermore, a constructivist paradigm (as perhaps all paradigms) in being presented as distinct from other paradigms such as positivism, is often not clearly distinguished from its various orientations. For example, a researcher can easily describe themselves as both a positivist and constructivist, if what is meant is that there is an ontologically objective, mind-independent reality, but where access to this reality is governed by epistemological constructions of that reality rather than direct perception (Bhaskar, 2013; Hammersley, 1995; Maxwell, 2017). Such a position has in fact been a largely dominant one in philosophical and scientific traditions going back as far as Plato (Bhaskar, 2013). Thus the major difficulty with presentations of positivism versus constructivism is the tendency to conflate the distinction between ontology and epistemology and instead associate positivism with objectivity and constructivism with subjectivity. This then leads to those who argue for the absolute incommensurability of combining the two (Guba & Lincoln, 1994). Instead, it is more than possible for both positivists and constructivists to assert the existence of an ontologically mind-independent reality and to affirm a mediated epistemological access to that reality. The differences will lie in how such constructions of reality relate to reality and how they can be evaluated.

Post-positivism

Post-positivism is typically presented as an attempt to combine elements of positivism and constructivism as discussed above, valuing both quantitative and qualitative data (Johnson & Gray, 2010). The post-positivist research paradigm, while offering a middle ground between positivism and constructivism, has also been claimed to be the basis for a mixed-methods paradigm which will be discussed below (Denzin, 2010; Tashakkori & Teddlie, 2021). In essence, it was developed as a response to the failures of the more original positivist positions associated with logical positivism or logical empiricism (Johnson & Gray, 2010). Johnson and Gray state that post-positivism "accepts the following positions: a) theory-ladenness of facts, b) fallibility of knowledge, c) underdetermination of theory by fact, d) value-ladenness of facts, and e) social construction of parts of reality" (Johnson & Gray, 2010, 20^{th}-Century Developments Section, para 4). The post-positivist paradigm is however, criticized for the following reasons. Firstly, the post-positivist paradigm's pursuit of objectivity while acknowledging the role of subjectivity is argued to still maintain a positivistic foundation (Holliday & Macdonald, 2020). Additionally, the paradigm's instrumentalist emphasis on methods as simply tools to be used by a researcher may risk marginalising issues regarding social justice, or emancipatory type research (Denzin, 2010). Lastly, the post-positivist paradigm's commitment to probabilistic inference may result in findings that lack certainty, which can pose challenges in educational contexts that demand definitive answers or practical solutions (Gorard, 2013).

The key issue with portrayals of post-positivism are in fact the lack of substantive distinction between it and descriptions of other paradigms. If one takes the position that post-positivism equates to the statement that there is an ontological mind-independent reality which is only partially known through epistemologically constructed processes, then such a view has been already represented by a number of positivists, constructivists, and philosophers throughout history (Bhaskar, 2013). As such, it appears to offer little contribution other than an option for researchers to adopt to avoid the fact that being a positivist has come to be seen as largely pejorative in the educational research landscape (Denzin, 2010; Phillips, 2004). On the other hand, if post-positivism is equated with particular scholars such as Popper, Feyerabend, Lakatos, then there are distinctive approaches to the methodology of science that bear consideration. While a thorough treatment of these authors is far beyond the scope of this chapter, Popper is perhaps the most distinctive and instructive and therefore some remarks are worth making. Popper diverged from other approaches to scientific methodology in two ways (Shearmur, 2021). Firstly, Popper, "was always a staunch opponent" (Phillips, 2004, p. 78) of positivism and disagreed with the attempt to make any neat distinction between science and metaphysics, instead including metaphysical statements as open to evaluation, albeit with clear procedures for doing so (Popper, 1963; Popper, 1982; Shearmur, 2021). Secondly, Popper diverged from all other approaches in his rejection of the principle of induction. In brief terms, this meant a rejection of any attempt to justify claims and instead a commitment to testing, critiquing, and falsifying them in order to make progressive modifications to their content.

Pragmatism

In a similar vein to post-positivism in being also referred to as a middle way between quantitative and qualitative paradigms, pragmatism is considered as an approach to seeking practical solutions to real-world problems, that allow for the integration of diverse methods (Johnson & Onwuegbuzie, 2004; Tashakkori & Teddlie, 2021). For example, Heyvaert et al., write “pragmatism offers the research alternatives to the dichotomous choice between (post)positivism and constructivism” (2013, p. 303). Criticisms of such an approach tend to lie in its potential to prioritize utility and pragmatic solutions over theoretical rigor, which may compromise the depth and rigor of educational research (McCaslin et al., 2008). Furthermore, the emphasis on practicality may also result in a fragmented or eclectic approach, as researchers may selectively adopt methods without a strong theoretical grounding (Hampson & McKinley, 2023). This can hinder the development of coherent and cumulative bodies of knowledge within the field of education. Additionally, the pragmatic paradigm's focus on problem-solving and context-specific solutions may limit its ability to address broader, systemic issues in education, as it may prioritize immediate practical concerns at the expense of a more comprehensive understanding of complex educational phenomena (Biesta, 2010). Additionally, the application of pragmatist principles can be challenging in situations where stakeholders have conflicting goals or where practical solutions do not align with ethical or moral considerations, as it “leaves little space for issues connected to empowerment, social justice, and a politics of hope” (Denzin, 2010, p. 420).

The major issue in treatments of pragmatism such as above, is the relationship between it and other paradigms such as mixed-methods paradigm as well as its lack of clarity (Biesta, 2009; Denzin, 2012). For example, there is the distinction between being pragmatic and philosophies labelled as pragmatist (Hampson & McKinley, 2023). Regarding philosophy, there are widely varying positions which can clearly be seen when comparing the views of Peirce (Peirce, 1992) with Rorty (Rorty, 1999) (see Johnson et al., 2017). Furthermore, it is not the case that pragmatism should be associated with the choice of any method, since as previously discussed, both positivism and constructivism may also be combined with various methods (Gorard 2013; Gorard & Taylor, 2004; Biesta, 2010). Furthermore, as is the case with these previous paradigms, the questions at issue with pragmatism relate to whether there is an external mind-independent reality, whether we have epistemological access to that reality, and if so, what the nature of that relationship is.

Mixed-methods

Although often using pragmatism as justification (Greene, 2008), mixed methods research blends qualitative and quantitative approaches for comprehensive insights and is also sometimes referred to as a paradigm separately to pragmatism (Creswell, 2018; Tashakkori & Teddlie, 2021). For example, Tashakkori and Teddlie (2021) argue that mixed methods refers to “The broad inquiry logic that guides the selection of specific methods and that is informed by conceptual positions common to mixed methods practitioners (e.g., the rejection of ‘either-or’ choices at all levels of the research process)” (Tashakkori & Teddlie, 2021, An Overview of Part II section, para 2). This type of positioning of mixed methods however raises a number of issues. Firstly, one primary concern is the potential for increased ambiguity, as researchers must determine what it means to integrate data from both quantitative and qualitative sources (Biesta, 2010). A further set of difficulties facing mixed methods paradigms largely stem from how it is to be distinguished from other paradigms. For example, if by mixed methods, a researcher simply means they have used two or different methods, then this conveys no information as to what position they may hold ontologically or epistemologically. In this case, a researcher could be a positivist, constructivist, or pragmatist while describing themselves as operating from a mixed-methods paradigm. In fact, this may be the appeal of many who adopt such a paradigm (Sammons & Davis, 2017). However, an alternative adoption of a mixed methods paradigm is to explicitly claim that all other paradigms are equally beneficial or to reject any binaries or dualisms or incommensurability between them (Tashakkori & Teddlie, 2021). This presents two major points of confusion. Firstly, such a claim has epistemological and ontological implications that require explanation (Biesta, 2010). For instance, if one posits an external mind-independent reality, then this will surely be in tension with paradigms that deny such a reality (Morgan, 2007). As such, it is unsatisfactory for a mixed methods paradigm to reject incommensurability between competing paradigms without explicating how such a rejection makes coherent sense (Hampson & McKinley, 2023). Secondly, since it is often (mistakenly) the case that one's research paradigm dictates particular methods, a mixed methods paradigm requires an alternative foundation on which to determine methodological choices. The solution proposed is to let the research question, rather than paradigm, inform what is most appropriate for the research study (Gorard, 2013; Tashakkori & Teddlie, 2021). Such a proposal however, only relocates the various debates rather than resolving them. Just as is the case with particular methods that a researcher employs, particular research questions do not entail any particular set of ontological or epistemological views. A researcher who asks whether smoking causes cancer and employs a randomly controlled trial may hold to either ontological idealism, materialism, or dualism. Research questions alone, just as with methods alone, do not dictate methodological choices.

Critical Theory

The final major paradigm to be discussed is critical theory. It examines power structures and social injustices, often employing post-qualitative approaches (Talburt & Rasmussen, 2010). However, as with many of the other treatments of paradigms discussed above, there is no one universally accepted approach to defining such a paradigm. Instead, a number of different traditions and scholars may be grouped under the paradigm of critical theory. These range from Foucault, Giroux, Freire, Marx, Adorno, and Habermas. Prominent researchers in education who have adopted approaches influenced from these thinkers include Lather, St.Pierre, Kincheloe, and McLaren. According to Kincheloe and McLaren, it is difficult to explain precisely what critical theory is "because a) there are many critical theories, not just one; b) the critical tradition is always changing and evolving; and c) critical theory attempts to avoid too much specificity, as there is room for disagreement among critical theorists" (Kincheloe & McLaren, 2011, p. 287). A number of concerns can thus be raised against a critical theory paradigm. Firstly, a primary concern pertains to its potential for ideological bias, as researchers often engage in normative critique that aligns with particular ideological perspectives (Biesta, 2005; Gorard, 2013). Furthermore, the critical theory paradigm's emphasis on uncovering inequalities and power imbalances may sometimes overlook the nuanced ways in which it itself reproduces such power imbalances (Biesta, 2005). In contrast to the previous paradigms discussed above, which tend to focus on the question of ontology and epistemology, critical theory makes significantly different claims and therefore choices regarding educational research (Bazzul & Carter, 2017). This is most clearly seen in its emphasis on ethical or axiological concerns such as power (Foucault, 1972). Given this distinction however, there is no inherent contradiction between being a critical theorist and a positivist, constructivist, or pragmatist provided one defines those according to ontological or epistemological considerations only, or unless one explicitly makes the claim that versions of these considerations are against one's values. For example, one may argue for the existence of categories such as "white empiricism" (Prescod-Weinstein, 2020), "epistemic violence" (Teo, 2008), "colonial epistemology", or "anthropocentrism" (Ferrante & Sartori, 2016) that are associated with particular views of ontology or epistemology. Even with these types of claims, a critical theory paradigm can allow for various ontological or epistemological positions regarding the existence of a mind-independent reality and our epistemological access or relation to that reality. In fact, perhaps the key question with regard to a critical theory paradigm is whether or not axiology is in some sense dependent on ontology. For example, moral realists argue that there are moral facts of the matter which are true independent of whether anyone believes, knows, apprehends or perceives them (Deutsch, 2011; Williamson, 2021).

Scientific realism

As evident in the discussion above, the traditional treatment of paradigms and their promotion as necessarily dictating particular research questions or methods can result in unhelpful confusion concerning the fundamental nature of research (Biesta, 2010). This stems primarily from the practice of treating paradigms as rigid, mutually exclusive categories, each demanding adherence to a specific set of methodological principles (Hammersley, 1995). In reality, such a binary and categorical approach oversimplifies the complex spectrum of epistemological and methodological positions within the broader realm of research. This oversimplification perpetuates the misconception that researchers must choose a single paradigm, or adopt some form of eclectic methodological pluralism (Biesta et al., 2011). This leads to a fragmented and compartmentalized understanding of research, obscuring the substantive issues involved. To advance a more nuanced and comprehensive understanding of research, it is imperative to recognize the limitations of the typical paradigm-selection approach and embrace a more flexible and inclusive perspective that accommodates methodological diversity and interdisciplinary collaboration, thereby fostering a more holistic endeavor.

As such, this research argues for the adoption of a broad understanding of scientific realism that can be compatible with all of the above education research paradigms to a degree. Scientific realism, in its broadest sense, posits that there exists an objective reality that is mind-independent (Deutsch, 2011). There are two aspects to this position. The first is the notion of realism or objective reality. It is vital to distinguish between two often conflated notions of objectivity. Objectivity can refer to uniqueness or to mind-independence (Clarke-Doane, 2020). For example, a mathematical realist can assert the mind-independent truth of a mathematical statement (objective) while also denying that there is a unique truth for each mathematical question (non-objective) (Clarke-Doane, 2020). In the realism being outlined therefore, all that is being advocated for is the existence of a mind-independent reality without further commitment to what that reality consists of. The second notion relates to the methodology of science. By science what is meant is any activity that seeks to contribute to knowledge and therefore includes disciplines such mathematics, philosophy, or art (Bronowski, 1956). The crucial methodological principle of science is that in so far as any piece of knowledge makes a difference in reality, it can be critiqued (Popper, 1963). For example, in philosophy, there is no problem with metaphysical speculation of two sorts. The first enquires into what necessarily must be the case in order for the things we hold to be true to be true (Williamson, 2021). This approach is mostly confined to philosophy. The second makes specific metaphysical conjectures that are in principle able to be critiqued by their implications for reality. This second approach is most evident in the theoretical end of most disciplines where theories, hypotheses, or conjectures are offered and then either refuted or supported by logical, empirical or experimental results (Deutsch, 2011; Popper, 1963). In the case of art, in so far as there is an expression of some truth, then such expression can also be critiqued and therefore rejected or supported (Bronowski, 1956). Although much less common there are even attempts to argue for aesthetic realism or objective beauty (Deutsch, 2011) however these are beyond what is being advocating here. The combination of a mind-independent reality with the scientific principle as outlined is compatible with many of the paradigms discussed above, but guards against two sets of propositions. The first set includes any paradigm that explicitly rejects any existence of a mind-independent reality. The second set includes any position that employs justificationism. Justificationism is the attempt to justify knowledge by appeal to grounds such as empiricism, rationalism, fideism, foundationalism or any other authoritative grounds (Williamson, 2021). The key reason for this is that the scientific principle outlined above provides no method for generating or deriving knowledge, only a means by which different theories, explanations, or conjectures can be refuted according to what differences they make to reality (Popper, 1963; Williamson, 2021). Returning again to the paradigm of critical theory the following argument can now be made. In so far as any particular value, belief, or ideological viewpoint makes no claim of any discernible difference to reality in any sense, it therefore seems by definition to be of no relevance to research. The approach taken in this research therefore disagrees with positions which appeal to values or beliefs which guide one's research and are completely immune from criticism as this would be fideism (Selwyn, 2015). On the other hand, to the extent to which a researcher's ideological position does make a difference to reality, such a position is open to critique. This is a key reason for why it is not necessarily helpful to adopt a mixed methods paradigm where one can eclectically move between other paradigms. On the view outlined, some positions are truer than others.

In summary, considerable detail has been given to the discussion of paradigms if only because such is required in order to provide a case for resisting the customary practice of merely adopting a research paradigm in educational research. Instead what has been argued for is a broad understanding of scientific realism that can coexist with all education research paradigms to the extent they allow for the recognition of an external reality and a principle for criticizing knowledge about that reality.

Research Design

On the basis of the arguments provided in the previous section, it will hopefully seem clear that the language of research design is almost entirely independent of the paradigms discussed above. By this it is meant that none of the paradigms dictate the use of any particular methods or organization of methods. To reiterate the example mentioned previously, the use of a ruler says nothing about whether one is an idealist, materialist or dualist. It is as possible to conduct a randomized control trial of qualitative interviews as it is to perform a phenomenological analysis of quantitative data. Research design language such as cross sectional, longitudinal, or sample may be more present within certain traditions than others but are in fact agnostic of such traditions. As such, the research design is described here using language commonly and most widely understood across paradigms and disciplines.

Accordingly, the research design employed in this study can be referred to as mixed-methods in that it captures both quantitative and qualitative data to investigate levels of pre-service teacher motivation and self-efficacy in teaching numeracy (Tashakkori & Teddlie, 2021). The research design can also be described as a descriptive cross-sectional study rather than an explanatory or experimental one

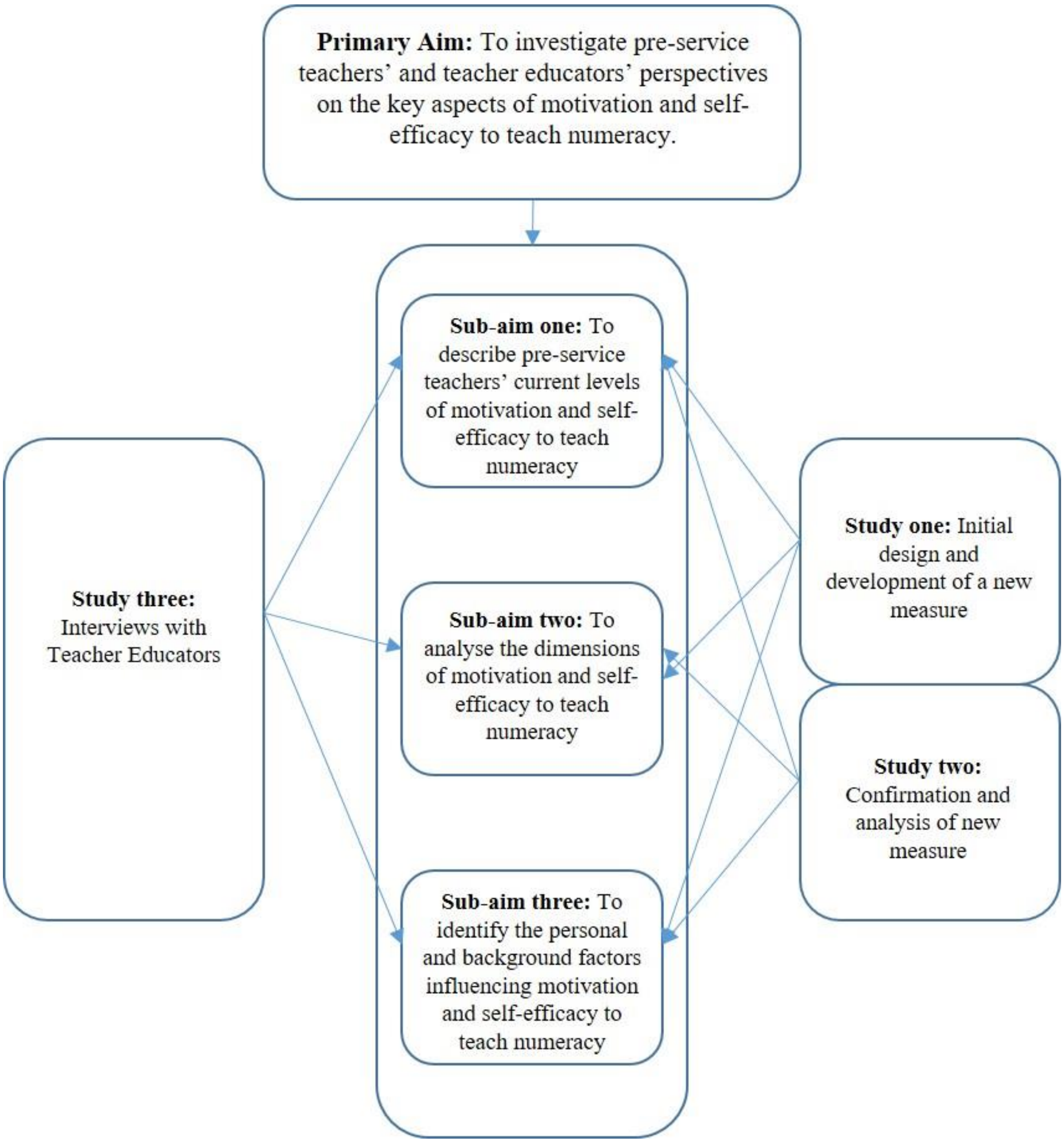
(Gorard, 2013). In a descriptive cross-sectional design, data is collected at a single point in time from a sample of participants to describe the characteristics or relationships of interest. In this study, data collection through the survey questionnaire and interviews occurred at a single point in time, providing a snapshot of pre-service teacher motivation and self-efficacy levels and the perspectives of teacher educators. This approach does not involve experimental manipulation or intervention, nor does it seek to establish causal relationships or explanations for observed phenomena. Furthermore, the research design emphasizes the measurement and description of pre-service teacher motivation and self-efficacy, rather than attempting to manipulate variables to determine causation. The survey instrument was designed to measure these constructs, and the interviews with teacher educators aimed to gather insights and descriptions. Thus, the study's primary focus is on describing and understanding the current state of pre-service teacher motivation and self-efficacy in numeracy instruction, making it consistent with a descriptive cross-sectional research design. Overall, the study's characteristics, including the concurrent collection of data, the absence of experimental manipulation, and the emphasis on description and measurement, align with the characteristics of what is commonly referred to as a mixed-methods descriptive cross-sectional research design.

The research can also be divided into two perspectives. The two perspectives are generated from pre-service teachers and teacher educators. The first perspective was gained through the development and administration of a survey questionnaire designed to measure levels of pre-service teacher motivation and self-efficacy to teach numeracy. The survey instrument was crafted based on a thorough review of relevant literature and was refined through pilot testing to ensure validity and reliability. Data collected through the survey provided quantitative insights into the levels of motivation and self-efficacy among pre-service teachers. The specific details are provided in chapters four and five. The second perspective was developed from qualitative interviews with teacher educators. These semi-structured interviews were conducted to gain an additional understanding of the nature of and factors that influence pre-service teacher motivation and self-efficacy in teaching numeracy. The specific details of this method are outlined in each of the relevant chapters.

The combination of these two research methods—quantitative survey data and qualitative interviews with teacher educators—allowed for a comparative examination of pre-service teacher motivation and self-efficacy in numeracy teaching. By integrating both perspectives, this research design ensures a more robust and nuanced exploration of pre-service teacher motivation and self-efficacy to teach numeracy, contributing to a deeper understanding of this critical aspect of teacher preparation.

Figure 2

Diagram of Research Design



Research Phases

In addition to incorporating two perspectives, the research was carried out over three phases or studies. These phases are presented in the order they were conducted in chapters four, five and six. The first phase focused on the initial development of the survey measure using a purposive sample and exploratory factor analytic techniques. The second phase then administered the measure to a larger and independent sample, utilizing confirmatory factor analytic techniques. Finally, the third phase of the research was conducted with a sample of teacher educators involving semi-structured interviews and thematic analysis.

Positionality

In conducting this research project on pre-service teacher motivation and self-efficacy in teaching numeracy, my positionality as a former secondary school mathematics teacher and an educator of pre-service teachers at the university level holds both advantages and limitations that require careful consideration throughout the research process. Firstly, my background as a secondary school mathematics teacher provides valuable insight into the practical challenges and classroom dynamics faced by pre-service teachers when teaching numeracy. However, it is crucial to acknowledge that my experiences may influence my interpretation of the data, potentially introducing bias in the analysis.

Furthermore, my role as an educator of pre-service teachers affords me a unique perspective in understanding the pedagogical concerns and training processes that impact pre-service teachers' motivation and self-efficacy. Nevertheless, this proximity to the subject matter may inadvertently influence participants' responses during interviews or in the design of surveys. To address this, techniques have been employed to emphasise the confidentiality and anonymity of their participant responses where possible. Additionally, external peer input has been sought through supervisors who can offer diverse perspectives and enhance the validity of the research findings.

In particular, the following actions were taken. First, to mitigate potential bias in data interpretation, a reflexive approach was adopted throughout the study. This entails regular self-examination of my own experiences, beliefs, and assumptions, ensuring that they do not unduly influence the analysis of research findings. Second, to minimize the risk of influencing participants' responses due to the researcher's educational background, ethical research practices have been followed. Informed consent has been obtained from all participants, emphasizing their autonomy and the voluntary nature of their participation. Additionally, anonymity and confidentiality of participants' responses has been maintained, assuring them that their candid input will not impact their academic progress or evaluations as pre-service teachers.

Third, to address any potential conflicts of interest arising from the researcher's role as both an educator and a researcher, different roles have been delineated. When interacting with pre-service teachers participating in the study, a researcher role was emphasized, clarifying that their involvement in the research will not influence their educational experiences or outcomes. This demarcation has been reinforced through explicit communication and formal agreements, ensuring that participants perceive a clear separation between my roles. It was also ensured that no pre-service teachers in units that the researcher was currently teaching at the time were surveyed.

Fourth, external input was sought to validate the research process and findings. This has involved engaging supervisors who do not share my background but possess expertise in research methodology and qualitative analysis. Their perspectives and critical feedback have served to challenge assumptions and interpretations, contributing to the overall rigor and credibility of the study.

In conclusion, these specific steps undertaken within the research process have been instrumental in addressing the issues arising from my positionality as a former secondary school mathematics teacher and an educator of pre-service teachers. Through reflexive practices, ethical considerations, role delineation, and external input deliberate measures were undertaken to enhance the rigor and validity of this research study. In summary, my background as a former secondary school mathematics teacher and my current role as an educator of pre-service teachers at the university level have afforded me valuable insights into the research topic, but they also introduce potential biases and conflicts of interest.

Ethics

Ethics clearance was received from VU HREC (HRE20-165) however a holistic approach to ethics was also taken which holds that ethical considerations are an ongoing feature of research.

Chapter Four: Developing a Measure of Preservice Levels of Motivation and Self-efficacy to Teach Numeracy

This chapter details the first study of this thesis by focusing on the development and initial validation of a new instrument designed to measure pre-service teachers' levels of motivation and self-efficacy to teach numeracy. This study stems from the recognition of numeracy's foundational role in education, and the broader educational requirement that every teacher, regardless of their specialization, is responsible for teaching numeracy across all year levels and curriculum areas (AITSL, 2017). This chapter generates new evidence to address both the existing conceptual ambiguities surrounding numeracy teaching and the gap in empirical data regarding robust measures to assess pre-service teachers' motivation and self-efficacy in this domain.

The need for a specific, validated measure stems from the broader discourse on numeracy education, which has evolved to recognize numeracy as a critical, cross-disciplinary capability essential for students' successful navigation of both their personal and professional lives. Numeracy underpins a vast array of educational, personal, social, and occupational activities, with various outcomes linked to levels of numeracy proficiency. Research has consistently shown robust associations between numeracy and individual outcomes, such as early mathematics proficiency, employment prospects, STEM careers, and decision-making capacities across financial and health contexts (Cumming, 2000; Mononen et al., 2015; Peters & Shoots-Reinhard, 2022). These findings underscore the urgency of addressing numeracy within educational settings and the importance of equipping pre-service teachers with the requisite motivation and self-efficacy to effectively teach numeracy.

Addressing this need, this chapter outlines the methodological approach employed in the development of the new measure, beginning with the generation of questionnaire items. This process was informed by an extensive literature review and consultations with experts in the field of numeracy education. The items were designed to capture the nuanced aspects of motivation and self-efficacy specific to numeracy teaching, reflecting the complex, multi-faceted nature of numeracy as both a domain of knowledge and a pedagogical challenge. This approach acknowledges the distinctiveness of numeracy from general mathematical proficiency, highlighting the specialized pedagogical knowledge and skills required to teach numeracy effectively across diverse educational contexts.

The construction and validation of psychometric measures are integral to the exploration of complex psychological constructs, particularly within educational research focusing on pre-service teachers' motivation and self-efficacy to teach numeracy. The methodology adopted for this study reflects an engagement with both classical and contemporary psychometric theories. Classical Test Theory (CTT) and Item Response Theory (IRT) represent the two primary frameworks underpinning current psychometric measure development. CTT, with its focus on decomposing observed test scores into true scores and error, provides a foundational approach to understanding measurement accuracy. This framework assumes that measurement errors are randomly distributed, thus allowing for the estimation of a true score for each individual (Gorsuch, 1997). On the other hand, IRT advances this discourse by emphasizing the characteristics of individual test items, particularly how item response probabilities relate to underlying ability levels. IRT's item-centric approach is said to offer insights into how different items discriminate across ability levels, enhancing the precision of ability estimations (Watkins, 2018).

Despite ongoing debates between proponents of CTT and IRT, empirical evidence suggests minimal substantive differences in outcomes derived from these frameworks. Consequently, the choice between CTT and IRT often hinges on pragmatic considerations such as simplicity, sample size requirements, and the historical precedence of psychometric techniques. Given its relative straightforwardness, efficacy with smaller samples, and extensive evidential support, CTT has been selected as the guiding framework for this study. The decision between linear and non-linear approaches in factor analysis, akin to choosing between CTT and IRT, is controversial due to the conflicting aspects of simplicity and realism. The linear model, often synonymous with CTT, is preferred for its simplicity and utility, especially when analyzing a large set of items in a relatively small sample, provided the items have approximately normal distributions (Lloret et al., 2017). Further, the debate around the selection of factor analysis methods, whether factor or component analysis, typically results in very similar outcomes for well-designed studies, suggesting that differences in outcomes between CTT and IRT might also be minimal for well-structured psychometric research (Velicer et al., 2000). This aligns with the broader discussion on the critical decision of the number of factors to retain in exploratory factor analysis, a decision that significantly impacts the derived measurement model but is guided by similar principles in both CTT and IRT frameworks (Velicer et al., 2000).

The primary methodological tool employed within the CTT framework for this study is Exploratory Factor Analysis (EFA) (Gorsuch, 1997; Watkins, 2018). EFA serves as a technique for uncovering the latent structure of psychological constructs (Beavers et al., 2013; Lloret et al., 2018), facilitating the identification of underlying factors that represent distinct dimensions of motivation and self-efficacy to teach numeracy. This approach is particularly well-suited to the early stages of measure development, where theoretical assumptions about the construct's dimensionality are tested empirically (Tabachnick et al., 2013). By applying EFA, this study aims to construct a psychometrically sound instrument that captures the nature of pre-service teachers' motivation and self-efficacy in numeracy teaching. The process involves generating a pool of items that reflect the conceptual breadth of numeracy teaching, followed by rigorous statistical analysis to validate the measure's structural integrity and the relevance of its components.

The development of this measure addresses a critical gap in the field of initial teacher education (ITE). Previous research has highlighted the conceptual ambiguity surrounding numeracy and the challenges it poses for both teachers and teacher educators. The lack of clear definitions and robust, empirically validated measures has hindered efforts to assess and improve pre-service teachers' readiness to teach numeracy effectively. By offering a reliable and valid tool for measuring motivation and self-efficacy to teach numeracy, this chapter contributes to the broader goal of enhancing ITE programs. It provides a foundation for future research aimed at understanding the factors that influence pre-service teachers' motivation and self-efficacy in this area and exploring interventions to strengthen these attributes.

Method

This section details the development of a new measure of motivation and self-efficacy to teach numeracy. It first presents the demographic items captured and scale format before articulating the item generation process, content and face validity assessment, and participant recruitment procedures. It then outlines the Exploratory Factor Analysis (EFA) techniques, including factor number determination, factor extraction method, and factor labelling, used to interrogate the reliability and validity of the measure.

Instrumentation

Two instruments were used in this study, namely, a set of demographic questions along with scales measuring self-efficacy and motivation to teach numeracy. These were employed to gather data, aiming to provide insights into the current levels of these constructs among pre-service teachers. The use of both instruments stems from the potential in identifying areas for enhancing initial teacher education practices by examining the influence of demographic variables on motivation and self-efficacy levels.

Demographics Items

The demographics section of this study comprised 13 questions, designed to capture a detailed profile of each participant. These questions encompassed the following key demographic and educational characteristics of age, gender, postcode, academic year, degree program, and teaching intention (primary or secondary). Additionally, the questions asked for participants' status as domestic or international students, their teaching specialisations, and whether they enjoyed activities such as programming, puzzles, and playing musical instruments. The inclusion of these last three questions resulted from both the review of literature and the researcher’s own teaching experience. As definitions of numeracy were found to overlap with other concepts such as computational thinking, or logical reasoning, there is the potential that participants with interests in programming and logical puzzles may demonstrate higher levels of motivation or self-efficacy in numeracy. Regarding the inclusion of playing musical instruments, the relationship between mathematics and music is well attested to in the literature. However, less is known as to whether musical interest of background contributes to numeracy self-efficacy or motivation. Finally, each of these questions have also demonstrated a recurrent trend in the researcher’s own teaching experience in mathematics classrooms. Critical to understanding the mathematical background of participants, questions also asked whether they had studied mathematics in their final year of high school and if they had experience tutoring in mathematics. This detailed set of demographic questions was strategically developed to correlate participants' backgrounds with their motivation and self-efficacy to teach numeracy, with the aim of facilitating an analysis of how these personal and educational factors might influence their levels of motivation and self-efficacy to teach numeracy.

Self-efficacy and Motivation Survey Items

The final scales consisted of 25 items for the self-efficacy scale and 20 items for the motivation scale. No items were worded negatively. The response format of the scales were sliders that ranged from 0 to 100. Anchors at the extremes of 0 and 100 were titled ‘not confident at all’ and ‘totally confident’ respectively. For the motivation scale, ‘not motivated at all’ and ‘totally motivated’ were used. Some have attempted to determine whether the initial placement of the slider has a bias on responses with a possible result being that respondents perceive the starting position to reflect the intended response (Sellers, 2013). For instance, placing the initial position of the slider at zero biases responses towards zero, while placing it at 100 biases responses towards 100. The initial position of the slider was therefore placed in the middle at 50 to encourage respondents to actively engage with the scale, making a deliberate choice that reflects their true level of self-efficacy or motivation rather than being swayed by default positions. This approach aligns with findings from Roster et al. (2015), which indicate minimal difference in data quality between slider and categorical response formats, supporting the use of a midpoint start as a means to enhance the validity of collected data by reducing response bias. Only the numbers 0 and 100 were placed above the slider, however upon moving the slider, the exact number reflecting the position of the scale was displayed to the respondents. A response could take any positive integer value from 0 to 100. This design choice is grounded in psychometric principles that suggest clear, unambiguous scale endpoints facilitate more accurate self-assessments by providing respondents with definitive reference points (Bandura, 2006). Moreover, the dynamic display of numerical values as respondents adjust the slider allows for precise, granular feedback on their perceived levels of self-efficacy and motivation, enhancing the measure's sensitivity and specificity. This method aligns with recommendations for improving the validity and reliability of self-reported data, as it encourages respondents to consider their position along a continuum rather than selecting among more arbitrary, fixed categories (Pajares et al., 2006).

Scale Construction

Prior to initiating the development of survey items, a comprehensive literature review on motivation and self-efficacy in numeracy teaching, alongside theories of motivation and various conceptualizations of numeracy and its instruction, was undertaken. This review led to the selection of Goos' framework as the most suitable foundation for item generation (Geiger et al., 2015). Crucially, Goos' framework was distinguished by its comprehensive and nuanced interpretation of numeracy, extending beyond computational ability to encompass mathematical literacy, the pragmatic application of mathematics in daily life, and the critical analysis of quantitative information (Geiger et al., 2015). This broad and inclusive definition resonated with the literature's portrayal of various aspects of numeracy as an integral, cross-curricular competency necessary for full participation in society. The decision to base item generation on Goos' framework was further justified by its original design to assist educators in teaching numeracy across the curriculum, offering a structured approach to embedding numeracy education in various subjects and enhancing the coherence and relevance of numeracy teaching and learning practices (Goos et al., 2019).

A key issue for developing the scales was operationalising motivation and self-efficacy constructs. In this study and based on the insights from the literature review chapter, a deliberate choice was made to gauge pre-service teachers' perceived levels of motivation rather than their individual reasons for their motivation towards teaching numeracy. This decision aligns with Brehm's theory of motivation intensity (Brehm et al., 1983), which posits that the effort individuals are willing to exert is directly linked to the subjective value they assign to a goal and their perceived likelihood of achieving it. This approach also has the benefit of paralleling the theoretical framework of self-efficacy as articulated by Bandura (1986), which emphasizes individuals' beliefs in their capacities to execute actions required to manage prospective situations, rather than the underlying reasons for these beliefs. By directly querying individuals about their levels of motivation, the study seeks to capture the total value of any of the intrinsic and extrinsic motivators that drive the effort and persistence in numeracy teaching tasks, reflecting a holistic approach that avoids narrow categorization of motivational types.

This approach diverges from other dominant motivational theories that focus primarily on the reasons behind individuals' motivations, such as Attribution Theory, Achievement Goal Theory, Self-Determination Theory, Social Cognitive Theory, and Situated Expectancy Value Theory, each of which emphasizes different beliefs or expectations that influence motivation (Eccles & Wigfield, 2020; Ryan & Deci, 2000; Weiner, 2012). While the literature review demonstrated that these theories offer valuable insights into the nature of motivation, it was argued that focusing on the perceived levels of motivation, as opposed to the reasons for these levels, allowed for a more straightforward assessment of pre-service teachers' desire to teach numeracy. This approach facilitates the identification of the level of subjective value placed on numeracy teaching providing a direct measure of motivation intensity that will be valuable for educational research and practice.

By adopting this pragmatic approach, the study leverages the accessibility and directness of self-report measures to assess motivation levels, offering an adaptable and context-sensitive tool for measuring motivation in educational settings (Turner & Patrick, 2008). This approach acknowledges the diversity of factors, both intrinsic and extrinsic, that influence motivational states across different contexts, cultures, and individuals, thereby providing a holistic framework for measuring and enhancing motivation in teaching numeracy.

Item Generation

To generate items relevant to the teaching of numeracy, Goos' numeracy framework was utilised. Goos et al.'s rich interpretation of numeracy (see Figure 3), encompasses a wide array of competencies beyond basic arithmetic, integrating mathematical literacy, the practical use of mathematics in daily life, and the critical analysis of quantitative data (Geiger et al., 2015). While the original framework elaborates on what it means to be numerate, its specific application to teaching numeracy required adaptation. To achieve this, the development of items leveraged insights from Goos and colleagues' discussions on the application of their framework within educational settings. These focused on how teachers and schools can foster students' numeracy (Goos et al., 2019). This exploration involved a detailed analysis of Goos' perspectives on numeracy education, extracting key principles that could inform the operationalization of numeracy teaching within the research instrument. The result was the development of five specific question items for each domain (see Figure 4) identified in Goos' framework, tailored to assess self-efficacy and motivation in teaching numeracy. For example, under the domain of contexts, instances of what teachers would be required to do were identified from Goos et al. (2019). An instance of this is illustrated by Goos et al.’s discussion of designing tasks (Chapter 6) where it is explained that teachers need to be able to identify a numeracy idea, shape that numeracy idea into a task and then actualize the task in a classroom setting. Using these remarks as a basis, items were then generated accordingly. For instance, “How confident are you that you can identify the mathematical skills and concepts present in all the learning areas you teach?”, “How confident are you that you can create tasks that improve both students' numeracy and their understanding of a learning area e.g. English, or PE?”, and “How confident are you that you can give feedback to students on how they should change their mathematical thinking when faced with a new situation?”. For the motivation items, only the initial wording of the stem “How confident are you that you can…” was changed to “How motivated are you to…” while the remaining wording was kept constant.

Figure 3

Goos' Model for Numeracy in the twenty-first century (Goos et al., 2019

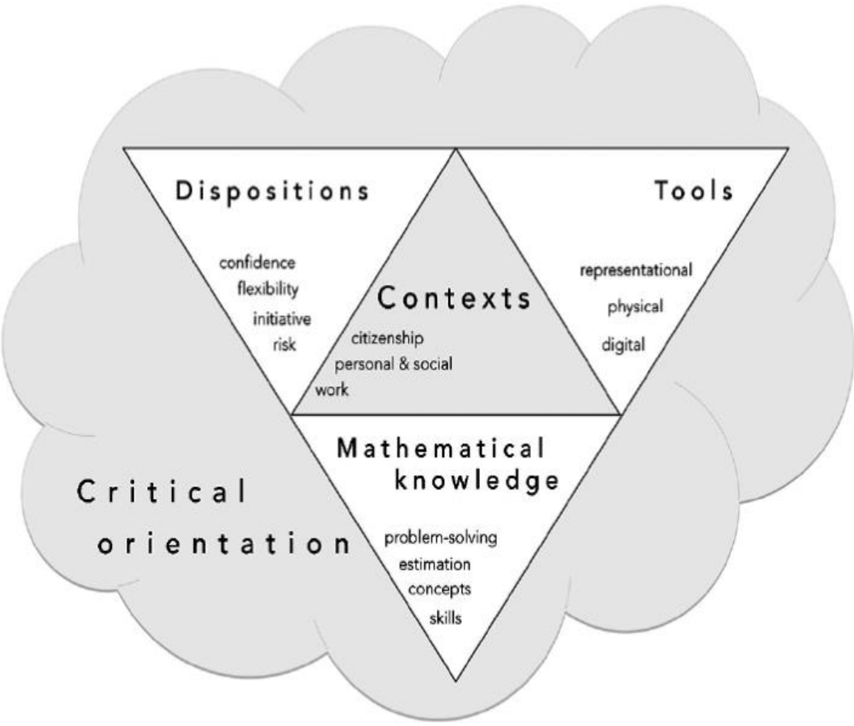


Figure 4

Dimensions of Goos' Model of Numeracy (Goos et al., 2019)

Dimensions	Explanations
Contexts	Use of mathematics to act in and on the world and thus in a range of real-world situations both within schools and beyond school settings
Mathematical knowledge	Concepts and skills, problem-solving strategies and estimation capacities
Dispositions	Confidence and willingness to use mathematical approaches to engage with life-related tasks; preparedness to make flexible and adaptive use of mathematical knowledge
Tools	Use of physical (e.g., models, measuring instruments), representational (e.g., symbol systems, graphs, maps, tables) and digital (e.g., computers, applications, internet) tools to mediate and shape thinking
Critical orientation	Use of mathematical information and activity to analyse and evaluate information and data within a given context, make decisions and judgements, form opinions, add support to arguments and challenge an argument or position

Content and Face Validity

The question items were subject to a content and face validity test by experts and pre-service teachers respectively. Content validity was ensured through a review by three academic teacher educators employed at the author's university with extensive backgrounds in mathematics and numeracy teaching, who evaluated the items for their relevance, consistency and alignment with the domain of numeracy teaching. This step grounded the items in the disciplinary knowledge and pedagogical content knowledge essential for developing such a measure (Gorsuch, 1997; Nunnally, 1978; Watkins, 2018). Face validity, aimed at assessing the clarity and comprehensibility of the items, was examined through a review by five pre-service teachers, mirroring the target demographic of the study (Nunnally et al., 1994; Tabachnick et al., 2013). This content and face validation approach ensured that the items were not only conceptually sound but also resonant with the experiences and perceptions of those relevant to the task of numeracy teaching.

Procedure

The study's participants comprised pre-service teachers enrolled at the university where the research was conducted. Authorization for the research was secured from the institutional ethics committee, ensuring compliance with ethical standards. The recruitment process targeted students pursuing a Bachelor of Education P-12 or Bachelor of Early Childhood and Primary program but not a standalone Early Childhood degree. In Australia, students of a Bachelor of Education P-12 program can be qualified to teach at any level from Primary to Secondary. This type of course is relatively unique both in Australia and Internationally." These students received an email communication detailing an invitation to participate in the research survey, accompanied by comprehensive information regarding the study's objectives, procedures, and ethical considerations. This initial email included a hyperlink directing recipients to a Qualtrics platform, where they were presented with an opportunity to review the project's details thoroughly and express their informed consent to participate.

To reinforce participation and remind potential respondents, a follow-up email was sent two weeks subsequent to the initial invitation, reiterating the invitation to contribute to the research. In addition to the electronic communication, the researcher was also granted approval to engage directly with students through visits to classes. During these sessions, conducted virtually via Zoom due to prevailing Coronavirus lockdown measures, the researcher provided a detailed overview of the research project, underscored the principles of anonymity and confidentiality governing the survey, and emphasized its entirely voluntary nature. This approach not only facilitated a comprehensive understanding of the research among potential participants but also provided a platform for immediate survey completion. The direct engagement with students through classroom visits, complemented by the electronic communication, was executed over a span of approximately four weeks.

Participants

The composition of the survey respondents included a group of 255 undergraduate pre-service teachers, comprising 79 males, 171 females, and 5 individuals identifying as non-binary. The age range of participants extended from 18 to 55 years. Of these participants, 18 individuals aimed to specialize in primary education, 77 in secondary education, 157 exhibited a preference for teaching across P-12 (primary through to year 12), and a small group of 3 respondents indicated a focus on Early Childhood combined with Primary education. 82 participants were in their first year, 78 in their second, 44 in their third, and 51 in their final fourth year. Lastly, 239 were domestic students, 16 were international students, while 55 respondents had a mathematics specialization, contrasting with 200 respondents without one.

Data Analysis

The data analysis was primarily driven by an examination of validity, reliability and the factor structure of the newly constructed measure of levels of self-efficacy and motivation to teach numeracy. As such, the following procedures were conducted.

1. Data preparation and suitability for factor analysis. All data were exported from Qualtrics in csv format and imported into RStudio and SPSS. The primary tool used for data analysis was RStudio, but SPSS was also used in order to confirm results. Any discrepancies were

followed up to ensure no errors were committed. Unless otherwise stated, all results were produced using the R programming language.

2. As the survey forced responses, any completed survey response contained no missing values. However, some responses which were unfinished and not submitted were captured by Qualtrics. These partial responses were filtered out before exporting the data. Although exploratory factor analysis typically does not require univariate or multivariate normality, it is still relevant to the solution. Furthermore, it was important to assess these characteristics of the data for future studies involving the measure. It was also important to determine the factorability of the data. As such, the following tests were undertaken.
3. The skew and kurtosis of the items were inspected. Bartlett's test of sphericity and the Kaiser-Meyer-Olkin of sampling adequacy were also run to confirm appropriate correlations of the data. Univariate normality and outliers were checked by inspection of boxplots, Q-Q plots and using Shapiro-Wilk's significance test. Multivariate normality was checked using Mardia's test. Multicollinearity and singularity were checked by computing and inspecting squared multiple correlations (SMCs) for each item.
4. Descriptive statistics including the mean and standard deviations for items were computed to inform evaluation of items' adequacy.
5. A measure of the internal consistency for the self-efficacy items scale and levels of motivation scale was calculated using Cronbach's alpha coefficient. Item-item correlations and item deleted alphas were also evaluated.

6. Exploratory factor analysis to investigate the factor structure of the scales. The approach to EFA involved the use of an iterative procedure to compare results across a number of analytic choices. EFA is sometimes critiqued for being able to identify any pattern by the researcher. As such, the intention here was to ensure that results appeared to be robust across a range of possible analytic options. To determine the number of factors, eigenvalues were computed, scree tests were inspected, and parallel analyses were run for each scale. As the choice of the number of factors is vital for EFA, but no unanimous and objective criterion exists, several factor solutions were obtained using different numbers of factors as suggested by the eigenvalues, scree tests and parallel analyses, to compare results. Since a correlation between factors of numeracy teaching was expected, principal factor analysis was used. Maximum likelihood and principal axis factoring were both used as methods of factor extraction. Each of these extractions were run with no rotation, Promax and Oblimin rotations, to again compare results. The resulting pattern and structure matrices were then inspected for the emergence of a simple structure where each item had a high loading on a factor, no cross-loading values greater than .4, and an approximately equal number of items per factor. Judgements were made where there was some ambiguity regarding a simple structure based on an evaluation of what aspects of the factor solutions appeared consistent across the multiple trials and on iterations of factoring only the ambiguous items, that is, after removing those factors which were clear. Finally, the factors were

named according to the perceived content of each factor's items and with the purpose of clear communication in mind.

7. Correlations between factors were calculated and examined too.

Results

The following section details the results gained from the initial screening of the data, the descriptive statistics, and exploratory factor analytic results including number of factors, factor loadings and factor structure.

Data Screening and Factor Suitability

Bartlett's test was statistically significant for both the motivation (χ^2(171) = 4779.61, p<0.001) and self-efficacy scales (χ^2(276) = 4738.07, p<0.001) also indicating factorability. The KMO value was .95 for both scales indicating that the sampling adequacy was 'Marvellous' according to Kaiser's criteria (Kaiser, 1974). Boxplots and Q-Q plots indicated the presence of univariate outliers and non-normality. Shapiro-Wilk's normality test for each item was statistically significant, also indicating non-normal data. The p-values for Mardia's test of multivariate normality for both skewness and kurtosis were statistically significant indicating a rejection of the null-hypothesis that the data were multivariate normal. None of the SMCs for either the motivation or self-efficacy scales were 1, indicating no evidence for singularity. Two values were above .8 however the rest were all below, suggesting a lack of evidence of multicollinearity (Tabachnick & Fidell, 2007).

Descriptive Statistics

The means and standard deviations for each item of both scales are presented in Tables 1 and 2 below. The means ranged from 70.76 (item 3) to 79.64 (item 13) for the motivation items and from 66.10 (item 12) to 81.87 (item 21) for the self-efficacy items.

Table 1

Means, Standard Deviations, Skew and Kurtosis for Self-efficacy Items

	Item	M	SD	Skew	Kurtosis
1	How confident are you that you can learn mathematical skills and concepts?	75.55	20.78	-1.15	1.55
2	How confident are you that you can apply mathematics to tasks associated with your work as a teacher?	74.44	19.96	-0.81	0.73
3	How confident are you that you can look for the mathematics present in your everyday work?	77.43	20.40	-1.01	0.85
4	How confident are you that you can use a range of physical, graphical and digital tools to help your mathematical thinking, e.g. rulers, graphs, and/or computers?	79.16	19.18	-1.1	1.52
5	How confident are you that you can decide if and when mathematics is appropriate?	76.43	18.68	-1.14	2.01
6	How confident are you that you can identify the mathematical skills and concepts present in all the learning areas you teach?	72.22	20.70	-0.79	0.53
7	How confident are you that you can design real world tasks that require students to apply mathematics in all the learning areas you teach?	70.33	20.80	-0.78	0.64
8	How confident are you that you can create tasks that improve both students' numeracy and their understanding of a learning area e.g. English, or PE?	68.87	19.46	-0.71	0.58
9	How confident are you that you can identify what physical, graphical or digital tools are needed to help students’ mathematical thinking e.g. rulers, graphs, and/or computers?	75.24	18.59	-0.81	0.77

	Item	M	SD	Skew	Kurtosis
10	How confident are you that you can use tasks to promote discussion about the societal importance of mathematics?	66.14	21.53	-0.65	-0.03
11	How confident are you that you can ask students questions that promote their mathematical skills and knowledge?	69.34	20.19	-0.63	0.27
12	How confident are you that you can give feedback to students on how they should change their mathematical thinking when faced with a new situation?	66.10	21.08	-0.6	-0.08
13	How confident are you that you can motivate students to persevere when applying mathematics to unfamiliar situations?	69.56	18.88	-0.63	0.33
14	How confident are you that you can demonstrate the use of physical, graphical and/or digital tools such as rulers, graphs and/or computers?	75.44	17.74	-0.58	0.02
15	How confident are you that you can assess students' ability to interpret mathematical information?	69.02	19.72	-0.56	-0.02
16	How confident are you that you can reach out to other teachers for help with understanding mathematical skills and concepts?	79.13	21.29	-1.41	2.00
17	How confident are you that you can continually look out for new mathematical opportunities to use in each of the learning areas you teach?	69.96	21.02	-0.57	-0.22
18	How confident are you that you can seek feedback on your willingness to apply mathematics in your work as a teacher?	76.98	19.23	-0.8	0.42
19	How confident are you that you can locate resources to improve your use of physical, graphical, and/or digital tools such as rulers, graphs and/or computers?	74.46	19.75	-0.69	-0.06

	Item	M	SD	Skew	Kurtosis
20	How confident are you that you can use mathematical information and data to evaluate your own teaching performance?	71.87	19.86	-0.68	0.15
21	How confident are you that numeracy requires mathematical skills and concepts?	81.87	17.79	-1.19	1.82
22	How confident are you that numeracy means being able to apply mathematics to any situation?	75.60	19.88	-0.82	0.47
23	How confident are you that numeracy means wanting to see the mathematics present in everyday situations?	72.75	21.23	-0.65	-0.13
24	How confident are you that numeracy requires being able to use a range of physical, graphical and digital tools to help mathematical thinking e.g. rulers, graphs, and/or computers?	75.64	19.98	-0.72	0.22
25	How confident are you that numeracy means deciding if and when mathematics is appropriate?	73.55	20.76	-0.75	0.12

Table 2

Means, Standard Deviations, Skew and Kurtosis for Motivation Items

	Item	M	SD	Skew	Kurtosis
1	How motivated are you to learn mathematical skills and concepts as a teacher?	77.84	21.46	-1.03	0.65
2	How motivated are you to apply mathematics to tasks associated with your work as a teacher?	75.91	19.99	-0.86	0.45
3	How motivated are you to look for the mathematics present in your everyday work?	70.76	22.52	-0.82	0.39
4	How motivated are you to use a range of physical, graphical and digital tools to aid your mathematical thinking?	75.45	20.04	-1.01	1.37
5	How motivated are you to decide if and when to use mathematics in your teaching?	74.56	20.28	-1.08	1.42
6	How motivated are you to identify the mathematical skills and concepts in all the learning areas you teach?	73.11	20.79	-0.89	0.73
7	How motivated are you to design real-world tasks that require students to apply mathematics in all the learning areas you teach?	76.88	19.93	-1.18	1.77
8	How motivated are you to create tasks that help improve both students' numeracy and their understanding of a learning area, e.g. English, or PE?	74.36	20.36	-1.04	1.09
9	How motivated are you to identify what physical, graphical or digital tools are needed to help students' mathematical thinking?	76.87	19.06	-1.14	1.93
10	How motivated are you to use tasks to promote discussion about the societal importance of mathematics?	74.58	19.79	-0.88	0.56

	Item	M	SD	Skew	Kurtosis
11	How motivated are you to ask students questions that promote their mathematical skills and knowledge?	77.03	18.62	-0.78	0.5
12	How motivated are you to give feedback to students on how they can change their mathematical thinking when faced with a new situation?	76.37	19.20	-0.84	0.51
13	How motivated are you to encourage students to persevere when applying mathematics to unfamiliar situations?	79.64	18.40	-1.07	1.22
14	How motivated are you to demonstrate the use of physical, graphical, and/or digital tools?	76.70	18.78	-0.87	0.77
15	How motivated are you to assess students' ability to interpret mathematical information?	76.23	19.39	-0.96	0.67
16	How motivated are you to reach out to other teachers for help with understanding mathematical skills and concepts?	79.02	21.48	-1.25	1.29
17	How motivated are you to continually look out for new mathematical opportunities that you can use in your teaching?	73.22	22.16	-0.95	0.67
18	How motivated are you to seek feedback on your willingness to apply mathematics in your work as a teacher?	78.04	19.54	-1.03	0.86
19	How motivated are you to locate resources to improve your use of physical, graphical, and/or digital tools, e.g. rulers, graphs and/or computers?	76.72	20.94	-1.23	1.7
20	How motivated are you to use mathematical information and data to evaluate your own teaching performance?	77.69	19.39	-1.02	1.2

Internal Consistency

The evaluation of the internal consistency of the measurement scales employed in the study was conducted through the utilization of Cronbach's alpha, a widely recognized statistical tool for assessing the reliability of psychometric instruments. The analysis yielded a Cronbach's alpha of .96 for the self-efficacy scale and .97 for the motivation scale. Further analysis involved computing item-item correlations using Pearson’s correlation coefficient, a method that assesses the degree of linear relationship between variables. The findings demonstrated that each item within the self-efficacy scale had a correlation of at least .3 with one or more other items within the same scale, evidencing coherent relationships among the items. A similar pattern was observed for the motivation scale. Additionally, an examination of item-deleted alphas, which involves recalculating the Cronbach's alpha after sequentially removing each item from the scale, indicated no increase in internal consistency for either the self-efficacy or motivation scales upon the removal of any item.

Exploratory Factor Analysis

Number of Factors

For the self-efficacy scale, there were four eigenvalues above one with values of 12.78, 1.66, 1.16, and 1.04. The scree plot suggested the possibility of four, five, or six factors while parallel analysis suggested four factors. Maximum likelihood and principal factor methods for each number of factors using no rotation, Promax and Oblimin rotations. Using four factors resulted in a relatively large number of items loading on one factor. Five factors tended to split these items across two factors without affecting the other factors significantly. The use of six factors resulted in no significant differences from the five factor solution, often simply adding a new factor with only one or two items. As such, five factors was chosen as the most interpretable.

Five factor solutions were then compared across combinations of maximum likelihood and principal factor solutions using no rotation, Promax and Oblimin rotations. The pattern and structure matrices resulting from the above combinations revealed that the majority of items had consistently high loadings on corresponding factors. The remaining items either loaded highly on more than one factor or loaded on different factors according to which combination of factor extraction and rotation was used. No unambiguous simple structure was found using any of the combinations of factor methods and rotations. Pattern and structure matrices were then obtained using just the ambiguously loading items to determine the most appropriate groupings of these items. Each group of items was then added to the factor using the clearest item-factor loading of the group.

For the motivation scale, there were two eigenvalues above one with values of 11.95 and 1.29. The scree plot suggested the possibility of three, four, or five factors while parallel analysis suggested four factors. Maximum likelihood and principal factor methods using no rotation, Promax and Oblimin rotations. The pattern and structure matrices resulting from the above combinations of numbers of factors and factor methods revealed that the majority of items had consistently high loadings on factors. The remaining items either loaded highly on more than one factor or loaded on different factors according to which combination of factor extraction and rotation was used. As was the case with the self-efficacy scale, using three factors resulted in a relatively large number of items loading on one factor. Four factors tended to split these items across two factors without affecting the other factors significantly. The use of five factors resulted in no significant differences from the four factor solution, often simply adding a new factor with only one or two items. As such, four factors was chosen as the most acceptable.

Factor Loadings

The final pattern matrices for each scale are shown below.

Table 3

Factor Loadings for Exploratory Factor Analysis for the Self-efficacy Section

Item	F1	F2	F3	F4	F5
CON1	**0.59**	0.16	0.05	-0.12	0.13
CON2	**0.74**	0.08	0.18	-0.13	0.02
CON4	0.33	-0.07	**0.72**	0.02	-0.13
CON5	0.45	0.22	**0.46**	-0.10	-0.09
CON6	**0.71**	0.09	0.05	0.05	0.00
CON7	**0.69**	-0.02	-0.02	0.15	-0.02
CON8	**0.74**	-0.12	0.02	0.29	-0.13
CON9	0.17	-0.03	**0.74**	0.03	0.04
CON10	**0.54**	0.02	0.02	-0.02	0.26
CON11	**0.56**	-0.10	0.08	-0.02	0.42
CON12	**0.52**	-0.09	-0.03	-0.01	0.50
CON13	0.10	0.02	-0.02	0.21	**0.58**
CON14	-0.11	-0.02	**0.71**	0.11	0.25
CON15	0.15	0.01	0.00	-0.06	**0.81**
CON16	0.11	0.26	0.00	**0.39**	0.04
CON17	**0.41**	0.05	-0.1	0.51	0.08
CON18	0.02	0.03	0.15	**0.74**	-0.07
CON19	-0.15	-0.04	**0.46**	0.27	0.32
CON20	0.07	0.12	0.18	-0.14	**0.60**
CON21	-0.04	**0.65**	0.07	0.06	0.12
CON22	-0.04	**0.83**	-0.10	0.12	0.08
CON23	0.07	**0.80**	-0.20	0.04	0.08
CON24	-0.15	**0.69**	0.33	0.02	-0.15
CON25	0.14	**0.74**	-0.03	-0.09	-0.05
CON24	-0.15	**0.69**	0.33	0.02	-0.15
CON25	0.14	**0.74**	-0.03	-0.09	-0.05

Table 4

Factor Loadings for Exploratory Factor Analysis for the Motivation Section

Item	F1	F2	F3	F4
MOT1	**0.80**	0.02	0.03	0.02
MOT2	**0.92**	0.08	-0.21	0.06
MOT4	0.22	**0.87**	-0.24	0.03
MOT5	**0.75**	-0.09	-0.22	0.42
MOT6	**0.60**	-0.05	-0.07	0.46
MOT7	-0.09	0.22	0.14	**0.69**
MOT8	0.03	0.02	0.18	**0.68**
MOT9	-0.14	**0.92**	0.02	0.12
MOT10	**0.54**	0.06	0.12	0.15
MOT11	**0.49**	0.12	0.19	0.18
MOT12	**0.48**	0.09	0.30	0.09
MOT13	**0.46**	0.10	0.38	-0.03
MOT14	0.12	**0.80**	0.03	-0.08
MOT15	**0.65**	0.11	0.32	-0.15
MOT16	-0.01	-0.04	**0.80**	0.03
MOT17	**0.54**	-0.12	0.22	0.22
MOT18	-0.05	-0.07	**0.84**	0.15
MOT19	0.01	**0.69**	0.10	0.12
MOT20	**0.77**	0.10	0.12	-0.23

Resultant Factors

Factor two, *Numeracy technology*, captured all items relating to the use, identification, demonstration of digital, graphical tools except for one item in the self-efficacy scale. This item, measuring self-efficacy in the belief that numeracy requires such technology, instead consistently loaded onto factor 5, *Numeracy concept*. Factor four, *Teaching craft*, captured those items relating to the student focused tasks a teacher typically engages in in a classroom setting, such as asking, engaging, assessing students.

Factor one and factor three, *Personal general numerac*y, and *Personal contextual numeracy*, both consisted of items measuring teachers' own abilities to carry out numeracy related tasks. The key difference, however, was a general orientation towards numeracy such as 'learning mathematical skills and concepts' and a contextual orientation when taking the tasks of teaching into account. Thus, factor one consisted of items such as 'identifying mathematical concepts in learning areas'. Factor five, from the self-efficacy scale, was named *Numeracy concept*. This factor involved teachers' self-efficacy in understanding what numeracy was, including items such as 'numeracy requires mathematical skills and concepts' and 'numeracy means deciding if and when mathematics is appropriate'.

Means and Standard Deviations for Factors

The descriptive statistics for the factors for each section are displayed below in tables 5 and 6.

Table 5

Means, Standard Deviations of Factors for Self-efficacy Section

Factors	M	SD
Personal general (4 items)	305.66	63.48
Numeracy technology (4 items)	303.60	65.13
Personal contextual (4 items)	281.50	68.21
Teaching craft (4 items)	274.08	72.19
Numeracy concept (5 items)	378.62	81.07

Table 6

Means, Standard Deviations of Factors for Motivation Section

Factors	M	SD
Personal general (4 items)	308.04	69.92
Numeracy technology (4 items)	303.88	73.61
Personal contextual (4 items)	299.21	71.24
Teaching craft (4 items)	308.31	70.27

Factor correlations

Factor correlations for each section of the MSETN are shown below in tables 7 and 8.

Table 7

Factor Correlations for Self-efficacy Section.

	Personal general	Numeracy technology	Personal contextual	Teaching craft	Numeracy concept
Personal general	1				
Numeracy technology	0.78	1			
Personal contextual	0.77	0.73	1		
Teaching craft	0.78	0.76	0.82	1	
Numeracy concept	0.63	0.61	0.58	0.58	1

Table 8

Factor Correlations for Motivation Section.

	Personal general	Numeracy technology	Personal contextual	Teaching craft
Personal general	1			
Numeracy technology	0.78	1		
Personal contextual	0.82	0.77	1	
Teaching craft	0.84	0.78	0.84	1

Discussion

Upon examination of the reliability and validity evidence surrounding the newly developed motivation and self-efficacy to teach numeracy (MSETN) instrument, the data underscored its appropriateness for Exploratory Factor Analysis (EFA). The statistical analysis of item means and standard deviations revealed a relatively uniform performance across items, suggesting a homogeneous contribution to the overall scale. Notably, the MSETN demonstrated high internal consistency at both the individual item and collective factor levels, confirming the coherence and reliability of the instrument in measuring the targeted constructs. Further analysis through Pearson's correlation coefficient unveiled a coherent relationship among items within each scale. Specifically, all items within the self-efficacy scale exhibited correlations of no less than .3 with at least one other item in the scale, a pattern that was consistently mirrored in the motivation scale items. This finding implies a robust inter-item consistency, reinforcing the internal structure of the MSETN. EFA supported the retention of a five-factor model for the efficacy section and a four-factor model for the motivation section of the MSETN. This structure suggests a degree of stability and coherence within the numeracy teaching domain as reflected across both sections of the MSETN. The parallelism observed between the efficacy and motivation sections further contributes to the theoretical grounding of the instrument, hinting at an underlying consistency in the domains of efficacy and motivation within numeracy teaching.

Data Suitability

Overall, the findings of the data suitability tests indicated that factor analysis was an appropriate analysis for the data. Bartlett's test was significant and the KMO value for both the efficacy and motivation sections was well above the cut-off of 0.5. Though outliers, and a degree of non-normality were present, factor analysis has been shown to be robust enough against these conditions or that they are not required. Furthermore, as the intent of the factor analysis was to explore relationships between variables rather than statistical inference, transformation of the data or the use of non-parametric methods were deemed unnecessary.

Descriptive Statistics

The descriptive statistics of the measure revealed evidence for item appropriateness and a variation in item difficulty. The appropriateness of items was evidenced by each item's mean and standard deviation having values approximately similar to other items. Similar values for means and standard deviations provide potential evidence that items are measuring a single construct. This seems evident for both the self-efficacy and motivation items of the measure. Also important is that item means and standard deviations are not exactly equivalent to allow for items having varying levels of difficulty such that some items could be regarded as more difficult to be confident or motivated in compared to others. Again this was evident for both sections of the measure.

The descriptive statistics are also comparable to other teacher self-efficacy and motivation scales although some conversion between response formats is required. This is because the MSETN utilised slider response formats, whereas the clear majority of other measures adopt a Likert format. To compare results between formats, at least two options exist. Firstly, the self-efficacy or motivation level of 0 on the slider could be correlated with lowest value on a corresponding Likert scale. This would be appropriate if the Likert scale used anchors or categories ranging from low or no self-efficacy to high self-efficacy. For example, the OSTES/TSES scale developed by Tschannen-Moran and Hoy (2001) used a Likert format of 1 to 9 with 1 being ‘nothing’ and 9 being ‘a great deal’ when asked to respond to items such as ‘How much can you do to motivate students who show low interest in schoolwork’ (Tschannen-Moran & Hoy, 2001). Tschannen-Moran and Hoy only reported the mean and standard deviation of the entire scale which was 7.1 and 0.94 respectively. Expressed as a percentage, the mean equates to (7.1-1)*12.5 = 76.25. This value is similar to that found in this study using the MSETN. The ratio of standard deviation to mean is also comparable with the OSTES/TSES scale of .94/7.1 = .13 and the MSETN ranging from .22 to .33.

The second option reflects the fact that some Likert scales utilise a neutral category and adopt a bipolar format. That is, Likert scales of this type may begin with a category of strongly disagree through to strongly agree with a neutral category in the middle such as Riggs and Enochs’ STEB-A measure (Riggs & Enochs, 1990) or Roberts and Henson’s SETAKIST (Roberts & Henson, 2000). In this case, it would not be appropriate to correlate the slider position of 0 self-efficacy with either the Likert category of strongly disagree or at the neutral position. As such, a comparison of descriptive statistics with these types of Likert scales was deemed irrelevant. Overall, the item means and standard deviations provide no evidence for the inadequacy of any particular item and appear consistent with other relevant measures.

Reliability

The analysis of the MSETN's internal consistency revealed a high level of reliability. Utilizing Cronbach's alpha, a statistical measure for evaluating the consistency of survey instruments, the MSETN's internal consistency was quantified. The results demonstrated Cronbach's alpha values of .96 for the self-efficacy scale and .97 for the motivation scale, indicating a high level of reliability that exceeds the benchmarks set forth in the literature. Nunnally (1978) posited that a Cronbach's alpha of .7 is deemed acceptable for social science research, while other scholars advocate for a more stringent threshold of .9 to signify high internal consistency (Nunnally & Bernstein, 1994). Moreover, the examination of item-deleted alphas, which assess the impact of removing each item on the overall scale reliability, showed that the exclusion of any item from either the self-efficacy or motivation scales did not enhance the scales' internal consistency. This finding underscores the integral role each item plays in measuring the respective constructs effectively. In comparison with other instruments developed to measure teacher efficacy and motivation, the MSETN's alpha reliability coefficients demonstrated higher values. For instance, the Ohio State Teacher Efficacy Scale (OSTES) and the Teacher Sense of Efficacy Scale (TSES) reported a long-form alpha reliability of .94 and a short-form reliability of .9 (Tschannen-Moran & Hoy, 2001). Similarly, the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) recorded Cronbach alphas of .88 for the personal mathematics teaching efficacy (PMTE) scale and .77 for the mathematics teaching outcome expectancy (MTOE) scale (Enochs et al., 2000). The Self-Efficacy for Teaching Mathematics Instrument (SETMI) reported Cronbach alphas ranging from .86 to .93 (McGee & Wang, 2014). These comparisons highlight the MSETN's high internal consistency.

Exploratory Factor Analysis

Overall, EFA suggested a relatively interpretable factor structure across both the self-efficacy and motivation sections of the MSETN, although some difficulties were evident. The iterative method of EFA used in this study provided strongest support for a five factor structure of the self-efficacy section and a four factor structure for the motivation section. That is, there was a consistent pattern of groups of items loading on a consistent set of factors regardless of the factor analytic choices of number of factors, factor extraction and factor rotation methods. For example, the choice of number of factors did not significantly alter which items loaded on which factor so much as either combine or split factors. In each of these choices, there emerged a clear set of items being factored together. Likewise, combinations of the factor extraction methods of principal axis and maximum likelihood with no rotation, Promax and Oblimin rotations confirmed a picture of which items consistently loaded against which factor.

Importantly however, a number of items failed to clearly load consistently on a single factor or had high cross-loadings on several factors. It is possible therefore that these items should be dropped from the MSETN for this reason as well as the following reasons. Firstly, Item 3, ‘How confident are you that you can/motivated are you to look for the mathematics present in your everyday work’, was initially flagged during the face validity test as being similar to Item 2. Furthermore, this item tended to load across various factors indicating that it could be understood differently by respondents. For example, when grouped with Item 1, it could be understood as one’s ability to look for mathematics and therefore an aspect of their personal numeracy capability. However, when grouped with Items 7 and 8, it could reflect an aspect of performing a task to produce a result. Given that Item 3 seems open to different interpretations and that these interpretations are already assessed using other items, Item 3 should be removed.

Secondly, a similar argument can be made for items 16, 17 and 18. Items 16 and 18 were sometimes factored together and this could reflect the clear conceptual similarity of both referring to other teachers. Item 16 ‘How confident are you that you can/motivated are you to reach out to other teachers for help with understanding mathematical skills and concepts’. Item 18 ‘How confident are you that you can/motivated are you to seek feedback on your willingness to apply mathematics in your work as a teacher’. Again, the fact that these items also inconsistently loaded with other factors may reflect that they could be interpreted as either a part of or separate to the activity of teaching. It is possible that some see these items as a natural and necessary aspect of teaching while others view it as distinct.

Lastly, Item 17, ‘How confident are you that you can/motivated are you to continually look out for new mathematical opportunities to use in each of the learning areas you teach’, did not consistently load on any particular factor and seems to suffer from similar issues to Item 3. Given these issues however, it is not necessarily the case that items 16, 17 and 18 should automatically be removed. It is also possible that the results are a feature of the study sample and that an additional sample may produce a different outcome. As such, it is suggested that both an original and revised factor structure be subject to a CFA in study 2.

Apart from these item level difficulties, the proposed factor structure also raises several issues. Of primary interest is the fact that the factors which emerged from both the self-efficacy and motivation sections appeared to be equivalent. By this it is meant that corresponding sets of items between the self-efficacy and motivation sections formed the same factors. For example, items 1, 2, 5 and 20 formed a factor of the self-efficacy section as well as in the motivation section. On one level, this may not be surprising as the only difference between items on the two sections is the initial stem.

That is, the 20 items of the motivation section match exactly the first 20 items of the self-efficacy section except that the motivation items begin with ‘How motivated are you to…’ and the self-efficacy items begin with ‘How confident are you that you can…’. On the other hand, it is not necessarily immediately apparent that a factor structure should remain invariant despite a change in the wording of the stem.

Typically, small changes in item level wording of efficacy measures have been found to produce different results. Guskey and Passaro (1994) for instance, reworded items on the Gibson and Dembo TES to reflect an internal and external aspect and found different factor level results to Gibson and Dembo. As an example, they reworded at item such as ‘When a student does better than usually, many times it is because I exert a little extra effort’ to ‘When a student does better than usually, many times it is because *the teacher* exerts a little extra effort’ (Guskey & Passaro, 1994, p. 633). This small change in wording by Guskey and Passaro was enough to find contrary evidence regarding the factor structure of the instrument compared to Gibson and Dembo’s previous study.

The investigation into the factor structures of the MSETN instrument, particularly regarding efficacy and motivation measures, highlights critical considerations in the use and objectives of factor analysis within educational psychology research. The MSETN's parallel factor structures across its two sections, despite differing content focuses on efficacy and motivation, underscore the essential role of distinguishing between the nature of motivation or self-efficacy and their levels when interpreting measure outcomes. This distinction is pivotal in understanding the constructs these instruments aim to assess (Guskey & Passaro, 1994). Instruments designed to measure motivation often probe the various reasons an individual might engage in a particular behaviour, reflecting a qualitative diversity in motivation.

Conversely, measures of efficacy are traditionally conceptualized to quantify the degree to which individuals believe in their capability to achieve specific outcomes. This dichotomy is evident in the literature, where motivation and efficacy are treated as distinct yet overlapping constructs, each contributing uniquely to the understanding of teacher behaviours and attitudes (Bandura, 1997; Tschannen-Moran & Hoy, 2001). However, a closer examination of several efficacy measures reveals an implicit assessment of motivation's qualitative aspects. This is exemplified by Guskey and Passaro's (1994) adaptation of Gibson and Dembo's Teacher Efficacy Scale, where rewording items to reflect internal versus external factors resulted in distinct factor structures. The differentiation introduced by changing the referent from 'I' to 'the teacher' suggests an underlying assessment of reasons for efficacy, thus blurring the lines between the constructs of efficacy and motivation. This rewording illuminates how efficacy measures may inadvertently capture variations in motivational reasons, indicating a complex interplay between the belief in one's capabilities and the reasons underlying such beliefs. The implications of these findings extend beyond methodological considerations, touching on the theoretical foundations of efficacy and motivation within the context of teaching numeracy. The factor analysis aims to delineate items that vary only by degree (i.e., factors) from those that represent distinct categories or types (i.e., separate factors). The observation that differences in factor structures of efficacy measures may stem from the inclusion of varied reasons for being efficacious points to a fundamental aspect of how these constructs are operationalized and measured (Deci & Ryan, 2000; Eccles & Wigfield, 2002).

This discussion suggests that the distinction between kind and degree, or the qualitative versus quantitative dimensions of efficacy and motivation, is a critical driver of factor analytic outcomes. Recognizing this distinction can inform the design and interpretation of measures within educational research, advocating for a nuanced approach that accommodates the multifaceted nature of teacher efficacy and motivation. Such an approach would enable researchers to better capture the complexity of these constructs, facilitating more accurate and meaningful assessments of teachers' beliefs and attitudes towards teaching numeracy.

Factor Correlations

The factor correlation results from the Exploratory Factor Analysis (EFA) of the MCT) instrument reveal correlations between factors within the self-efficacy and motivation sections. These correlations were examined to understand the relationships among the underlying constructs of numeracy teaching efficacy and motivation. Tables 7 and 8 presented the correlation coefficients between factors, indicating the degree to which factors are related to each other within the respective sections of the MSETN.

Factor correlations within the self-efficacy section ranged from moderate to high, suggesting that while factors are distinct, they share a significant degree of variance. For instance, the correlation between the “Personal general” and “Numeracy technology” factors was 0.78, indicating a strong relationship between general self-efficacy in numeracy and self-efficacy in using technology for numeracy teaching. Similarly, correlations between “Personal contextual” and “Teaching craft” factors were high, at 0.82, reflecting a strong link between contextual understanding of numeracy and the application of numeracy in teaching practices. These correlations imply that while factors represent different dimensions of numeracy teaching efficacy, they are not entirely independent and influence each other to a considerable extent.

The motivation section exhibited a similar pattern of correlations, with “Personal general” and “Teaching craft” showing a high correlation of 0.84. This suggests a strong association between general motivation towards numeracy and motivation to engage in numeracy teaching practices. The consistency in patterns of correlation between the self-efficacy and motivation sections suggests that the constructs of efficacy and motivation in numeracy teaching are interrelated and possibly reflective of a coherent underlying structure of numeracy teaching competency. The presence of significant correlations between factors raises the possibility of higher-order factors that might encapsulate these interrelated constructs. Such an observation aligns with the multifaceted nature of teacher efficacy and motivation, as discussed in the educational psychology literature, where individual dimensions of efficacy and motivation are often interrelated, contributing to an overarching construct of teacher competency (Bandura, 1997; Tschannen-Moran & Hoy, 2001). Given these correlations, future studies could explore the potential for higher-order factor models that consolidate these related constructs into broader dimensions of numeracy teaching competency. This approach aligns with suggestions from psychometric literature advocating for the exploration of hierarchical factor structures in complex psychological constructs (Gustafsson & Balke, 1993; Reise et al., 2010).

Study limitations

The study involved several limitations which can be discussed in terms of methodological, theoretical, and contextual factors. Firstly, the choice of Classical Test Theory (CTT) over Item Response Theory (IRT) for the development of the measure, while pragmatic, presents certain limitations. CTT assumes that each item contributes equally to the construct being measured, disregarding the possibility that some items might be more informative at different levels of the trait being assessed (Embretson & Reise, 2000). This limitation could lead to a lack of understanding of the measure's ability to differentiate between levels of motivation and self-efficacy across a diverse pre-service teacher population. However, there is scope within CTT to also address this issue by employing differential item functioning (DIF) analysis within subgroups of the pre-service teacher sample. Secondly, the reliance on Exploratory Factor Analysis (EFA) for determining the factor structure of the measure, without subsequent validation through Confirmatory Factor Analysis (CFA) in a separate sample, may limit the generalizability of the findings. EFA is a powerful tool for identifying potential underlying factor structures, but it is inherently exploratory. Without CFA, the stability and fit of the derived factor structure remain untested in new samples (Brown, 2015). This limitation however will be addressed in chapter five which performs a confirmatory factor analysis of the measure with a new independent sample. Thirdly, the item generation process, informed by literature review and expert consultation, might not fully capture the complexity of the constructs of motivation and self-efficacy in the context of numeracy teaching. This process may omit aspects of these constructs that are relevant to pre-service teachers' experiences but are not well-documented in the literature or recognized by experts in the field. The resulting measure might not reflect the full construct of motivation and self-efficacy as experienced by pre-service teachers (DeVellis, 2017). Finally, the study's sample, drawn from a specific geographical and educational context, may limit the applicability of the findings to different contexts. Variations in educational systems, cultural norms, and numeracy teaching practices across regions and countries might influence pre-service teachers' motivation and self-efficacy in ways not accounted for in this study. This limitation underscores the need for cross-cultural validation of the measure to ensure its relevance and utility across diverse educational settings (Van de Vijver & Tanzer, 2004).

Chapter Summary

This chapter outlined the development and exploratory factor analysis (EFA) of the MSETN instrument, aimed at measuring pre-service teachers' levels of motivation and self-efficacy in teaching numeracy. This chapter was motivated by the need for a new psychometric measure due to the identified gaps in the literature concerning the definitional clarity of numeracy teaching and the extent of pre-service teachers' motivation and self-efficacy in this domain. The chapter detailed the methodological approach, including item generation based on Goos 21st century numeracy framework and theoretical considerations, and the process of validating the content and face validity of the items through expert reviews and pre-service teacher assessments.

The instrumentation section described the demographic and survey items designed to collect data, emphasizing the use of slider scales for responses. The methods section further detailed the sample selection and data collection process, adhering to ethical considerations and employing a combination of email invitations and class presentations to recruit participants. The data analysis described the preparatory steps for EFA, including tests for data suitability and factorability, alongside a detailed account of the internal consistency checks using Cronbach's alpha.

The exploratory factor analysis described, highlighted the decision-making process in determining the number of factors for the efficacy and motivation sections of the MSETN. This included the rationale behind choosing specific factor extraction methods and rotations, aiming for the most interpretable factor structure. The resultant factor structures for both sections were presented, indicating a coherent grouping of items into factors that represent distinct dimensions of numeracy teaching motivation and self-efficacy. The implications of the findings suggest ongoing development of the MSETN and its potential application in educational research. Chapter five addresses this need by recruiting an independent sample of pre-service teachers with which to conduct a confirmatory factor analysis of the instrument.

Chapter Five: Refining and Analysing the Measure of Preservice Levels of Motivation and Self-efficacy to Teach Numeracy

This chapter builds upon the results of Chapter 4, where Exploratory Factor Analysis (EFA) was employed to develop a new measure of motivation and self-efficacy to teach numeracy. It advances to a confirmatory phase that validates the factor structure of the newly developed measure using Confirmatory Factor Analysis (CFA). The transition from EFA to CFA is a logical and necessary step in scale development and validation processes (Brown, 2015). While EFA is used to identify possible underlying factor structures without imposing a predefined structure, CFA is applied to test the hypothesis that a specific factor structure, suggested by EFA, fits the data collected (Kline, 2016). This progression is essential for establishing the reliability and validity of the measure, ensuring that it can serve as a robust tool for measuring pre-service teachers' motivation and self-efficacy to teach numeracy. The need for a valid and reliable measure of these constructs arises from the significant role that teacher motivation and self-efficacy play in educational outcomes (Tschannen-Moran & Hoy, 2001). Research has consistently demonstrated that teachers' beliefs about their capabilities significantly influence their teaching practices and, subsequently, student achievement (Bandura, 1997). In the context of numeracy education, equipping pre-service teachers with the necessary motivation and self-efficacy is imperative for educational success (Geiger et al., 2015). This chapter's methodology includes a detailed description of the CFA procedures, model fit indices evaluation, and the interpretation of results. The chosen statistical software and rationale for the selection of specific model fit indices, such as the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root

Mean Square Residual (SRMR), will be discussed, following recommendations from Schreiber et al. (2006) and Hu & Bentler (1999) on best practices in CFA analysis. Upon establishing the measure's validity and reliability through CFA, this chapter explores the implications of the confirmed factor structure for numeracy teaching within Initial Teacher Education (ITE). The findings from this study are situated within the broader aims of the thesis to contribute to the improvement of ITE programs by providing empirical evidence on the motivational and self-efficacy beliefs of pre-service teachers regarding numeracy teaching. This contribution is particularly timely and relevant given the increasing emphasis on numeracy across educational curricula and the recognized need for highly competent and confident numeracy teachers (ACARA, 2023b).

Method

The method of this study involves a multi-step approach aimed at refining and analyzing the Measure of Preservice Levels of Motivation and Self-efficacy to Teach Numeracy (MSETN). Initially, revisions were made to the MSETN based on insights from Chapter four, specifically at the item level. Items showing inadequate correlations and those deemed less relevant to the numeracy teaching domain were removed, leading to a revised instrument composed of 21 items for the self-efficacy scale and 16 for the motivation scale. The method section then transitions into detailing the participant selection process for a new independent sample from Chapter four, involving pre-service teachers from various educational backgrounds enrolled in an approved initial teacher education degree at a Victorian University. Finally, it describes the data analysis techniques used to ensure a rigorous examination of the measure's internal consistency, item distributions, and factor structure through CFA. This analysis was complemented by criterion validity studies, aiming to elucidate the impact of demographic variables on the constructs of interest. Statistical software such as RStudio, SPSS, and AMOS were employed for data analysis, with attention paid to assumptions underlying CFA and statistical tests like MANOVA.

Revisions Made to MSETN

The analysis detailed in the preceding chapter critically evaluated the validity and reliability of the MSETN instrument, leading to the decision to omit items 3, 16, 17, and 18 from further analyses. This decision was informed by several key findings. Initially, item 3 was excluded because its correlation with other items failed to surpass the threshold of 0.3, indicating a weak relationship and suggesting it contributed little to the construct being measured (Watkins, 2018). Additionally, items 16, 17, and 18 exhibited significant cross-loadings across multiple factors, which underscored their divergence from the core set of items and raised questions about their direct relevance to the domain of numeracy teaching (Lloret et al., 2017). Consequently, the refined MSETN now comprises 21 items dedicated to assessing self-efficacy and 16 items focused on motivation. The decision to limit revisions to the removal of these items was supported by the instrument's demonstration of high internal consistency and a robust factor structure, as compared with existing research (Beavers et al., 2013; Henson & Roberts, 2006). No additional modifications were considered necessary, affirming the instrument's readiness for confirmatory factor analysis.

Confirmatory Factor Analysis and Criterion Validity Study

Participants

Participants involved pre-service teachers enrolled in any approved initial teacher education degree at a Victorian University. In Australia, there are several differences between approved initial teacher education programs. Students can study degrees which focus only on Secondary year levels (Master of Teaching Secondary, Bachelor of Education Secondary), only Primary year Levels (Master of Teaching Primary, Bachelor of Education primary), or combined degrees including a Bachelor of Education P-12 or a Bachelor of Education Early Childhood and Primary. As with Study one, no participants from standalone Early Childhood degrees were accepted. The final sample comprised 474 participants, with 134 males, 332 females, and 8 non-binary. Ages ranged from 18 to 58. 74 were planning to teach primary, 186 secondary, 174 P-12, and 40 Early Childhood + Primary. The proportions of year levels were 213 first year students, 156 second year, 50 third year, and 55 fourth year students. 420 were domestic and 54 were international students. 88 possessed a mathematics specialisation while 386 did not.

Instruments

Demographic items. The demographics section of this study comprised 13 questions, designed to capture a detailed profile of each participant. These questions encompassed the following key demographic and educational characteristics of age, gender, postcode, academic year, degree program, and teaching intention (primary or secondary). Additionally, the questions asked for participants' status as domestic or international students, their teaching specialisations, and whether they enjoyed activities such as programming, puzzles, and playing musical instruments. Critical to understanding the mathematical background of participants, questions also asked whether they had studied mathematics in their final year of high school and if they had experience tutoring in mathematics. This detailed set of demographic questions was strategically developed to correlate participants' backgrounds with their motivation and self-efficacy to teach numeracy, with the aim of facilitating an analysis of how these personal and educational factors might influence their levels of motivation and self-efficacy to teach numeracy.

Revised MSETN Instrument. The instrument administered to the sample was the measure developed in the previous chapter. It consisted of two scales, measuring the levels of motivation and self-efficacy to teach numeracy. The self-efficacy scale consisted of 25 items using the stem 'How confident are you that…', while the motivation scale used the stem 'How motivated are you to…'. Sliders were used as a response format ranging from 0 to 100. Above the slider at each end were the headings 'Not confident at all' and 'totally confident' for the self-efficacy scale, while the motivation scale used 'Not motivated at all' and 'totally motivated'. Response could take any positive integer value between 0 and 100. The self-efficacy scale consisted of five factors, Numeracy concept, Numeracy technology, Personal general numeracy, Personal contextual numeracy, and Numeracy teaching craft. Cronbach's alpha for the self-efficacy scale was .96. The motivation scale consisted of four factors which were equivalent to the self-efficacy factors minus the Numeracy concept factor. Cronbach's alpha for the motivation scale was .97.

Procedure

Ethical approval was obtained from the Victoria University ethics committee. Subsequent to this approval, requests for research support were dispatched via email to the Deans of the Faculty of Education at eight Victorian universities. A 75% response rate was achieved, with six universities consenting to facilitate engagement with course chairs of initial teacher education programs. The role of these course chairs was critical in allowing communication with potential pre-service teacher participants. Upon receipt of contact details for course chairs, a detailed project overview was provided via email, accompanied by a request to disseminate participant information within their pre-service teacher cohorts. As a result, pre-service teachers were directly contacted by their respective course chairs with an invitation to participate in the study, inclusive of all relevant study information and a link to the Qualtrics survey platform. This link enabled participants to review study details and express consent by proceeding with the survey. A follow-up reminder was issued through the course chairs two weeks subsequent to the initial contact. The project information sheet and corresponding communications emphasized the principles of anonymity, confidentiality, and the voluntary basis of participation. The survey window was held open for a duration of approximately four weeks.

Data Analysis

1. The data analysis involved the following procedures in order to re-examine the revised measure's internal consistency, item distributions, to verify its factor structure, and to investigate the evidence for criterion validity. Data were exported from Qualtrics in csv format, and imported into RStudio, SPSS and AMOS.
2. As CFA, and statistical tests such as MANOVA make several assumptions regarding the type and distribution of data, it is important to assess whether these assumptions have been met. As such, univariate normality and outliers were checked by inspection of boxplots, Q-Q plots and using Shapiro-Wilk's significance test. Multivariate normality was checked using Mardia's test. Multicollinearity was checked by computing squared multiple correlations (SMCs) for each item.
3. Means and standard deviations for pre-service teachers with a mathematics specialisation and those without were computed.
4. Internal consistency was evaluated using Cronbach's alpha coefficient.
5. An analysis of the item-total, item-factor correlations and item deleted alphas was conducted to assess each item's suitability.

6. The factor structure proposed in the previous chapter was verified using confirmatory factor analysis with the following steps. Correlation matrices computed using both Kendall's and Pearson's method were consulted to identify any correlations less than .3 and the most appropriate matrix to be used for CFA. Furthermore, Bartlett's test of sphericity and the Kaiser-Meyer-Olkin of sampling adequacy were also run to confirm appropriate correlations of the data. CFA was performed using both the R programming language (Lavaan packages) and SPSS AMOS software (version 27) to compare results and reduce the risk of errors. Maximum likelihood estimation was used in all cases. Goodness of fit was examined using the following fit indices. Although not very reliable, the Chi-Squared statistic was evaluated simply as a precautionary measure. To more rigorously evaluate the CFA models, a combination of different types of fit indices was used. CFI, TLI, RMSEA, NFI. As each index is sensitive to different aspects of a model, meeting the cut-offs of a range of different indices provides a greater self-efficacy in the model's fit.
7. MANOVAs were conducted as evidence of criterion validity and to better understand the influence of demographic variables on motivation and self-efficacy to teach numeracy.

Results

Descriptive Statistics for Individual Items

The means and standard deviations of each item and for a group with a mathematics specialisation and a group with no mathematics specialisation for both the motivation and self-efficacy scales are shown below in Tables 9 and 10. For the self-efficacy items, means ranged from 65.82 to 82.43. For the motivation items, means ranged from 69.19 to 77.78. For both sets of items, means were higher for the group with a mathematics specialisation.

Table 9

Means and Standard Deviations for Self-efficacy Items

	Item	Total		Maths		Non-maths	
		M	SD	M	SD	M	SD
1	How confident are you that you can learn mathematical skills and concepts?	78.72	19.42	88.98	11.09	76.38	20.15
2	How confident are you that you can apply mathematics to tasks associated with your work as a teacher?	77.20	18.82	85.72	12.95	75.26	19.41
4	How confident are you that you can use a range of physical, graphical and digital tools to help your mathematical thinking, e.g. rulers, graphs, and/or computers?	79.81	18.24	86.94	13.56	78.18	18.79
5	How confident are you that you can decide if and when mathematics is appropriate?	76.79	17.92	84.51	11.80	75.03	18.62
6	How confident are you that you can identify the mathematical skills and concepts present in all the learning areas you teach?	74.11	20.00	82.64	13.07	72.17	20.79
7	How confident are you that you can design real world tasks that require students to apply mathematics in all the learning areas you teach?	70.54	20.28	75.53	18.08	69.40	20.61
8	How confident are you that you can create tasks that improve both students' numeracy and their understanding of a learning area e.g. English, or PE?	70.31	19.25	74.93	17.06	69.26	19.59
9	How confident are you that you can identify what physical, graphical or digital tools are needed to help students' mathematical thinking e.g. rulers, graphs, and/or computers?	74.47	19.06	83.58	12.05	72.40	19.76
10	How confident are you that you can use tasks to promote discussion about the societal importance of mathematics?	66.53	21.79	75.86	17.06	64.41	22.21
11	How confident are you that you can ask students questions that promote their mathematical skills and knowledge?	69.55	20.10	80.41	13.01	67.07	20.62
12	How confident are you that you can give feedback to students on how they should change their mathematical thinking when faced with a new situation?	65.82	21.55	77.17	15.63	63.23	21.89

13	How confident are you that you can motivate students to persevere when applying mathematics to unfamiliar situations?	69.61	19.36	76.48	14.76	68.04	19.95
14	How confident are you that you can demonstrate the use of physical, graphical and/or digital tools such as rulers, graphs and/or computers?	75.32	18.53	81.83	13.08	73.83	19.26
15	How confident are you that you can assess students' ability to interpret mathematical information?	69.10	19.76	79.92	13.98	66.64	20.07
19	How confident are you that you can locate resources to improve your use of physical, graphical, and/or digital tools such as rulers, graphs and/or computers?	74.00	19.59	81.47	14.66	72.30	20.18
20	How confident are you that you can use mathematical information and data to evaluate your own teaching performance?	72.95	19.62	80.88	15.52	71.15	20.02
21	How confident are you that numeracy requires mathematical skills and concepts?	82.43	17.16	88.68	11.90	81.00	17.86
22	How confident are you that numeracy means being able to apply mathematics to any situation?	75.34	20.68	81.91	17.41	73.84	21.10
23	How confident are you that numeracy means wanting to see the mathematics present in everyday situations?	71.61	22.30	78.99	17.65	69.93	22.92
24	How confident are you that numeracy requires being able to use a range of physical, graphical and digital tools to help mathematical thinking e.g. rulers, graphs, and/or computers?	75.41	19.94	80.39	18.95	74.28	20.02
25	How confident are you that numeracy means deciding if and when mathematics is appropriate?	73.83	20.83	80.30	16.75	72.35	21.40

Table 10

Means and Standard Deviations for Motivation Items

	Item	Total		Maths		Non-maths	
		M	SD	M	SD	M	SD
1	How motivated are you to learn mathematical skills and concepts as a teacher?	76.16	20.99	90.98	14.52	76.16	20.99
2	How motivated are you to apply mathematics to tasks associated with your work as a teacher?	74.44	19.66	86.65	15.05	74.44	19.66
4	How motivated are you to use a range of physical, graphical and digital tools to aid your mathematical thinking?	74.27	19.44	82.99	17.90	74.27	19.44
5	How motivated are you to decide if and when to use mathematics in your teaching?	72.70	19.94	85.39	15.68	72.70	19.94
6	How motivated are you to identify the mathematical skills and concepts in all the learning areas you teach?	71.95	20.40	84.07	16.35	71.95	20.40
7	How motivated are you to design real-world tasks that require students to apply mathematics in all the learning areas you teach?	74.54	19.89	84.72	15.61	74.54	19.89
8	How motivated are you to create tasks that help improve both students' numeracy and their understanding of a learning area, e.g. English, or PE?	73.40	20.82	80.94	15.15	73.40	20.82
9	How motivated are you to identify what physical, graphical or digital tools are needed to help students' mathematical thinking?	73.95	20.04	84.89	14.46	73.95	20.04
10	How motivated are you to use tasks to promote discussion about the societal importance of mathematics?	71.56	21.47	83.49	14.70	71.56	21.47
11	How motivated are you to ask students questions that promote their mathematical skills and knowledge?	74.84	19.21	87.65	13.40	74.84	19.21
12	How motivated are you to give feedback to students on how they can change their mathematical thinking when faced with a new situation?	73.08	19.96	88.64	10.35	73.08	19.96
13	How motivated are you to encourage students to persevere when applying mathematics to unfamiliar situations?	77.48	18.48	88.25	12.81	77.48	18.48
14	How motivated are you to demonstrate the use of physical, graphical, and/or digital tools?	74.79	20.43	82.88	15.96	74.79	20.43
15	How motivated are you to assess students' ability to interpret mathematical information?	72.97	20.88	87.39	11.58	72.97	20.88

	Item	Total		Maths		Non-maths	
		M	SD	M	SD	M	SD
19	How motivated are you to locate resources to improve your use of physical, graphical, and/or digital tools, e.g. rulers, graphs and/or computers?	74.08	22.05	82.88	17.46	74.08	22.05
20	How motivated are you to use mathematical information and data to evaluate your own teaching performance?	75.99	20.41	83.43	18.26	75.99	20.41

Confirmatory Factor Analysis

The models for both the self-efficacy and motivation sections developed in the previous study were tested for the fit indices listed in tables 11 and 12. Fit indices were computed using the Lavaan package in R. The fit indices indicated that no further models needed to be tested.

Table 11

Fit Indices for the Self-efficacy Section

	χ^2 (df)	NFI	AGFI	TLI	RMSEA	CFI	GFI
Model	310.679(179)	.931	.916	.964	.040	.970	.935

Table 12

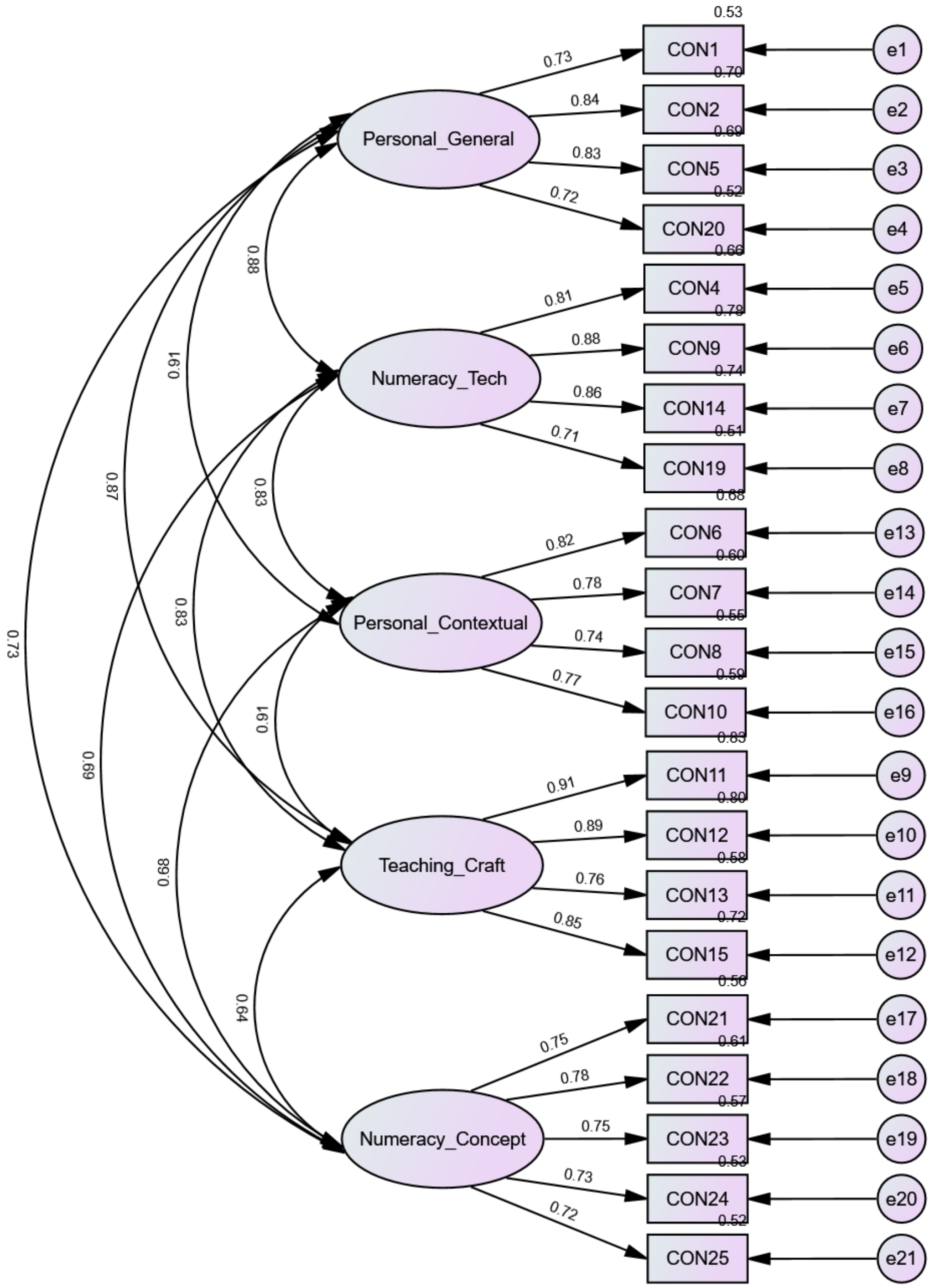
Fit Indices for the Motivation Section

	χ^2 (df)	NFI	AGFI	TLI	RMSEA	CFI	GFI
Model	215.93(101)	.954	.918	.97	.050	.975	.939

The factor model for the self-efficacy section is presented below in figure 5.

Figure 5

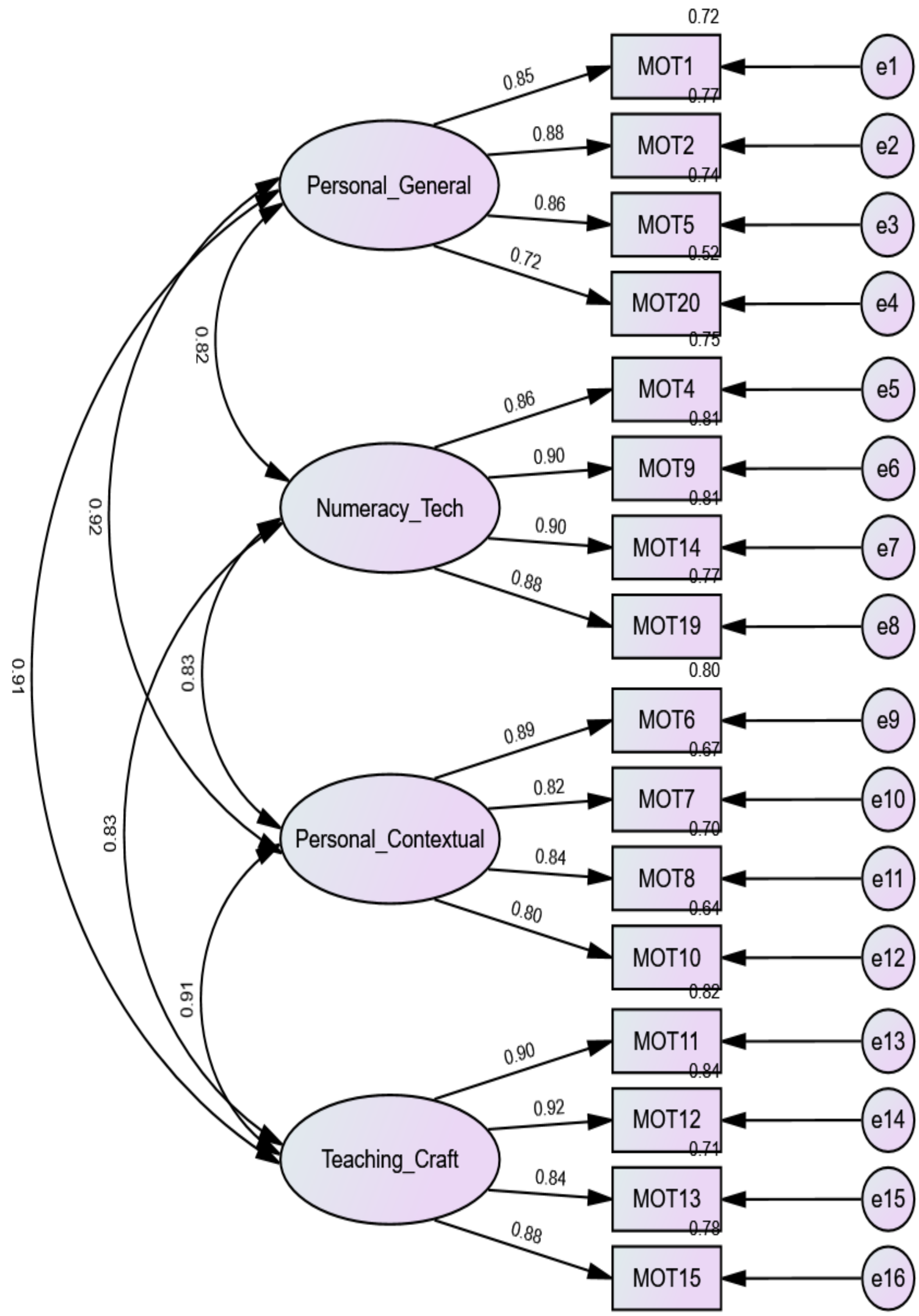
Factor Model for Self-efficacy Section



The factor model for the motivation section is presented in figure 6 below.

Figure 6

Factor Model for Motivation Section



Internal consistency

Cronbach's alpha was .96 and .97 for the self-efficacy and motivation scales respectively.

Factor Correlations

Correlations between factors for the self-efficacy and motivation scales are provided in tables 13 and 14.

Table 13

Factor Correlations for the Self-efficacy Section

	Personal general	Numeracy technology	Personal contextual	Teaching craft	Numeracy concept
Personal general	1				
Numeracy technology	0.78	1			
Personal contextual	0.77	0.73	1		
Teaching craft	0.78	0.76	0.82	1	
Numeracy concept	0.63	0.61	0.58	0.58	1

Table 14

Factor Correlations for the Motivation Section

	Personal general	Numeracy technology	Personal contextual	Teaching craft
Personal general	1			
Numeracy technology	0.78	1		
Personal contextual	0.82	0.77	1	
Teaching craft	0.84	0.78	0.84	1

MANOVAs

Gender

Self-efficacy gender MANOVA did not reveal a statistically significant difference, *Pillai*, $F(12, 934) = .99$, $p > .05$.

Table 15

Descriptive Statistics for Self-efficacy Factors According to Gender

Factor name	Gender	count	M	SD	M	SD
Personal general numeracy	Female	332	302.33	63.96	75.58	15.99
	Male	134	313.01	62.58	78.25	15.65
	Non-binary	8	320.5	51.05	80.13	12.76
Numeracy technology	Female	332	302.89	64.22	75.72	16.06
	Male	134	304.13	67.71	76.03	16.93
	Non-binary	8	324.13	63.24	81.03	15.81
Personal contextual numeracy	Female	332	281.18	69.7	70.3	17.43
	Male	134	281.15	64.69	70.29	16.17
	Non-binary	8	300.38	69.21	75.09	17.3
Numeracy teaching craft	Female	332	272.48	72.19	68.12	18.05
	Male	134	276.36	71.97	69.09	17.99
	Non-binary	8	302.5	78.56	75.63	19.64
Numeracy concept	Female	332	378.45	82.12	75.69	16.42
	Male	134	377.28	76.23	75.46	15.25
	Non-binary	8	407.75	117.23	81.55	23.45

Motivation gender MANOVA did not reveal a statistically significant difference, *Pillai*, $F(10, 936) = .831$, $p > .05$.

Table 16

Descriptive Statistics for Motivation Factors According to Gender

Factor Name	Gender	count	M	SD	M	SD
Personal general numeracy	Female	332	309.32	68.59	77.33	17.15
	Male	134	304.4	72.63	76.1	18.16
	Non-binary	8	316.38	85.03	79.1	21.26
Numeracy technology	Female	332	305.22	71.71	76.31	17.93
	Male	134	299.61	78.16	74.9	19.54
	Non-binary	8	319.63	78.45	79.91	19.61
Personal contextual numeracy	Female	332	302.63	70.47	75.66	17.62
	Male	134	290.48	72.03	72.62	18.01
	Non-binary	8	303.38	86.7	75.85	21.67
Numeracy teaching craft	Female	332	309.15	71.69	77.29	17.92
	Male	134	305.61	66.07	76.4	16.52
	Non-binary	8	318.63	86.23	79.66	21.56

Dom/International

Self-efficacy Dom/International MANOVA did not reveal a statistically significant difference, *Pillai*, $F(6, 467) = 1.430$, $p > .05$.

Table 17

Descriptive Statistics for Self-efficacy Factors According to Dom/International

Factor Name	Type	count	M	SD	M	SD
Personal general numeracy	Domestic	420	303.78	64.93	75.94	16.23
	International	54	320.3	48.85	80.07	12.21
Numeracy technology	Domestic	420	302.91	66.14	75.73	16.54
	International	54	308.96	56.95	77.24	14.24
Personal contextual numeracy	Domestic	420	279.31	69.7	69.83	17.43
	International	54	298.54	52.85	74.63	13.21
Numeracy teaching craft	Domestic	420	271.99	73.45	68	18.36
	International	54	290.31	59.6	72.58	14.9
Numeracy concept	Domestic	420	376.5	82.8	75.3	16.56
	International	54	395.07	64.27	79.01	12.85

Motivation Dom/International MANOVA did not reveal a statistically significant difference, *Pillai*, $F(5, 468) = 1.286$, $p > .05$.

Table 18

Descriptive Statistics for Motivation Factors According to Dom/International

Factor Name	Type	count	M	SD	M	SD
Personal general numeracy	Domestic	420	306.3	71.54	76.58	17.88
	International	54	321.65	54.39	80.41	13.6
Numeracy technology	Domestic	420	302.55	74.96	75.64	18.74
	International	54	314.24	61.71	78.56	15.43
Personal contextual numeracy	Domestic	420	296.9	73.16	74.23	18.29
	International	54	317.17	51.11	79.29	12.78
Numeracy teaching craft	Domestic	420	307.29	72.18	76.82	18.04
	International	54	316.22	53.06	79.06	13.27

Music

Self-efficacy Music MANOVA did not reveal a statistically significant difference, *Pillai*, $F(6, 467) = 1.19$, $p > .05$.

Table 19

Descriptive Statistics for Self-efficacy Factors According to Music

Factor Name	Enjoy music?	Count	M	SD	M	SD
Personal general numeracy	No	228	300.46	63.46	75.11	15.87
	Yes	246	310.48	63.24	77.62	15.81
Numeracy technology	No	228	300.48	64.88	75.12	16.22
	Yes	246	306.49	65.36	76.62	16.34
Personal contextual numeracy	No	228	275.87	67.42	68.97	16.86
	Yes	246	286.71	68.67	71.68	17.17
Numeracy teaching craft	No	228	269.17	72.3	67.29	18.08
	Yes	246	278.63	71.94	69.66	17.99
Numeracy concept	No	228	371.13	79.38	74.23	15.88
	Yes	246	385.56	82.15	77.11	16.43

Motivation Music MANOVA did not reveal a statistically significant difference, *Pillai*, $F(5, 468) = .824$, $p > .05$.

Table 20

Descriptive Statistics for Motivation Factors According to Music

Factor Name	Enjoy music?	count	M	SD	M	SD
Personal general numeracy	No	228	303.41	69.92	75.85	17.48
	Yes	246	312.34	69.79	78.09	17.45
Numeracy technology	No	228	299.95	72.58	74.99	18.14
	Yes	246	307.52	74.51	76.88	18.63
Personal contextual numeracy	No	228	296.06	69.1	74.02	17.28
	Yes	246	302.13	73.19	75.53	18.3
Numeracy teaching craft	No	228	303.59	70.15	75.9	17.54
	Yes	246	312.69	70.24	78.17	17.56

Year

Self-efficacy Year MANOVA revealed a statistically significant difference *Pillai*, $F(18, 1401) = 3.138$, $p < .001$.

Table 21

Descriptive Statistics for Self-efficacy Factors According to Year

Factor Name	Year	Count	M	SD	M	SD
Personal general numeracy	First year	13	308.41	67.05	77.1	16.76
	Fourth year	5	312.36	53.88	78.09	13.47
	Second year	56	308.94	56.71	77.24	14.18
	Third year	0	276.32	71.29	69.08	17.82
Numeracy technology	First year	13	302.92	66.46	75.73	16.62
	Fourth year	5	314.25	55.4	78.56	13.85
	Second year	56	304.68	68.25	76.17	17.06
	Third year	0	291.44	58.59	72.86	14.65
Personal contextual numeracy	First year	13	281.54	71.43	70.38	17.86
	Fourth year	5	296.75	62	74.19	15.5
	Second year	56	286.75	63.25	71.69	15.81
	Third year	0	248.16	66.85	62.04	16.71
Numeracy teaching craft	First year	13	271.55	77.15	67.89	19.29
	Fourth year	5	289	55.95	72.25	13.99
	Second year	56	276.76	73.13	69.19	18.28
	Third year	0	260.06	60.73	65.02	15.18
Numeracy concept	First year	13	368.15	86.57	73.63	17.31
	Fourth year	5	396.69	66.24	79.34	13.25
	Second year	56	391.62	75.63	78.32	15.13
	Third year	0	362.78	80.27	72.56	16.05

Motivation Year MANOVA revealed a statistically significant difference, *Pillai*, $F(15, 1404) = 3.883$, $p < .001$.

Table 22

Descriptive Statistics for Motivation Factors According to Year

Factor Name	Year	Count	M	SD	M	SD
Personal general numeracy	First year	13	307.62	72.76	76.91	18.19
	Fourth year	5	332.76	55.39	83.19	13.85
	Second year	56	311.7	64.43	77.93	16.11
	Third year	0	271.26	75.23	67.82	18.81
Numeracy technology	First year	13	299.96	77.09	74.99	19.27
	Fourth year	5	320.02	70.82	80.01	17.7
	Second year	56	311.91	65.84	77.98	16.46
	Third year	0	277.76	78.04	69.44	19.51
Personal contextual numeracy	First year	13	296.47	76.55	74.12	19.14
	Fourth year	5	323.22	56.96	80.81	14.24
	Second year	56	305.99	65.11	76.5	16.28
	Third year	0	263.32	67.18	65.83	16.79
Numeracy teaching craft	First year	13	304.2	76.52	76.05	19.13
	Fourth year	5	337.51	50.82	84.38	12.71
	Second year	56	310.83	66.02	77.71	16.5
	Third year	0	285.86	64.3	71.47	16.08

Level

Self-efficacy Level MANOVA revealed a statistically significant difference, *Pillai*, $F(18, 1401) = 4.538$, $p < .001$.

Table 23

Descriptive Statistics for Self-efficacy Factors According to Level

Factor Name	Level	count	M	SD	M	SD
Personal general numeracy	Early Childhood + Primary	40	320.5	43.53	80.13	10.88
	P-12	174	295.21	61.16	73.8	15.29
	Primary	74	314.36	54.41	78.59	13.6
	Secondary	186	308.78	71.04	77.19	17.76
Numeracy technology	Early Childhood + Primary	40	309.33	45.98	77.33	11.5
	P-12	174	302.71	61.29	75.68	15.32
	Primary	74	317.72	52.86	79.43	13.22
	Secondary	186	297.59	75.24	74.4	18.81
Personal contextual numeracy	Early Childhood + Primary	40	301.48	47.36	75.37	11.84
	P-12	174	273.47	66.18	68.37	16.55
	Primary	74	296.22	57.4	74.05	14.35
	Secondary	186	278.86	76.08	69.72	19.02
Numeracy teaching craft	Early Childhood + Primary	40	294.98	49.45	73.74	12.36
	P-12	174	276.94	63.87	69.24	15.97
	Primary	74	289.26	56.64	72.31	14.16
	Secondary	186	260.87	85.78	65.22	21.45
Numeracy concept	Early Childhood + Primary	40	391.73	65.08	78.35	13.02
	P-12	174	383.7	72.68	76.74	14.54
	Primary	74	398.01	68.41	79.6	13.68
	Secondary	186	363.33	93.14	72.67	18.63

Motivation Level MANOVA revealed a statistically significant difference, *Pillai*, $F(15, 1404) = 3.883$, $p < .001$.

Table 24

Descriptive Statistics for Motivation Factors According to Level

Factor Name	Level	count	M	SD	M	SD
Personal general numeracy	Early Childhood + Primary	40	328.5	45.79	82.13	11.45
	P-12	174	303.22	68.52	75.81	17.13
	Primary	74	330.03	53.93	82.51	13.48
	Secondary	186	299.41	78.35	74.85	19.59
Numeracy technology	Early Childhood + Primary	40	314.5	49.12	78.63	12.28
	P-12	174	304.11	71.83	76.03	17.96
	Primary	74	332.27	52.09	83.07	13.02
	Secondary	186	290.09	83.13	72.52	20.78
Personal contextual numeracy	Early Childhood + Primary	40	321.83	41.2	80.46	10.3
	P-12	174	298.68	64.05	74.67	16.01
	Primary	74	327.84	56.5	81.96	14.13
	Secondary	186	283.45	82.67	70.86	20.67
Numeracy teaching craft	Early Childhood + Primary	40	327.45	43.32	81.86	10.83
	P-12	174	311.66	61.42	77.92	15.36
	Primary	74	335.3	55.16	83.83	13.79
	Secondary	186	290.32	82.43	72.58	20.61

Degree

Self-efficacy Degree MANOVA revealed a statistically significant difference, *Pillai*, $F(6, 467) = 8.266$, $p < .001$.

Table 25

Descriptive Statistics for Self-efficacy Factors According to Degree

Factor Name	Degree	count	M	SD	M	SD
Personal general numeracy	Bachelor	189	295.9	62.8	73.98	15.7
	Masters	285	312.13	63.21	78.03	15.8
Numeracy technology	Bachelor	189	303.08	63.24	75.77	15.81
	Masters	285	303.94	66.46	75.99	16.62
Personal contextual numeracy	Bachelor	189	274.33	66.18	68.58	16.55
	Masters	285	286.25	69.24	71.56	17.31
Numeracy teaching craft	Bachelor	189	277.46	64.97	69.37	16.24
	Masters	285	271.84	76.64	67.96	19.16
Numeracy concept	Bachelor	189	382.28	72.75	76.46	14.55
	Masters	285	376.19	86.18	75.24	17.24

Motivation Degree MANOVA revealed a statistically significant difference, *Pillai*, $F(5, 468) = 3.50$, $p < .01$.

Table 26

Descriptive Statistics for Motivation Factors According to Degree

Factor Name	Degree	count	M	SD	M	SD
Personal general numeracy	Bachelor	189	302.47	70.81	75.62	17.7
	Masters	285	311.74	69.2	77.94	17.3
Numeracy technology	Bachelor	189	303.71	72.95	75.93	18.24
	Masters	285	303.99	74.17	76	18.54
Personal contextual numeracy	Bachelor	189	295.99	67.8	74	16.95
	Masters	285	301.34	73.48	75.34	18.37
Numeracy teaching craft	Bachelor	189	309.98	64.74	77.5	16.18
	Masters	285	307.2	73.8	76.8	18.45

Puzzles

Self-efficacy Puzzles MANOVA revealed a statistically significant difference, *Pillai*, $F(6, 467) = 6.41$, $p < .001$.

Table 27

Descriptive Statistics for Self-efficacy Factors According to Puzzles

Factor Name	Enjoy puzzles	count	M	SD	M	SD
Personal general numeracy	No	90	271.12	66.41	67.78	16.6
	Yes	384	313.76	60.05	78.44	15.01
Numeracy technology	No	90	273.44	71.51	68.36	17.88
	Yes	384	310.67	61.53	77.67	15.38
Personal contextual numeracy	No	90	257.54	67.94	64.39	16.99
	Yes	384	287.11	67.14	71.78	16.79
Numeracy teaching craft	No	90	245.4	67.37	61.35	16.84
	Yes	384	280.8	71.71	70.2	17.93
Numeracy concept	No	90	355.59	86.1	71.12	17.22
	Yes	384	384.02	78.99	76.8	15.8

Motivation Puzzles MANOVA revealed a statistically significant difference, *Pillai*, $F(5, 468) = 6.476$, $p < .001$.

Table 28

Descriptive Statistics for Motivation Factors According to Puzzles

Factor Name	Enjoy puzzles	count	M	SD	M	SD
Personal general numeracy	No	90	273.22	72.5	68.31	18.13
	Yes	384	316.21	66.81	79.05	16.7
Numeracy technology	No	90	278.06	87.85	69.52	21.96
	Yes	384	309.93	68.59	77.48	17.15
Personal contextual numeracy	No	90	275.84	74.57	68.96	18.64
	Yes	384	304.68	69.41	76.17	17.35
Numeracy teaching craft	No	90	284.16	77.63	71.04	19.41
	Yes	384	313.97	67.3	78.49	16.82

Programming

Self-efficacy Programming MANOVA revealed a statistically significant difference, *Pillai*, $F(6, 467) = 11.045$, $p < .001$.

Table 29

Descriptive Statistics for Self-efficacy Factors According to Programming

Factor Name	Enjoy programming	count	M	SD	M	SD
Personal general numeracy	No	360	300.9	64.16	75.23	16.04
	Yes	114	320.68	59.09	80.17	14.77
Numeracy technology	No	360	296.66	66.38	74.17	16.6
	Yes	114	325.51	55.84	81.38	13.96
Personal contextual numeracy	No	360	276.28	68.84	69.07	17.21
	Yes	114	297.97	63.74	74.49	15.94
Numeracy teaching craft	No	360	267.54	72.52	66.89	18.13
	Yes	114	294.72	67.37	73.68	16.84
Numeracy concept	No	360	374.43	80.92	74.89	16.18
	Yes	114	391.86	80.43	78.37	16.09

Motivation Programming MANOVA revealed a statistically significant difference, *Pillai*, $F(5, 468) = 5.607$, $p < .001$.

Table 30

Descriptive Statistics for Motivation Factors According to Programming

Factor Name	Enjoy programming	count	M	SD	M	SD
Personal general numeracy	No	360	299.98	71.1	75	17.78
	Yes	114	333.52	59.49	83.38	14.87
Numeracy technology	No	360	294.91	75.3	73.73	18.83
	Yes	114	332.21	59.98	83.05	15
Personal contextual numeracy	No	360	292.33	72.36	73.08	18.09
	Yes	114	320.94	63.09	80.24	15.77
Numeracy teaching craft	No	360	302.04	70.46	75.51	17.61
	Yes	114	328.11	66.16	82.03	16.54

Tutoring

Self-efficacy Tutoring MANOVA revealed a statistically significant difference, *Pillai*, $F(6, 467) = 11.045$, $p < .001$.

Table 31

Descriptive Statistics for Self-efficacy Factors According to Tutoring

Factor Name	Maths tutor	count	M	SD	M	SD
Personal general numeracy	No	289	289.1	66.05	72.28	16.51
	Yes	185	331.53	49.26	82.88	12.32
Numeracy technology	No	289	289.67	67.96	72.42	16.99
	Yes	185	325.37	53.79	81.34	13.45
Personal contextual numeracy	No	289	267.72	72.63	66.93	18.16
	Yes	185	303.02	54.23	75.75	13.56
Numeracy teaching craft	No	289	255.39	75.01	63.85	18.75
	Yes	185	303.27	56.43	75.82	14.11
Numeracy concept	No	289	364.84	84.78	72.97	16.96
	Yes	185	400.14	69.85	80.03	13.97

Motivation Tutoring MANOVA revealed a statistically significant difference, *Pillai*, $F(5, 468) = 9.514$, $p < .001$.

Table 32

Descriptive Statistics for Motivation Factors According to Tutoring

Factor Name	Maths tutor	count	M	SD	M	SD
Personal general numeracy	No	289	292.88	70.38	73.22	17.59
	Yes	185	331.73	62.37	82.93	15.59
Numeracy technology	No	289	291.46	78.2	72.87	19.55
	Yes	185	323.28	61.12	80.82	15.28
Personal contextual numeracy	No	289	288.58	76.14	72.15	19.03
	Yes	185	315.81	59.32	78.95	14.83
Numeracy teaching craft	No	289	293.26	74.68	73.32	18.67
	Yes	185	331.82	55.27	82.96	13.82

Year 12 Subject

Self-efficacy Year 12 Subject MANOVA revealed a statistically significant difference, *Pillai*, $F(42, 2796) = 2.437$, $p < .001$

Table 33

Descriptive Statistics for Self-efficacy Factors According to Year 12 Subject

Factor Name	Final maths subject	count	M	SD	M	SD
Personal general numeracy	An Australian calculus based maths subject	144	315.8	58.51	78.95	14.63
	An Australian non-calculus based maths subject	132	297.74	58.12	74.44	14.53
	An Australian non-calculus based maths subject, An Australian calculus based maths subject	28	345.93	48.53	86.48	12.13
	An Overseas calculus based maths subject	51	336.02	49.57	84	12.39
	An Overseas non-calculus based maths subject	15	314.93	39.12	78.73	9.78
	An Overseas non-calculus based maths subject, An Overseas calculus based maths subject	8	349.13	21.89	87.28	5.47
	I did not do a maths subject in my final year of school	95	268	72.66	67	18.17
Numeracy technology	An Australian calculus based maths subject	144	312.25	59.24	78.06	14.81
	An Australian non-calculus based maths subject	132	299.8	62.88	74.95	15.72
	An Australian non-calculus based maths subject, An Australian calculus based maths subject	28	337.64	64.07	84.41	16.02
	An Overseas calculus based maths subject	51	323.73	55.52	80.93	13.88
	An Overseas non-calculus based maths subject	15	307.53	42.68	76.88	10.67
	An Overseas non-calculus based maths subject, An Overseas calculus based maths subject	8	323.75	39.91	80.94	9.98
	I did not do a maths subject in my final year of school	95	272.67	74.73	68.17	18.68
Personal contextual numeracy	An Australian calculus based maths subject	144	289.85	64.11	72.46	16.03
	An Australian non-calculus based maths subject	132	272.22	68.12	68.05	17.03

Factor Name	Final maths subject	count	M	SD	M	SD
	An Australian non-calculus based maths subject, An Australian calculus based maths subject	28	299.14	61.54	74.79	15.39
	An Overseas calculus based maths subject	51	312.75	53.67	78.19	13.42
	An Overseas non-calculus based maths subject	15	306.07	43.68	76.52	10.92
	An Overseas non-calculus based maths subject, An Overseas calculus based maths subject	8	299.13	40.49	74.78	10.12
	I did not do a maths subject in my final year of school	95	254.96	77.15	63.74	19.29
Numeracy teaching craft	An Australian calculus based maths subject	144	284.19	69.1	71.05	17.28
	An Australian non-calculus based maths subject	132	267.82	68.31	66.95	17.08
	An Australian non-calculus based maths subject, An Australian calculus based maths subject	28	302.43	70.61	75.61	17.65
	An Overseas calculus based maths subject	51	299.92	65.46	74.98	16.37
	An Overseas non-calculus based maths subject	15	283.33	51.83	70.83	12.96
	An Overseas non-calculus based maths subject, An Overseas calculus based maths subject	8	292.5	64.75	73.13	16.19
	I did not do a maths subject in my final year of school	95	242.82	78.47	60.71	19.62
Numeracy concept	An Australian calculus based maths subject	144	378.83	80.36	75.77	16.07
	An Australian non-calculus based maths subject	132	382.42	69.78	76.48	13.96
	An Australian non-calculus based maths subject, An Australian calculus based maths subject	28	416.89	66.72	83.38	13.34
	An Overseas calculus based maths subject	51	408.39	68.53	81.68	13.71
	An Overseas non-calculus based maths subject	15	368.13	57.02	73.63	11.4

Factor Name	Final maths subject	count	M	SD	M	SD
	An Overseas non-calculus based maths subject, An Overseas calculus based maths subject	8	406.88	73.79	81.38	14.76
	I did not do a maths subject in my final year of school	95	346.17	97.87	69.23	19.57

Motivation Year 12 Subject MANOVA revealed a statistically significant difference, *Pillai*, $F(35, 2330) = 2.162$, $p < .001$.

Table 34

Descriptive Statistics for Motivation Factors According to Year 12 Subject

Factor Name	Final maths subject	count	M	SD	M	SD
Personal general numeracy	An Australian calculus based maths subject	144	314.19	70.16	78.55	17.54
	An Australian non-calculus based maths subject	132	301.45	66.5	75.36	16.62
	An Australian non-calculus based maths subject, An Australian calculus based maths subject	28	347.07	50.61	86.77	12.65
	An Overseas calculus based maths subject	51	339.57	52.07	84.89	13.02
	An Overseas non-calculus based maths subject	15	308.53	55.29	77.13	13.82
	An Overseas non-calculus based maths subject, An Overseas calculus based maths subject	8	335.75	58.97	83.94	14.74
	I did not do a maths subject in my final year of school	95	277.38	76.94	69.35	19.23
Numeracy technology	An Australian calculus based maths subject	144	303.44	75.47	75.86	18.87
	An Australian non-calculus based maths subject	132	303.52	66.92	75.88	16.73
	An Australian non-calculus based maths subject, An Australian calculus based maths subject	28	342.39	48.74	85.6	12.18
	An Overseas calculus based maths subject	51	332.31	49.55	83.08	12.39
	An Overseas non-calculus based maths subject	15	304.13	52.16	76.03	13.04
	An Overseas non-calculus based maths subject, An Overseas calculus based maths subject	8	324.13	73.96	81.03	18.49
	I did not do a maths subject in my final year of school	95	276.09	88.46	69.02	22.12
Personal contextual numeracy	An Australian calculus based maths subject	144	300.28	65.22	75.07	16.31
	An Australian non-calculus based maths subject	132	290.75	72.25	72.69	18.06

Factor Name	Final maths subject	count	M	SD	M	SD
	An Australian non-calculus based maths subject, An Australian calculus based maths subject	28	319.79	68.94	79.95	17.23
	An Overseas calculus based maths subject	51	329.61	53.67	82.4	13.42
	An Overseas non-calculus based maths subject	15	307.27	55.31	76.82	13.83
	An Overseas non-calculus based maths subject, An Overseas calculus based maths subject	8	325.38	63.7	81.35	15.93
	I did not do a maths subject in my final year of school	95	283.72	84.2	70.93	21.05
Numeracy teaching craft	An Australian calculus based maths subject	144	313.88	66.87	78.47	16.72
	An Australian non-calculus based maths subject	132	305.66	68.53	76.42	17.13
	An Australian non-calculus based maths subject, An Australian calculus based maths subject	28	337.07	67.59	84.27	16.9
	An Overseas calculus based maths subject	51	329.9	56.23	82.48	14.06
	An Overseas non-calculus based maths subject	15	304.27	58.28	76.07	14.57
	An Overseas non-calculus based maths subject, An Overseas calculus based maths subject	8	333.13	61.24	83.28	15.31
	I did not do a maths subject in my final year of school	95	282.41	80.12	70.6	20.03

Discussion

This discussion section critically evaluates the outcomes of the Confirmatory Factor Analysis (CFA) conducted on the Measure of Preservice Teachers' Levels of Motivation and Self-efficacy to Teach Numeracy (MSETN). The analysis aims to validate the instrument's factor structure as initially identified through Exploratory Factor Analysis (EFA) and further examine the influence of demographic variables on the constructs of motivation and self-efficacy within the context of numeracy teaching in initial teacher education (ITE). The CFA conducted as part of this study reaffirms the multidimensional nature of the MSETN, underscoring its validity and reliability in assessing preservice teachers' motivation and self-efficacy. This finding aligns with the theoretical framework posited by Bandura (1997), which emphasizes the role of self-efficacy in educational settings and its impact on motivation and performance. The factor structure, consisting of distinct but related dimensions of motivation and self-efficacy, corroborates the conceptualization of these constructs as separate yet interconnected entities, influencing preservice teachers' readiness to teach numeracy (Bandura, 1997; Schunk et al., 2008). Moreover, the analysis of demographic variables revealed nuanced insights into how various factors such as age, educational background, and teaching experience influence motivation and self-efficacy levels. This aspect of the study draws upon the work of Eccles and Wigfield (2020), who suggest that personal and contextual factors significantly shape educational outcomes through their impact on motivation and self-efficacy beliefs. The findings suggest that tailored interventions in ITE programs might be necessary to address the diverse needs and backgrounds of preservice teachers, thereby enhancing their motivation and self-efficacy to teach numeracy. The study also contributes to the ongoing discourse on numeracy teaching in ITE, as highlighted by Geiger et al. (2015), who advocate for a more integrated approach to numeracy that transcends traditional boundaries of mathematical content knowledge. The MSETN's emphasis on both motivational and self-efficacy aspects provides a comprehensive tool for evaluating and subsequently enhancing ITE curricula to better prepare preservice teachers for the complexities of numeracy teaching. In light of these findings, this discussion underscores the imperative for ITE programs to incorporate targeted strategies that bolster both motivation and self-efficacy among preservice teachers. Such strategies could include professional learning communities, mentoring programs, and practical teaching experiences specifically designed to address numeracy teaching. This approach is supported by Garvis and Pendergast (2016), who argue for the significance of experiential learning and reflective practice in developing teacher self-efficacy and motivation.

Descriptive statistics

The descriptive statistics for the MSETN using an independent sample confirm several conclusions drawn from the sample used in study one. Examination of the item means for the mathematics versus non-mathematics group indicate that the former is both more confident and more motivated than the latter. This pattern was also evident across factor and scale means and standard deviations. The question of why those with specialising in mathematics produce higher levels of motivation and self-efficacy remains important. There are two substantive issues. The first is the relation between a preservice teacher’s self-efficacy in doing a subject and their self-efficacy in teaching that subject. The second is the relation between self-efficacy in mathematics versus self-efficacy in numeracy and teaching numeracy. Regarding the relationship between self-efficacy in a subject and teaching that subject, literature supports the contention that higher levels of self-efficacy in a subject correlates with higher levels of self-efficacy in teaching that subject. As far back as 1990, Kaur (1990) found that self-efficacy in doing mathematics correlated with a feeling of being secure in teaching mathematics with a coefficient of .71 (Kaur, 1990, p.). More recently, Newton et al. (2012), found a moderate correlation ranging from r = 0.452 to 0.456 between content knowledge in mathematics and personal teaching efficacy (Newton et al., 2012). Likewise, Brown (2012) and Bates et al. (2011) found that mathematics grades and mathematical performance correlated with preservice teacher teaching efficacy. Interestingly, Swars et al. (2007) found evidence of a correlation between preservice teachers' efficacy for teaching and their mathematics teaching knowledge (Swars et al., 2007). Possible reasons for this relate to the how mathematics knowledge, knowledge for teaching mathematics, and mathematical performance are measured in these studies, and whether teaching efficacy is construed as personal teaching efficacy or outcome teaching efficacy or expectancy (Twohill et al., 2022). Twohill et al. go on to suggest that while personal teaching efficacy seems correlated with preservice teachers' previous mathematical knowledge or competence, outcome expectancy, is not. The relevance of these studies to this current one concerns the second important relation which is between preservice teacher mathematical knowledge, competence or self-efficacy and self-efficacy or motivation to teach numeracy. If higher levels of self-efficacy in mathematics lead to higher levels of self-efficacy in teaching mathematics, it is possible to theorise that the same holds true for self-efficacy in numeracy leading to self-efficacy in teaching numeracy. The question then becomes whether self-efficacy in mathematics is correlated with self-efficacy in numeracy. Given this line of reasoning, previous literature and the pattern of higher means of mathematics preservice teachers in this sample, this is supportive evidence of the validity of the MSETN measuring what it has been designed to measure.

The pattern of item means and standard deviations also confirm study one's findings. For self-efficacy, item 12 had the lowest mean for both study one and two with values of 66.10 and 65.82 respectively. Item 21 had the highest mean of 81.87 in study one, and this item also had the highest mean of 82.43 in this study. For motivation, item 3 was lowest in both studies with values of 70.76 and 69.19, while item 13 was highest in both studies with values of 77.48 and 79.64. The similarity in means and the finding of equivalent lowest and highest items across both study one and this current study are evidence of the stability of measurement across independent samples,

Reliability

In reviewing the reliability evidence for the MSETN, internal consistency was again found to be high with values of .96 and .97 for self-efficacy and motivation scales respectively. These values are equivalent to those found in study one's sample and significantly above recommended thresholds such as .70 (Nunnally, 1978; Taber, 2018). When comparing to other studies revising measures through CFA, Twohill et al. produced values of .84 and .79 when measuring personal mathematics teaching efficacy and mathematics teaching outcome expectancy (Twohill et al., 2022). In a recent study on preservice teacher preparedness to teach, Abraham et al. found a value of .89 for their self-efficacy scale (Abraham et al., 2021). The current MSETN thus demonstrates a high level of internal consistency reflecting evidence of reliability.

Factor correlations

A comparison of the factor correlations of each scale to the results found in study one also supports the reliability of the MSETN. Values are similar for both the self-efficacy and motivation factors as is the pattern of highest and lowest factor correlations. The similarity in values adds further weight to the reliability of the MSETN.

Factor structure

The factor structure resulting from the confirmatory factor analysis indicated that the five factor model for self-efficacy and the four factor model for motivation provide a good to excellent fit of the data. The five factors associated with the self-efficacy scale and the four factors of the motivation scale exhibited the same groupings of items and were thus conceptualised and named equivalently. Factors one through four are present in both scales, while factor five is only present in the self-efficacy scale. The model of factors, namely, Personal General Numeracy, Personal Contextual Numeracy, Numeracy Technology, Numeracy Teaching Craft and Numeracy Concept (Self-efficacy scale only), was found to meet the cut offs for a variety of fit indices. No evidence was found for making modifications for either of the scales. A comparison with a recent example of confirmatory factor analysis on a personal teaching efficacy scale illustrates the close fit of the model achieved in this study. In an attempt to refine their model, Abraham et al. found an RMSEA of 0.055, TLI of 0.922 and a CFI of 0.931, describing the result as a good fit. (Abraham et al., 2021). The current models in this study found an RMSEA of .04, TLI of .964 and a CFI of .97 for self-efficacy and an RMSEA of .05, TLI of .97 and a CFI of .975 for motivation. Thus, meeting cut offs for a variety of fit indices provides strong support for the current factor structure of the MSETN.

Analysis of the Item, Factor and Scale Scores of the Measure.

The interpretation of the scores regarding items, factors and scales requires careful consideration and qualification. The two major reasons stem from the purpose of the scores and the theoretical judgement as to what they represent. Regarding the first reason, scores on an instrument may have the purpose of simply providing a consistent value across different points in time with no attribution or expectation regarding what that value should be. In this case, one is interested in whether and under what conditions the value increases or decreases over time. For example, measuring the height on a mercury thermometer has no meaning in and of itself except as a reliable correlation of the temperature in that context. A second purpose of such an instrument is to attribute standards or expectations of meaning or interpretation to its values. Thus, in the case of the thermometer, feelings of ‘hot’ or ‘cold’ can be ascribed to certain values or value ranges. The MSETN therefore can also be approached with these two purposes in mind.

The second reason for careful interpretation of the MSETN scores relates to the particular theoretical stance regarding what they refer to. For instance, on one account, the scale could be viewed from a frequentist viewpoint. In that case, a score of 50/100 or 50% on a self-efficacy item can be interpreted as meaning the participant is confident of successfully performing the task in five out of ten occasions. A score of 50/100 or 50% on a motivation item would be interpreted as the participant being motivated to do a particular task on five out of ten occasions. A contrasting view would be to understand the values on the scales as representing something such as a level of intensity. For example, a self-report of a level of pain typically does not indicate experiencing pain in five out of ten occasions but experiencing a constant level of pain across all occasions. In this case, a score of 50/100 on the MSETN for self-efficacy would represent a participant feeling that level of self-efficacy whenever that task is attempted, or that level of motivation whenever a task is attempted. The extra complication arising from this viewpoint is the difficulty in determining what constitutes an acceptable or desired level of motivation or self-efficacy. The majority of teacher efficacy and motivation scales adopt a Likert scale with five or six points. For those with five points, the typical ordering is 1 = strongly disagree; 2 = disagree; 3 = neutral or neither; 4 = agree; 5 = strongly agree. Given this setup, a score of 4/5 (80%) or 5/5 (100%) would be interpreted as high to very high. In a six-point Likert scale a score of 4/6 (66.67%), 5/6 (83.33%), 6/6 (100%) would be interpreted as high to very high. A seven point Likert would have scores of 5/7 (71%), 6/7 (85.7%), 7/7 (100%) as being interpreted as high to very high. A further complication with these types of Likert scales is whether they are unipolar or bipolar. That is, the typical Likert scale ranges from strongly disagree (or an equivalent) to strongly agree (or an equivalent). Others, however, begin at zero agreement (or equivalent) to full agreement (or equivalent). This makes comparing bipolar and unipolar scales difficult as strongly disagree is not necessarily equivalent to zero or no agreement. According to Bandura:

> In the standard methodology for measuring self-efficacy beliefs, individuals ...record the strength of their efficacy beliefs on a 100-point scale, ranging in 10-unit intervals from 0 (‘Cannot do’); through intermediate degrees of assurance, 50 (‘Moderately certain can do’); to compete assurance, 100 (‘Highly certain can do’). (Bandura, 2006, p. 312).

Apart from agreeing with Pajares et al. (2006) that a 0-100 response format is superior to a 5 point scale, Bandura also notes that “bipolar scales with negative gradations below the zero point that one cannot perform a given level of activity do not make sense” (Bandura, 2006, p. 312). This is also why the MSETN response format was designed as it is, as previously explained in study one. The critical reason for discussing the different types of response formats of teacher self-efficacy and motivation scales is to ensure that proper comparisons can be made between the results of this study and those of others and therefore aid any interpretation of those scores. I therefore now discuss some similarities and differences with other measures regarding item, factor and scale scores.

Item Means and SDs

The non-mathematics group reflected the same pattern in highest and lowest items as the overall case. The mathematics group however differed for both the lowest and highest items on both the self-efficacy and motivation scales. In their study, Twohill et al. conducted an analysis of the relationship between gender, educational attainment, and preparedness to teach and two outcome variables measuring efficacy, namely, personal mathematics teaching efficacy (PMTE) and mathematics teaching outcome expectancy (MTOE) (Twohill et al., 2022). They found an overall mean of 3.55 and 3.54 for PMTE and MTOE respectively. They also found an overall mean of 3.34 for their preparedness to teach index. For all these results, Twohill et al. interpret these means as evidence of “relatively high levels” (Twohill et al., 2022, Results section, para 2). The response format used for the PMTE, MTOE and preparedness to teach index was a five point Likert scale where 1 = strongly disagree and 5 = strongly agree. Regarding this study’s results, the highest rated self-efficacy item was item 21 with a mean of 82.43 for the overall sample, item 1 with a mean of 87.98 for the mathematics preservice teachers and item 21 with a mean of 81.00 for the non-mathematics teachers. The lowest rated self-efficacy item was item 12 with a mean of 65.82 for the sample overall, item 8 with a mean of 74.00 for the mathematics preservice teachers and item 12 with a mean of 63.23 for the non-mathematics teachers. To compare this study’s results to that of Twohill et al., there are two options. The first is to equate the response formats entirely such that 0 on the MSETN aligns with 1 and 100 on the MSETN aligns with 5. In this case, Twohill et al. means are approximately 70% producing a similar value to the MSETN mean ranges of 65.82 – 82.43 for the self-efficacy items listed above meaning preservice teachers could be described as having relatively high levels of self-efficacy to teach numeracy. The second option however, would align 0 on the MSETN to 3 on Twohill et al. five point Likert response scale, and 100 on the MSETN to 5. In this case, the MSETN mean values would correspond to ranging from 4.32 to 4.65, significantly higher than their results of 3.55, 3.54, and 3.34. Using Twohill et al. description of their results as “relatively high”, the results of the MSETN would thus likely be characterised as very high levels of self-efficacy to teach numeracy. Using either method, it appears that preservice teachers report between relatively high and very high levels of self-efficacy to teach numeracy across all items.

A similar comparison can be mode for the motivation section of the MSETN. The highest rated motivation item was item 13 with a mean of 77.48 for the overall sample, item 1 with a mean of 90.98 for the mathematics group and item 13 with a mean value of 77.78 for the non-mathematics group. The lowest rated motivation item was item 3 with a mean of 69.19 for the overall sample, item 8 with a mean of 80.94 for the mathematics group and item 3 with a mean of 69.19 for the non-mathematics group. As the motivation response format was designed analogous to the self-efficacy response format it makes more sense to compare it with self-efficacy measure rather than measure of motivation. The key reason being that most teacher motivation measures do not ask respondents to report the strength of their motivation but rather the reasons for their motivation. Therefore, following the same logic of comparison previously discussed for the self-efficacy section of the MSETN, the motivation item means could also be interpreted as indicating that preservice teachers hold relatively high to very high levels of motivation to teach numeracy across all items.

While the levels of motivation and self-efficacy to teach numeracy across items, factors and scales are perhaps not cause for alarm, they prompt a level of concern and suggest a need for further investigation. Given the psychometric evidence of the MSETN, it could be used in future intervention and longitudinal research to determine how much preservice teacher levels change and can be changed over time or determine what levels of the MSETN are associated and to what degree with quality numeracy teaching practices or student numeracy outcomes.

Statistical Analyses of the Demographic Variables

Research on gender differences in self-efficacy and motivation to teach presents a varied picture. In mathematics education for example, where there has been some consistency in studies finding that males report higher levels of self-efficacy in doing mathematics compared to females, there is still debate as to whether this remains evident when applied to self-efficacy to teach.

Explanations surrounding gender differences have appealed to Bandura's conception of the four types of experiences that contribute to self-efficacy, namely; vicarious experiences, modelling, mastery experiences and emotional and physiological states. It is hypothesized then that the differences in gender can perhaps be attributed to either males or females having more or less exposure to each of these experiences. For example, Tschannen-Moran and Hoy (2007) argue that while there is no theoretical reason for differences in relation to gender of levels of self-efficacy, they admit there could be variation in the availability of vicarious models (Tschannen-Moran & Hoy, 2007). Thus, in mathematics teaching, it has been suggested that females have had consistently less exposure to female mathematics teachers as role models and therefore may report lower levels of self-efficacy to teach mathematics. In so far as self-efficacy in numeracy is associated with self-efficacy in mathematics, then it is also possible that females may report lower levels of self-efficacy to teach numeracy. A recent study however concluded that gender was not statistically significant in predicting mathematics personal teaching efficacy but there was a significant difference when measuring MTOE and in which case females reported higher levels than males (Twohill et al., 2022).

The investigation into the impact of being a domestic versus an international student on motivation and self-efficacy to teach numeracy revealed no statistically significant differences. This finding suggests that the demographic variable of student origin does not significantly influence pre-service teachers' self-reported levels of motivation and self-efficacy in teaching numeracy. Specifically, the Multivariate Analysis of Variance (MANOVA) conducted on both self-efficacy and motivation related to teaching numeracy indicated that the differences between domestic (n=420) and international students (n=54) were not statistically significant, with Pillai's trace values of $F(6, 467) = 1.430$, $p > .05$ for self-efficacy and $F(5, 468) = 1.286$, $p > .05$ for motivation, respectively. These outcomes highlight the complexity of factors influencing motivation and self-efficacy in numeracy education, suggesting that other personal, educational, or contextual factors may play a more pivotal role than merely the distinction between domestic and international student status.

The result indicating no significant relationship between playing a musical instrument and motivation or self-efficacy to teach numeracy contrasts with findings in broader educational research. For instance, Hallam (2005) suggests that musical training can enhance cognitive abilities, including mathematical skills, potentially influencing teaching efficacy indirectly. Meanwhile, Costa-Giomi (1999) found that children who received piano lessons over three years improved their spatial-temporal reasoning, a skill closely related to mathematics, more than those who did not receive lessons. These studies imply that while direct effects on motivation or self-efficacy to teach numeracy might not be observable, the cognitive benefits of musical training could indirectly support teaching skills in numeracy.

The finding that pre-service teachers' year level of their course revealed a statistically significant difference in motivation to teach numeracy suggests that as pre-service teachers advance in their education, their motivation levels might also change, either increasing due to greater exposure and experience or varying due to the challenges encountered. This result aligns with the broader literature on teacher education, which suggests that the progression through teacher education programs impacts various facets of teacher identity, including motivation. For example, Ronfeldt et al. (2018) argue that experiences within teacher preparation programs, including the year of study, significantly influence pre-service teachers' feelings of preparedness and motivation to teach. Similarly, Watt and Richardson (2007) found that individuals' motivations to enter the teaching profession and their subsequent commitment are influenced by their experiences during teacher education, which could imply that as pre-service teachers progress through their courses, their motivations and self-efficacy levels are shaped by these experiences. These studies suggest that the development of motivation to teach is complex and influenced by a multitude of factors throughout the teacher education process.

The finding that pre-service teachers' intended level of teaching (primary vs. secondary) revealed a statistically significant difference in self-efficacy levels underscores the nuanced ways in which educational aspirations shape teacher efficacy beliefs. This result resonates with the broader educational literature, highlighting how the context of teaching intentions can influence teacher self-efficacy and motivation. For instance, Ronfeldt et al. (2018) argue that the specificities of the teaching context, including the intended teaching level, significantly impact pre-service teachers' sense of preparedness and efficacy. This is further supported by Watt and Richardson (2007), who found that motivations for choosing teaching careers differ significantly between those intending to teach at primary versus secondary levels, with these motivations influencing their professional engagement and self-efficacy. Similarly, Klassen and

Chiu (2010) demonstrate that teacher self-efficacy beliefs vary across different stages of teacher education and are influenced by the targeted teaching level, suggesting that the nature of the educational context (primary vs. secondary) plays a critical role in shaping these beliefs

The investigation into the impact of initial teacher education (ITE) level (Bachelor vs. Masters) on pre-service teachers' skills and preparedness to teach numeracy and literacy reveals a complex landscape. O'Sullivan's (2022) study indicated a statistically significant difference in certain aspects of pre-service teachers' knowledge or skills based on the level of ITE, highlighting the nuanced ways these programs contribute to teacher preparedness. This finding aligns with broader discussions in the literature regarding the efficacy and impact of teacher education programs. These references, taken together, suggest a nuanced view of how ITE impacts teacher preparedness. While O'Sullivan (2022) provides direct evidence of a statistically significant difference based on ITE level in certain areas, the broader literature, including White and Cranitch (2010) and Muir (2007), indicates that the content and structure of ITE programs, including the integration of literacy and numeracy teaching, are crucial for developing effective teaching skills. These findings collectively underscore the importance of examining both the level of ITE and the specific components of these programs when considering their impact on teacher preparedness.

The study also identified a statistically significant difference in motivation and self-efficacy levels among pre-service teachers who enjoyed puzzles compared to those who did not, with the former group displaying higher levels of both constructs (Sellings et al., 2018). This suggests that an affinity for puzzles, which are inherently mathematical and problem-solving in nature, may serve as a proxy for a broader engagement with and enthusiasm for numeracy. This finding contributes to the discourse on the importance of integrating engaging, real-world applications of mathematics within ITE programs to bolster pre-service teachers' self-efficacy and motivation to teach numeracy.

A further statistically significant difference was found regarding pre-service teachers’ motivation and self-efficacy and their interest in programming. This finding aligns with current educational research, underscoring the importance of integrating technology and computational thinking into teacher preparation programs. The analysis revealed that pre-service teachers who enjoyed programming exhibited higher levels of motivation and self-efficacy in their numeracy teaching abilities compared to those who did not enjoy programming. The significance of programming skills in enhancing pre-service teachers' self-efficacy and motivation to teach numeracy echoes the broader discourse on STEM education. Research by Ball et al. (2008) emphasizes the importance of content knowledge in teaching effectiveness. They argue that a deep understanding of subject matter not only influences teachers' instructional strategies but also their self-efficacy and motivation to teach complex topics. In this context, programming can be seen as enhancing mathematical understanding and pedagogical content knowledge, contributing to a more robust foundation for teaching numeracy. Similarly, Mishra and Koehler (2006) introduced the Technological Pedagogical Content Knowledge (TPCK) framework, which highlights the intersection of technology, pedagogy, and content knowledge as crucial for effective teaching. This framework suggests that pre-service teachers' engagement with programming could enhance their TPCK, particularly in numeracy, by integrating technological skills with mathematical content knowledge and pedagogical strategies. The positive correlation between interest in programming and numeracy teaching motivation and self-efficacy could be indicative of the TPCK effect in action. Moreover, Grover and Pea (2013) discuss the cognitive benefits of learning to program, including problem-solving, logical reasoning, and abstraction, all of which are integral to numeracy. Their research suggests that programming experiences could directly contribute to the development of these cognitive skills, thereby enhancing pre-service teachers' numeracy teaching capabilities.

Lastly, a statistically significant difference was found regarding pre-service teachers' motivation and self-efficacy and their experience with tutoring mathematics. This observation aligns with broader educational research, which emphasizes the importance of practical teaching experience in developing teacher efficacy. The significant difference in self-efficacy and motivation among pre-service teachers who have tutored mathematics can be understood through the lens of experiential learning theory. Kolb et al. (2014) suggest that concrete experiences provide the basis for observation and reflection. These experiences are crucial for the formation of abstract concepts and generalizations, which are then actively tested in new situations, leading to new experiences. Tutoring mathematics allows pre-service teachers to engage in this experiential learning cycle, enhancing their understanding of mathematical concepts, pedagogical strategies, and ultimately, their self-efficacy in teaching numeracy. Furthermore, Bandura's (1997) theory of self-efficacy underscores the role of mastery experiences in enhancing an individual's self-efficacy in their abilities. Tutoring can be considered a form of mastery experience, providing pre-service teachers with opportunities to successfully navigate the challenges of teaching mathematics, thereby strengthening their belief in their capacity to teach numeracy effectively.

Ball et al. (2008) articulate that deep content knowledge in mathematics is essential for effective teaching, suggesting that pre-service teachers' experiences with mathematics during their schooling, such as studying mathematics in Year 12, could significantly influence their self-efficacy and motivation to teach numeracy. This is supported by the statistical significance observed in the current study, indicating a direct correlation between studying Year 12 mathematics and enhanced motivation and self-efficacy levels. Moreover, Hattie (2008) highlights the importance of teachers' content knowledge as a key factor influencing student achievement. Hattie's synthesis of meta-analyses suggests that teachers who possess strong content knowledge are more likely to implement effective teaching strategies, thereby positively impacting student learning outcomes. This implies that pre-service teachers' prior study of mathematics could contribute to their ability to effectively teach numeracy by providing a strong content knowledge base.

Limitations

The study has several limitations which assist in contextualizing its findings within the broader scope of initial teacher education (ITE) research and practice, particularly concerning the teaching of numeracy. It is important to acknowledge the constraints under which the study was conducted and to provide a foundation for future research directions. Firstly, the sample's composition presents a limitation. While the study engaged a substantial number of pre-service teachers across various educational levels and specialties, its geographic and institutional concentration within Victorian universities might limit the generalizability of the findings. Such limitations suggest caution when extrapolating these results to broader national or international contexts, acknowledging the diversity of ITE programs and pre-service teacher experiences across different regions. Secondly, the methodological approach, specifically the reliance on confirmatory factor analysis (CFA) for the validation of the Measure of Preservice Levels of Motivation and Self-efficacy to Teach Numeracy (MSETN), carries inherent limitations. Although CFA is robust for confirming hypothesized factor structures, it does not account for potential model mis-specifications or explore alternative models that might fit the data equally well or better. This limitation points to the need for further methodological triangulation, perhaps incorporating qualitative methods or mixed-methods approaches to provide deeper insights into pre-service teachers' motivation and self-efficacy in teaching numeracy (Brown, 2015). Thirdly, the study's focus on self-reported measures of motivation and self-efficacy introduces the possibility of response bias, where participants might overestimate their abilities or provide socially desirable responses. Such biases can affect the accuracy and reliability of the data collected, suggesting the integration of observational or performance-based measures in future research to triangulate self-reported data and provide a more comprehensive understanding of pre-service teachers' competencies in numeracy teaching (Podsakoff et al., 2003). Lastly, the study's cross-sectional nature, limits its ability to capture the developmental nature of motivation and self-efficacy in teaching numeracy. Longitudinal research designs would offer valuable insights into how these constructs evolve throughout the ITE journey and beyond, into early career teaching, providing a dynamic perspective on the development of teaching competencies (Schunk et al., 2008).

Chapter Summary

This study further refined and substantiated the factor structure and evaluated the reliability and validity of the initial measure. Through comprehensive analysis, evidence of a robust fit for the proposed factor structure model was supported by various goodness-of-fit indices. The reliability and validity findings reinforced the initial study's conclusions, affirming the measure's psychometric appropriateness for assessing preservice teachers' motivation and self-efficacy in teaching numeracy. This investigation analysed the measure at the item, factor, and scale levels, thoroughly examining how demographic variables might influence these metrics. The key rationale behind these detailed analyses was to fulfil the sub aims of the thesis, which included describing the current state of preservice teachers' motivation and self-efficacy in teaching numeracy and identifying the factors that could potentially shape their development. Undertaking this investigation not only deepened the understanding of preservice teachers' readiness to teach numeracy but also sought to shed light on ways to enhance ITE programs.

Chapter Six: Investigating Teacher Educator Perspectives on Preservice Levels of Motivation and Self-efficacy to Teach Numeracy

An investigation into teacher educators' perspectives on preservice teacher motivation and self-efficacy for numeracy teaching is crucial for understanding and enhancing Initial Teacher Education (ITE). This study aims to further understanding of the educational dynamics between PSTs and teacher educators by integrating their insights with the previous findings on preservice teachers’ levels of motivation and self-efficacy towards numeracy teaching. This approach is intended to provide a holistic view of factors influencing preservice teacher motivation and self-efficacy, thereby addressing critical research gaps in the field.

Teacher educators play a pivotal role in shaping the competencies and dispositions of preservice teachers. Their perspectives offer invaluable insights into the complexities of teaching numeracy, including the challenges and opportunities present in current ITE frameworks. By exploring these perspectives, the study seeks to uncover underlying factors that may influence preservice teachers' motivation and self-efficacy levels. This investigation is particularly pertinent given the increasing recognition of numeracy as a foundational skill across educational curricula, essential for student success in diverse academic and life contexts.

The study's methodology involves qualitative interviews with teacher educators, aiming to capture their experiences, beliefs, and observations regarding the numeracy teaching preparedness of preservice teachers. These interviews are analyzed through thematic analysis, allowing for the identification of recurring themes and patterns. The analysis focuses on teacher educators' perceptions of the adequacy of current ITE programs in fostering numeracy teaching skills, the impact of preservice teachers' past mathematical experiences on their teaching motivation and self-efficacy, and the strategies employed by ITE programs to enhance these attributes.

This research contributes to the broader educational discourse by offering a nuanced understanding of how teacher educators view the integration of numeracy teaching within ITE programs. It examines the alignment between teacher educators' expectations and preservice teachers' self-perceived readiness to teach numeracy, exploring the potential discrepancies and areas for improvement. Additionally, the study considers the role of teacher educators in modelling effective numeracy teaching practices and their influence on preservice teachers' professional identity development.

The findings from this study are expected to inform the design and implementation of ITE programs, suggesting ways to better support preservice teachers in developing the motivation and self-efficacy to teach numeracy effectively. By addressing the gaps identified through teacher educators' perspectives, ITE programs can be optimized to meet the evolving demands of educational settings, ensuring that future teachers are well-equipped to foster numeracy skills among their students.

Method

Participants

Following approval from the Victoria University Human Research Ethics Committee (VUHREC), the research commenced with an initial outreach to Deans of Education Faculties across Victorian Universities. This step aimed to secure permission for engaging with potential teacher educator participants. From eight contacted institutions, responses from four provided potential candidates. Using the Deans' recommendations, additional background research through university directories and academic databases like Google Scholar facilitated a purposive selection process. This process was guided by criteria designed to ensure a diversity of views within the sample, considering factors such as gender, age, academic background (mathematical vs. non-mathematical), and teaching specialization (primary vs. secondary education). The selected candidates received invitations to participate, detailing the study's objectives and the nature of their involvement. These communications emphasized the voluntary aspect of participation, outlining the process for conducting interviews via Zoom at times that accommodated the participants' schedules. Of the twelve educators approached, nine consented to participate. Each interview, lasting between 30 to 45 minutes, commenced with a verbal consent protocol, ensuring participants were informed and consented to the recording of their contributions. This underscored the importance of participant autonomy and consent within research practices. The sample composition is detailed in Table 35.

Table 35

Sample Composition of Teacher Educators

Participant	Age	Gender	ITE exp.	Employment	Maths Background	Taught ITE Numeracy	Level
1	39	F	4	Ongoing	No	No	Secondary
2	40	F	4	Contract	Yes	Yes	Primary
3	41	M	6	Ongoing	No	No	Secondary
4	54	M	13	Ongoing	Yes	Yes	Secondary
5	40	M	6	Ongoing	No	Yes	Primary
6	74	F	30	Ongoing	Yes	Yes	Primary
7	60+	F	7	Ongoing	Yes	Yes	Secondary
8	53	F	21	Ongoing	No	Yes	Secondary
9	36	F	8	Contract	No	No	Primary

Note: Maths background does not include science, ITE numeracy means explicit numeracy teaching, Level is self-identified.

Procedure

Data collection was conducted via semi-structured interviews, incorporating a preliminary set of eight background inquiries to ascertain participants' demographic and professional profiles, including age, gender, years of teaching in Initial Teacher Education (ITE), academic and mathematical background, alongside their experience in numeracy teaching. The interview segment comprised ten questions, organized around three thematic categories: concepts of numeracy, pedagogical approaches to numeracy, and developing pre-service teachers' numeracy teaching. These themes were further divided into questions about definitions, and participants' motivation or self-efficacy levels across these categories. To ensure engagement and depth of response, questions were designed to be open-ended and were iteratively refined to minimise repetition, fostering a coherent narrative flow. This refinement process involved consultation with experienced ITE professionals to assess question relevance and phrasing, leading to the elimination of irrelevant questions and minor adjustments for clarity. The finalized questionnaire is documented in Appendix A.

The semi-structured interview methodology was operationalized through predetermined questions delivered consistently across sessions, while allowing for adaptive follow-up inquiries tailored to each participant's responses. This approach facilitated a dynamic exchange, encouraging elaboration through prompts such as "go on" and requests for clarification ("could you tell me more about..."; "so are you saying that..."). Participants had the latitude to explore topics beyond the initial questions. Subsequent to recording, the audio was professionally transcribed, omitting non-verbal cues and filler words. Transcripts underwent anonymization to exclude identifiable details, assigning pseudonyms to maintain confidentiality.

Data analysis

Thematic analysis was chosen as the method for analysing the interview data. Thematic analysis can be regarded as a family of methods that seek to identify, describe and report on patterns (themes) found within a set of qualitative data (Braun & Clarke, 2020). Although the most common basis for thematic analysis in the fields of psychology and education, Braun and Clarke's 2006 article has undergone subsequent clarifications by its authors (Braun & Clarke, 2019; Braun & Clarke, 2020). Initially described as a theoretically independent or flexible method, Braun and Clarke (2019) now describe their method as reflexive thematic analysis firmly situated within a big Q qualitative research framework. This has helped to clarify their method from others in the family of thematic analysis such as what Braun and Clarke (2020) refer to as coding reliability and codebook approaches. Specifically, while coding reliability approaches "themes are typically understood as topic summaries" (Braun & Clarke, 2020, p. 39), reflexive thematic analysis conceptualises themes as "patterns of shared meaning underpinned by a central organising concept" (Braun & Clark, 2020, p. 39). Furthermore, while codebook approaches typically adopt "the more structured approach", reflexive thematic analysis is, "unstructured and organic" (Braun & Clarke, 2020, p. 39). While Braun and Clarke's (2020) updated explanation of their reflexive thematic analysis has resulted in clarifying the details of their approach and its similarities and differences with other approaches, it has also perhaps led to a further array of methodological options. Reflexive thematic analysis has been employed inductively, both inductively and deductively, abductively, semantically, latently and each with various epistemological and ontological qualifications (Byrne, 2021). Despite these qualifications, each member of the family of thematic analyses still involves the same general steps of familiarisation, coding, theme generation, and reporting. Of these steps, the two most contentious are that of coding and thematization. The position taken here is that coding serves more as an auxiliary tool than a prerequisite for theme generation, with themes being assessed for their empirical support and interpretability (Lochmiller, 2021). This perspective aligns with thematic analysis methodologies, particularly the reflexive thematic analysis as detailed by Braun and Clarke (2019), emphasizing the critical role of data-driven and interpretable theme development within qualitative research frameworks.

Furthermore, this conception of codes and themes is consistent with the approach undertaken in the first two quantitative studies when implementing exploratory and confirmatory factor analysis. For example, analogous to the process of coding as an aid is how rotation choices are an aid for the discovery of a factor solution but are not a requirement or necessity for that solution (Gorsuch, 2014). Likewise, analogous to the generation of themes is how factor solutions are generated from and supported by the data and interpretability not the choice of aid.

To summarise, a key methodological aim in this thesis is to present evidence of patterns of commonality and variation within the data in interpretable statements whether as quantitative factor analytic solutions or qualitative thematic statements. To best facilitate the comparison of the preservice teacher perspective and the teacher educator one, a structure for each will be beneficial. Thematic analysis results in such a structure and hence was chosen as the method of analysis in this present qualitative study. The specifics have been chosen on the basis of consistency with the previous studies. Given the methodological alignment with Braun and Clarke's approach more than other thematic analysis methods, the specific steps undertaken in this study are therefore described using their terminological framework. This approach also aims to explain the adaptations made to their process.

One: Familiarisation with the data. The process of data familiarization involved thorough examination and re-examination of the interview dataset, incorporating multiple readings of transcripts alongside revisiting video and audio recordings. This comprehensive engagement was instrumental in deepening the understanding of the data, allowing for a detailed perception of the verbal, aural, and textual dimensions present. Such a detailed approach was critical in identifying subtle nuances and contextual details that might have been overlooked if analysis were confined solely to written transcripts. During this initial phase, particular attention was given to annotating quotations that emerged as significant to the aims of the research. This familiarization stage not only served to increase the researcher's knowledge of the dataset but also facilitated a preliminary identification of thematic elements relevant to the study's aims, laying the groundwork for more focused and nuanced analysis.

Two & Three: Generating initial codes/Searching for themes. Given the manageable scope and scale of the dataset, characterized by a relatively small sample size and concise interview duration, the decision was made to forgo the utilization of a predefined coding framework or codebook. This choice was further influenced by the singular nature of the analysis, conducted by an individual researcher rather than a collaborative team. The analytical process commenced with a systematic comparison of responses to individual questions across the dataset, followed by a contextual examination of adjacent questions to identify coherent clusters. This reiterative analysis across grouped questions facilitated the preliminary categorization of text segments, aligning with initial thematic identification while also resembling traditional coding practices (Lochmiller, 2021). For example, responses were able to be grouped according to a focus on numeracy, numeracy teaching, and the development of numeracy teaching. These groups were then inspected to identify possible sub-themes which could account for the majority of the interview response data. Given the first grouping of response data on numeracy, for instance, an emphasis on describing numeracy as ‘everyday’ was identified. After identifying and collating these emphases, more descriptive titles were then developed to capture each theme. For example, the first theme was later titled “Numeracy as an everyday skill required by pre-service teachers”. This phase embodies the fluidity between coding and theme generation, a distinction that often becomes nebulous, as articulated by Braun and Clarke (2012), who acknowledge the potential evolution of codes into themes. The coding process, characterized by iterative and recursive exploration of data, aimed at discerning a thematic structure that resonates with the dataset. Upon achieving a thematic framework that accurately encapsulates the data, the detailed history of coding iterations and modifications ceases to be directly relevant to the subsequent stages of theme review, evaluation, and description.

Four: Reviewing themes. The evaluation stage of thematic analysis focuses on ensuring thematic coherence, optimal data encapsulation by themes, and alignment with research questions. This involves assessing whether themes distribute data equitably, if each data segment is best represented by a single theme, and if themes offer meaningful insights relative to the research objectives. Following Braun and Clarke's (2006) methodology, this involves two levels of thematic scrutiny—internal consistency within themes and distinctiveness across themes—mirroring Patton's (1990) criteria of internal homogeneity and external heterogeneity. This dual-level review parallels quantitative approaches such as factor analysis in Study One, aiming for a “simple structure” where items significantly load on one factor but not on others, reflecting thematic integrity and delineation (Gorsuch, 2014, p. 187). This process ensures that themes are both analytically distinct and relevant, facilitating a rigorous examination of the data in light of the study's guiding questions.

Five: Define themes. The objective of this analytical phase is to synthesize a cohesive thematic framework that is substantiated by the empirical data and addresses the research objectives effectively. This phase involved a meticulous process of selecting and aligning data excerpts that most accurately represent, elucidate, and convey the essence of each identified theme. The iterative nature of this process necessitated multiple rounds of refinement, during which potential thematic titles and definitions were proposed, deliberated upon, and refined in consultation with academic supervisors. This collaborative review ensured the thematic framework's conceptual integrity, relevance to the research questions, and robustness in capturing the complexities of the data.

Six: Write up. In the final phase of analysis, the thematic structure was meticulously organized, and a decision was made to segregate the presentation of findings into distinct results and discussion sections. This approach adheres to the conventional structure prevalent in research articles and doctoral dissertations, diverging from Braun and Clarke’s (2020) suggestion for a unified section. Nonetheless, their methodology does not preclude such traditional formatting. Consequently, the results section is crafted to methodically delineate the themes with descriptive clarity, laying the groundwork for a subsequent discussion section. Here, a deeper interpretive analysis is conducted, integrating comparative evaluations with extant literature, thereby enriching the thematic insights with broader academic discourse. This bifurcated structure facilitates a clear exposition of the findings while allowing for an expansive discussion that contextualizes the themes within the wider scholarly landscape.

Results

Through the analysis of interview data, seven distinct themes emerged.

Theme 1: Numeracy as an everyday skill required by pre-service teachers.

All participants described numeracy as a broad, contextual skill that has an applied use, such as when cooking or budgeting. For example, representative phrases included: “we’re in the kitchen and we’re cooking a cake…or doing a budget” (Participant 2), “a kind of basic functional type of number type thing” (Participant 4), “there are basic numeracy skills that you need for every day” (Participant 7), “just absolutely anything that’s I guess to do with not just numbers but location mapping etc.” (Participant 8), “it’s an everyday practice” (Participant 9), and “it’s budgeting every day or it’s news type maths” (Participant 3). This was evident across all participants.

Participants also reported that a level of personal numeracy was required by all pre-service teachers but expressed it differently. For example, one participant referred to mathematical content knowledge: “So I guess in order to be able to teach well, they actually have to have really good [mathematical] content knowledge. So, I guess it’s not just…We see our role as educators here as developing their content knowledge.” (Participant 6). Another participant referred to numeracy competence more generally: “I mean objectively do I think that teachers should be in the top 30% of maths? Do I want my kid to be taught by someone who can add up? Yes. Sure.” (Participant 3). Though expressed differently, all participants communicated a required level of personal numeracy for pre-service teachers.

The level of personal numeracy required of pre-service teachers varied for groups of participants. Teacher educators with a mathematics background (n = 6) were more likely than those without to emphasise its necessity as well as its connection to mathematical knowledge or experience. For example, Participant 7 highlighted the following: “I think it [teaching numeracy] does need to be taught by an experienced teacher of Maths, someone perhaps who has taught Maths from primary through to Year 12 just so they know what the problems are that students face" (Participant 7). Alternatively, teacher educators without a mathematics background (n = 3) expressed a caution regarding the level of numeracy required for teaching different subjects as follows: "I think it's hard for pre-service teachers to see the importance of being numerate to a high level when they're teaching certain subjects" (Participant 8). Participant 3 reiterated the same sentiment:

> If I can use the English teacher, me, as an example, [I] completely agree that maths is in everything or numeracy is in everything, and therefore by extension every teacher is a teacher of numeracy, but not 100% confident about everyone being an expert numeracy teacher. (Participant 3)

This difference in emphasis (i.e. level of numeracy required and its connection to mathematics) illustrates how each group interpreted the mathematical component of the concept of numeracy differently. Teacher educators with a mathematics background were more likely to comment that experience and proficiency in mathematics was key. Teacher educators without a mathematics background also recognised a level of competence, but they cautioned against setting the level too high by appealing to subjects where numeracy may be less relevant or important than others. However, all participant groups identified that numeracy was a cross curricular skill, a level of which is required by teachers, even if that level varies for those of different subject backgrounds such as mathematics versus non-mathematics.

Theme 2: Mathematical education experience and (is a primary determinant of) pre-service teacher motivation or self-efficacy to be numerate.

All participants cited past experiences as a key determinant of pre-service teachers' motivation and self-efficacy to be numerate. For example, Participant 6 commented that, “Yes, I have a feeling a lot of the motivation comes from previous experiences” (Participant 6). Likewise, Participant 5 said “past success obviously. So, in my experience, if they have experienced success in the past, they’re more likely to be confident in the future” (Participant 5). These responses were consistent across participants.

All teacher educators noted the salience of past experiences of mathematics education in particular, as having a determinative impact on pre-service teachers’ motivation and self-efficacy to be numerate. Specifically, one participant commented that “quite often, they’ll say oh I never was any good at Maths so I can’t do it” (Participant 6). Additionally, Participant 5 expressed that for some pre-service teachers, “maths and science were the subjects they generally did well, so they’re motivated to continue that” (Participant 5). Furthermore, Participant 3 added, “For me, I lay 100% [of] the blame at having some really crappy [maths] teachers along the way” (Participant 3). Past mathematics education experience was identified as a significant influence on pre-service teachers.

Interview data highlighted several other factors mediating pre-service teachers’ motivation or self-efficacy to be numerate. First, several teacher educators (n = 3) reported that the specialisation in which pre-service teachers were planning to teach were important factors. All participants acknowledged that being numerate was important for all learning areas but planning to become a mathematics teacher made it more likely that pre-service teachers would find it easier to be motivated or self-efficacious in numeracy. Participant 4 pointed out, “Well, there’s the obvious one, some are maths teachers, so want to be and are motivated to impart what they know about their discipline” (Participant 4). Whereas in the case of arts-based learning areas, participants reported (how many) pre-service teachers may find it more difficult to be self-efficacious or motivated:

> I think when they can see it when it relates to their specialisations obviously. …I think a lot of pre-service teachers don't see the importance of it. Or don't I don't think it's that they don't see the importance of it, I don't think that they it's clear to them how they will be integrating it into their teaching and learning. (Participant 8)

Finally, personal attributes of the preservice teachers, such as their desire to gain employment or attain high marks during their course, also influenced pre-service teachers' numeracy motivation or self-efficacy to be numerate. One teacher educator commented that "for them, it's more, I suppose, now being proficient in it simply so that they pass tests like LANTITE and be able to get a job eventually" (Participant 4). Additionally, participant 5 highlighted the influence of grades, stating, "There are some students who just want to get good marks, so marks are the extrinsic motivator. They don't care what subject it is". Overall, factors such as what pre-service teachers were planning to teach, their desire to gain employment, or good grades were somewhat influential, however, interview data reinforced that past experience, particularly of mathematics education, was the predominant reason given for pre-service teacher motivation and self-efficacy to be numerate.

Theme 3: Numeracy teaching as independent of personal numeracy.

Eight of the participants described numeracy teaching independently of pre-service teachers' personal numeracy. Participant 1 was the only teacher educator who connected numeracy teaching to pre-service teachers' own level of numeracy:

> I suppose they do need to have they basic skills don't they? Because then they need to be able to reinforce those skills in their curriculum and they need to be

> able to know how to provide examples in their curriculum and in the context of their specialisation. (Participant 1)

The other participants (n = 8) described numeracy teaching in terms either implicitly or explicitly without connection to pre-service teachers' own numeracy. For example, Participant 4 was explicit about disconnecting a pre-service teachers' skill (in this case literacy) from their ability to teach stating that: "a colleague of mine who was a really smart physics person, really good… couldn't spell for anything… but that didn't make him less of a teacher…he probably wouldn't pass LANTITE today…so that's the irony of that isn't it?" (Participant 4). Furthermore, Participant 3 articulated that even teachers with minimal motivation and self-efficacy in being numerate, should at least not hinder the promotion of numeracy to their students:

> There's a real danger to me say being in an English classroom ….and slagging off maths as a subject, because if there's kids in there that like me or like my subjects, then they also buy…[that] maths doesn't really matter, it doesn't really count…if you're not going to help, at least don't be a block. (Participant 3)

In contrast, Participants 2 and 6 were more implicit in their dissociation of personal numeracy from numeracy teaching by referring to the affective aspects of numeracy teaching seen as more important. Participant 2 stated that teaching numeracy requires pre-service teachers "to be creative and imaginative" (Participant 2). Participant 6 focused on pre-service teachers' attitude, highlighting that "I think it's really important they have a positive attitude [towards numeracy teaching]". While Participant 5 referred to the pedagogical approaches of numeracy teaching rather than the necessity of being numerate: "So maybe you can start off with the explicit [teaching] and then go into more constructivism" (Participant 5). Overall, there was a strong tendency by the teacher educators (n = 8) to describe the task of numeracy teaching as either implicitly or explicitly independent of pre-service teachers' personal level of numeracy.

Theme 4: Time, placement, and individual beliefs are key difficulties facing motivation or self-efficacy to teach numeracy.

All participants described the development of motivation or self-efficacy to teach numeracy as facing significant difficulty, expressing it as one of three categories of time, placement, and individual beliefs. The majority of teacher educators (n = 5) referred to the issue of time when it came to pre-service teachers developing their motivation and self-efficacy to teach numeracy. This reference to time was either expressed as the time it takes for pre-service teachers to realise some aspect, such as participant 3's views. "but I think it takes a long time for students to realise that actually their content knowledge isn't what's keeping them afloat in the room" (Participant 3). More commonly, time was expressed as being too limited to make an impact on pre-service teachers' motivation and self-efficacy to teach numeracy. Participant 9 stated that "I think time….there's very little time for hands on practising learning of numeracy skills even teacher modelling" (Participant 9). "there's not enough time for pre-service teachers to get that space to play and to explore stuff without the pressure of yes but I've got an assignment due I don't' have time to think about this" (Participant 9). Additionally, Participant 6 commented as follows; "I have 72 hours in order to teach them everything that they need to know and it's an impossible task" (Participant 6). Time was identified as a significant factor affecting the development of pre-service teachers' motivation or self-efficacy to teach numeracy.

Second to the issue of time was the quality and nature of placement experiences to which pre-service teachers were exposed. Placement was described as a chance to experience success as well as an opportunity to witness successful teaching by mentors.

Participant 1 expressed that “well placement would be. So, if they’re gaining placement experience with a mentor who has the capacity to demonstrate that then I think they’re really understand the importance of it” (Participant 1).Similarly, Participant 6 highlighted that “if they go and try something and if it works and the kids learn something and there’s obviously some growth in the kids understanding they will try it, they will persevere” (Participant 6). Participant 6 also noted that such experiences are not guarantees: “unfortunately it doesn’t take very much for them to revert back to the ‘I’ll just focus on the rules’ because I know that works” (Participant 6).

Finally, some participants (n = 2) expressed that the motivation and self-efficacy of pre-service teachers to teach numeracy was dependent on the strength of personal beliefs or passion for teaching numeracy. For example, Participant 9 referred to a passion for teaching: “he’s really passionate about teaching numeracy…but he’s quite an anomaly because he’s really passionate” (Participant 9). While Participant 4 expressed a need for a basic belief, without which, it would be difficult to motivate a pre-service teacher to teach numeracy: “I think it’s the belief that kids need to know some basic numeracy. So it’s that basic belief that you shouldn’t be leaving primary school or high school without some level of basic numeracy and it’s my job to teach you that” (Participant 4).

When discussing the development of motivation and self-efficacy to teach numeracy, teacher educators highlighted three categories of difficulty - time, placement, and individual beliefs - faced by pre-service teachers.

Theme 5: Pre-service teachers’ motivation or self-efficacy to teach numeracy is relatively low.

All participants described the levels of pre-service teacher motivation and self-efficacy to teach numeracy as relatively low. Five participants gave a value out of 100 for either pre-service teachers' levels of motivation or self-efficacy with a mean value of 57. Non-numerical responses used descriptions such as low level or poor. For example, Participant 5 stated that "based on my experience in levels, it's poor to very poor" (Participant 5). Participant 1 responded with "probably they would be low" (Participant 1). No participants described pre-service teacher levels of motivation or self-efficacy to teach numeracy as high either numerically or non-numerically.

When describing the relatively low levels of pre-service teachers, the majority of participants (n = 7) did not explicitly distinguish levels of motivation from levels of self-efficacy. Instead, participants responded more generally, for example, by simply referring to "your average student" (Participant 3). Only one participant specifically made reference to motivation and self-efficacy separately, commenting that "the less confidence you have the less motivation you have and I would just say … confidence leads to motivation" (Participant 9). Furthermore, many participants began to describe pre-service teacher levels of motivation and self-efficacy in other terms, such as a sense of fear. Participant 3 commented that "I think they would be terrified if they're not maths trained in how to do it". Likewise, Participant 9 claimed:

> This is obviously a very loose statistic, but if I had to put a percentage on it I would say something like 80% of students don't want to, don't feel competent and have a sense of general fear or uncertainty. (Participant 9)

Participant 1 also highlighted that "teachers who weren't maths trained were freaking out". These references to fear or uncertainty were used instead of the terms motivation or self-efficacy when discussing pre-service teachers teaching numeracy.

Finally, two participants expressed pre-service teachers' levels as improving throughout their course. "hopefully by the time they leave we have got it up and we may have it around 75%" stated Participant 6. Likewise, although Participant 2 "was shocked in the beginning", they also indicated an improvement throughout the course "So, at the start, perhaps five out of ten. And now, they're good" (Participant 2). Despite these indications of improvement, overall, participants described pre-service teachers' levels of motivation and self-efficacy as relatively low.

Theme 6: Teacher educators develop thinking and provide expertise

Four of the participants described their role in assisting pre-service teachers' ability to teach numeracy as developing thinking. Participant 3 expressed that "we're in the world of creating mind-sets and ways of thinking about how schools work, how kids can work, how to approach a problem or how to think about a problem". Likewise, Participant 8 saw their role as getting pre-service teachers to think and reflect on their teaching: "and it was using a critical lens to look at the teaching of maths and to think about students in your class, their socioeconomic background. What kinds of examples are you using when you're talking about …budgeting?". Finally, Participant 4 best emphasised the need for thinking and the centrality of developing this thinking as teacher educators:

> to really think deeply about that and to think deeply about the people that they're engaging with, the students they should always be thinking about the nature of the work that they're doing…keep asking themselves questions and being reflective about their teaching…that's what I should be doing with pre-service teachers, If I can do that, then I think I'm doing my job. (Participant 4)

The second key aspect of teacher educators' work was expressed as a need for expertise, especially mathematical expertise. Though not seeing themselves as an expert, Participant 9 was emphatic stating that it is "100% they need academics who are experienced maths educators, numeracy educators. They need academics who have worked in the field of numeracy maybe even done research". While a more experienced teacher educator with a background in mathematics evaluated their role as “trying to model good practice” (Participant 6). Likewise, Participant 1 understood their role as “to show them how it [numeracy] can be woven into teaching the usual curriculum and not as a sidestep type thing”. Though not all teacher educators saw themselves as experts in numeracy teaching, both non-mathematics background and mathematics background teacher educators expressed a need for experts.

One participant in particular pointed out that numeracy teaching at the tertiary level should be taught analogously to numeracy at the primary and secondary levels. That is, by being embedded across initial teacher education units. Participant specifically stated that: “I think it [the teaching of numeracy teaching] needs to be embedded like literacy and numeracy, like they’re doing with indigenous viewpoints” (Participant 7). Although thinking and expertise were identified as key, only this one participant mentioned this analogy.

Theme 7: Teacher educators have high levels of motivation or self-efficacy

Teacher educators with a mathematics background (n = 6) or those who taught into ITE units with an explicit mathematical focus (n = 6) expressed high levels of self-efficacy and motivation. Some of these participants gave numerical answers between 90 and 100% - “I’ve always been very motivated so if I had to give myself a number, I’d give myself 100%” (Participant 4) and “I’ll never be 100% confident but I guess I hope I’m 90% confident, otherwise I need to give up the job” (Participant 6) or “I would be highly motivated…say 100%” (Participant 1). Others used phrases such as “Yes absolutely” (Participant 7) and “I’m quite confident” (Participant 2). Regarding their own level of motivation and self-efficacy to develop pre-service teachers teaching numeracy, this group of participants were consistently high.

Teacher educators without a mathematics background (n = 3) reported lower self-rating levels of self-efficacy or motivation in assisting pre-service teachers to teach numeracy. Numerically, answers ranged from “two out of ten” (Participant 3) to “probably 40%” (Participant 8), although Participant 8 noted that such “a percentage would reflect literally how many PE/Health people are in the class, science or maths teachers and how may are teaching arts subjects” (Participant 8). Importantly, Participant 3 stated that “if you’re asking how good I am at making someone ready to go and take a maths class, I would give myself a two out of ten, if it’s about an approach to teaching then yes, all good” (Participant 3). This pattern of responses reflected that these lower levels of motivation or self-efficacy were only relevant to teaching pre-service teachers to teach numeracy.

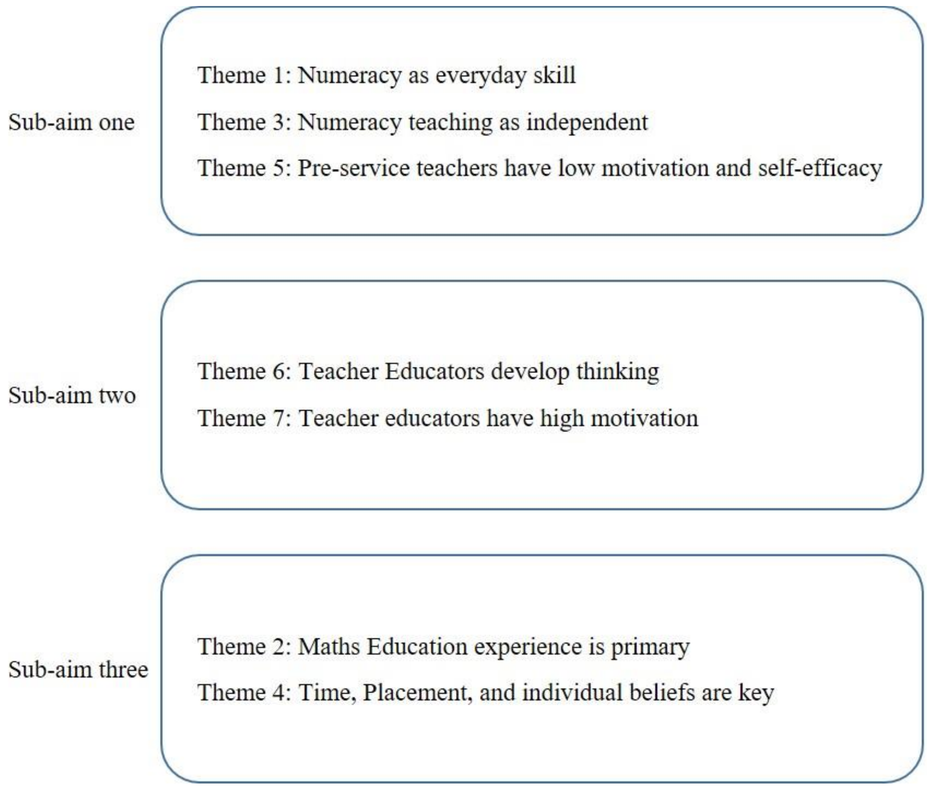
In fact, not all teacher educators acknowledged their role as developing pre-service teachers’ motivation, self-efficacy, or competence to teach numeracy. Representative of this attitude was Participant 9’s comment, who highlighted only the incidental nature of numeracy teaching to the units they taught in - “I would say I would link to why it’s important….and maybe noting here are opportunities as they come up…my teaching of it is very incidental with everything that comes into the units” (Participant 9). (Likewise), Participant 8’s comment that “I suppose there’s an argument to say that it should be embedded in my unit” (Participant 8), also revealed an incidental nature of numeracy teaching to what these participants considered as being involved in their work as teacher educators.

Discussion

The primary aim of this study was to use interview data with teacher educators to develop an additional perspective on understanding preservice teachers’ motivation and self-efficacy to teach numeracy. This perspective will then be combined with that resulting from studies one and two. Specifically, it addressed the three overall research aim by generating themes from teacher educators’ thoughts on the levels of preservice teacher motivation and self-efficacy to teach numeracy (SA1), their role in developing such preservice teachers (SA2), and the factors influencing such development (SA3). Secondary aims included interviewing teacher educators from a range of specialties, experience, mathematics and non-mathematics backgrounds, using a clear and justified thematic method as a contribution to the lack of research in this area.

Figure 7

Diagram of Themes and Sub-aims



The analysis of the interview data yielded seven themes, which are systematically categorized and examined in relation to the three overarching sub-aims of the research. For the first sub-aim, the discussion initiates with an examination of teacher educators' perspectives on preservice teachers' motivation and self-efficacy levels in teaching numeracy, highlighting a perceived deficiency despite an understanding of numeracy as practical and applicable in everyday contexts. It further addresses the notion that the capacity to teach numeracy is seen as somewhat detached from personal numeracy skills. The second sub-aim shifts focus to the teacher educators themselves, emphasizing their strong motivation and self-efficacy, particularly in fostering preservice teachers' critical thinking, rather than directly enhancing their numeracy or numeracy teaching skills. The final sub-aim delves into the factors influencing preservice teachers' numeracy competency, identifying mathematical education background as pivotal, while also noting challenges such as time constraints, placement experiences, and individual variances as significant barriers to developing the motivation or self-efficacy necessary for teaching numeracy effectively.

Research Sub-aim 1 - Themes 1,3,5

Sub-aim one seeks to develop an understanding of the current levels of preservice teacher motivation and self-efficacy to teach numeracy through a teacher educator perspective. Answering this question requires first discussing how numeracy and numeracy teaching are viewed from this perspective before commenting on preservice teacher motivation and self-efficacy to teach numeracy.

Theme 1 suggests teacher educators' perception of numeracy as inherently interdisciplinary, spanning various academic disciplines and everyday life applications. This perception underscores a widely acknowledged conceptualization of numeracy, resonating with prevalent definitions in the literature (Goos et al., 2019). This theme suggests that numeracy transcends traditional mathematical boundaries, highlighting its importance in a broad array of contexts, from professional settings to daily problem-solving tasks. Such a perspective reinforces the argument for a comprehensive approach to numeracy education, advocating for its integration across the curriculum to better prepare preservice teachers for the diverse demands of teaching numeracy.

While no previous studies were identified regarding teacher educators' thoughts on preservice teacher numeracy a number of studies have investigated teacher educators' views of preservice teachers' data literacy. Cowie and Cooper (2016) noted how the concept intersects strongly with mathematical literacy. They found that teacher educators "did not consider initially that their course included any aspects of mathematical thinking but on reflection most identified aspects such as identification of patterns, organisation of data into tables and graphs, and the use of simple statistics" (Cowie & Cooper, 2016, p. 154). Although focused on data literacy, this adds support to the conclusion that teacher educators hold a conception that numeracy is ubiquitous across disciplines.

The results of this study also indicate that numeracy is perceived of as not just ubiquitous but required by teachers. This may simply reflect that teacher educators are cognisant of the APST standard 2.5 that all teachers are required to teach numeracy and therefore be numerate to some level (AITSL, 2022). Barenthien & Dunekacke (2021) also found that "Teacher educators' reported aims reveal an overlap with the aims named in the ITE curricula" (Barenthien & Dunekacke, 2021, Conclusion section, para 1). However, it could also support a conviction or genuine belief that teachers of all disciplines encounter numeracy situations and therefore require being numerate to some level. Supportive of this latter point is the study by Obery et al., who found that "data was described as being 'key' to every interviewed teacher educator" (Obery et al., 2020, Interview Results section, para 2). They also found that "teacher educators place data and data driver decision making as a central portion of their pedagogy" (Obery et al., 2020, Discussion section, para 4). Their conclusion specifically relates to the necessity of teachers being able to meet the data literacy demands of the teaching profession. The participants in this study reported that a level of numeracy was required not just professionally but also educationally. Professionally, teachers face tasks that are already embedded with numeracy just as with data literacy. Educationally, teachers are not just required to be numerate enough to cope with these professional demands, but also because of the belief that one needs to be competent in something to teach it. To what extent these beliefs are true would require further investigation. It seems clear however, that teacher educators agree preservice teachers in all specialisations require a level of numeracy to be teachers.

Despite seeing numeracy as required of all teachers, Theme 3 indicates that the ability to teach numeracy is viewed as distinct from a preservice teacher's own numeracy skills, suggesting two primary interpretations. Firstly, proficiency in numeracy may be so fundamental that it's assumed to be a foundational requirement, not warranting further discussion. Alternatively, the capacity for teaching numeracy might depend less on personal numeracy competencies and more on other critical pedagogical skills. This theme aligns with teacher educators' perspectives, emphasizing that effective numeracy education encompasses a broader spectrum of abilities beyond the teacher's quantitative skills, highlighting the complex nature of teaching numeracy.

Though teacher educators distanced numeracy teaching from personal numeracy, preservice teachers’ were nevertheless regarded as having low levels of motivation or self-efficacy to teach numeracy (theme 5). Hoogland found teacher educators expressed that a positive attitude was not always present (Hoogland et al., 2016). Other studies too have found low levels of motivation or self-efficacy or other affective terms among preservice teachers regarding their teaching. Barenthien & Dunekacke (2021) focusing on primary school science preservice teachers concluded that “Teacher educators reported that they struggled most with PSPTs’ fears and low self-efficacy beliefs regarding science and science instruction” (Barenthien &

Dunekacke, 2021, Discussion Section, para 7). Interestingly, despite being deemed insufficient to teaching, these low levels of motivation or self-efficacy to teach numeracy still seem to stem from low levels of personal numeracy. There is some evidence of low levels of academic numeracy across university courses including ITE programmes (Woolcott et al., 2021). As well as teacher educators making assumptions about students' mathematical understanding Cowie and Cooper when interviewing preservice teachers concluded that "While most students could see the value of mathematics, a significant number reported they lacked confidence and motivation and did not enjoy mathematics" (Cowie & Cooper, 2016, p.10). The pieces seem to be that a) preservice teachers have anxiety about certain topics such as numeracy, b) this anxiety or lack of self-efficacy affects their self-efficacy or motivation to teach those subjects including numeracy, but c) teacher educators regard the teaching of subjects including numeracy as involving other far more important aspects and less about being competent in that subject or being numerate. There may therefore be a disconnect between preservice teachers' understanding of what it is involved in teaching and what teacher educators see. The question of personal numeracy seems much more relevant, influential, and perhaps impeding to the task of numeracy teaching from the preservice teachers' perspective than from the teacher educators'.

Research Sub-aim 2 - Themes 6, 7

Sub-aim two concerns the dimensions of numeracy teaching that teacher educators perceive in developing motivation and self-efficacy among preservice teachers teaching numeracy. This exploration reveals that teacher educators perceive themselves as both highly motivated and self-efficacious in their instructional roles. However, it also underscores a nuanced understanding that their primary responsibilities extend beyond merely enhancing preservice teachers' numeracy skills or their self-efficacy and motivation to teach numeracy. This suggests a broader pedagogical focus, where the emphasis is placed on developing comprehensive teaching competencies that encompass a wide range of educational strategies and approaches.

The teacher educator perspective involves high levels of motivation and self-efficacy in fulfilling their role although there were some differences regarding what their role was when it came to developing numeracy teachers. Some highlighted how it was incidental to their teaching or that it was not explicitly their job, and perhaps even that it should be embedded across the course. Previous literature highlights similar findings. In interviewing maths and statistics lecturers, Cowie and Cooper found that "The lecturers in our study were very clear they did not see it as their role to teach mathematical or statistical thinking outside the context of its use in their courses" (Cowie & Cooper, 2016, Concluding Comments section, para 3). They also found some hesitancy about their own ability to help pre-service teachers in other contexts than which they were familiar: "The lecturers who spoke to us were confident when talking about its use in their contexts albeit some of them initially responded that they were 'no good at maths'" (Cowie & Cooper, 2016, Concluding Comments section, para 3). They recommended that therefore "It is possible that data literacy should be progressed at university level through a pan faculty approach as after all, every citizen needs to be data literate in ways appropriate for their professional and personal circumstances and goals" (Cowie & Cooper, 2016, Concluding Comments section, para 4). The similarity of this statement with that of the need for every student to be numerate is clear. This approach is consistent with the notion of teaching mathematical thinking by 'embedding' it within the contexts and activities of a course/programme (DeLuca & Klinger, 2010; Galligan, 2013).

Other studies provide evidence that teacher educators see their role as developing the more critical or reflective aspects of teaching as opposed to preservice teachers' content knowledge. A study by Andrews et al. revealed views on the objective of teacher education such as educating teachers 'into agents of change' (Andrews et al., 2014, p. 18). Barenthien & Dunekacke found that "fewer than 10% of the teacher educators named the acquisition of content knowledge as a lesson aim" (Barenthien & Dunekacke, 2021, Discussion section, para 2). Even when speaking explicitly about [numeracy], a teacher educator interviewed by x was far more detailed about the "need to help students [PSTs] to interpret and then understand the social and political implications of the numerical categorisation and construction (numbering) of children with different disabilities" (Cowie & Cooper, 2016, Findings section, para 9).

Interestingly, there does seem to be an analogous relationship between teacher educators and their role in developing motivated or self-efficacious numeracy teachers and teachers' role in developing numerate students. Just as not all preservice or in-service teachers see their role as developing students' numeracy, not all teacher educators see their role as developing preservice teachers' ability to teach numeracy. At the same time however, teacher educators were relatively clear that all teachers are required to do so to some extent. If the solution is to assist teachers of all specialisations to better teach numeracy or be more motivated and self-efficacious in doing so, then this should perhaps also be the case for teacher educators.

Research Sub-aim 3 - Themes 2, 4

Sub-aim three addresses the issue of what factors are influential in developing preservice teacher motivation and self-efficacy to teach numeracy. Mathematical education experience was seen as the dominant factor in preservice teacher motivation or self-efficacy to be numerate, while the effects of time, placement, and individual differences were seen as key difficulties in developing preservice teacher motivation or self-efficacy to teach numeracy.

That theme 2 found that mathematical education experience is a dominant factor in one's orientation towards being numerate is no surprise. A wealth of literature supports the argument that negative mathematics education experience contributes to mathematical anxiety (see Dowker et al., 2016). Studies interviewing teacher educators about the reasons for preservice teacher motivation or self-efficacy however are minimal. Barenthien and Dunekacke interviewed science teacher educators concluding that they "perceived PSPTs' fears, low-self-efficacy, and limited science-specific knowledge as the key challenges in teaching science" (Barenthien & Dunekacke, 2021, Results section, para 6). Although not articulating whether limited knowledge causes fear or low self-efficacy, the study indicates that teacher educators see them as closely associated. Interesting research by Andrews et al., (2014), focused on the topic of Finnish mathematics teaching in relation to PISA and TIMSS results. One of the teacher educators they interviewed expressed that newly qualified teachers may "experience doubts about their own mathematical competence" (Andrews et al., 2014, p. 20) regarding their tendency to adhere closely to curriculum materials. Although not made explicit it could be interpreted that doubts about mathematical competence are clearly the domain of mathematical education. The relevance to this present study therefore is that teacher educators see preservice teachers' mathematics education as also influencing their motivation and self-efficacy regarding teaching numeracy. Finally, there is also research to indicate that many university students including preservice teachers struggle with the level of numeracy required, citing relationship to mathematical education as a contributing factor, especially for mature aged students. For instance, Woolcott et al. state, "Significantly for regional universities, one third

(33%) of education students at this institution were of mature age and hence well removed from their mathematics study at high school" (Woolcott et al., 2021, p. 462). Although research on teacher educators' thoughts regarding how mathematics education affects preservice teachers' motivation or self-efficacy to teach numeracy is almost non-existent, some studies with teacher educators do point to mathematics education or prior subject knowledge as closely associated with affective aspects such as fear, doubt and self-efficacy in teaching.

Theme 4 revealed that there were several factors influencing preservice teacher motivation or self-efficacy to teach numeracy as seen from a teacher educator perspective. Theme 4 categorised these as time, placement, or individual differences such as beliefs. Notably these all seem to be externally controlled or significantly outside the control of the teacher educators. Regarding early mathematics education Whyte et al. found that teacher educators reported a lack of time for mathematics content as a significant difficulty in teaching early mathematics preservice teachers (Whyte et al., 2018). Likewise, when interviewing teacher educators regarding science teaching education, "The small number of lessons and time restrictions were often cited" (Barenthien & Dunekacke, 2021, Discussion section, para 8). In addition to time, placement or practicum has also been identified as a challenge for teacher educators. According to Barenthien and Dunekacke, "The organization of practical training in ITE also seems to represent a challenge for teacher educators" (Barenthien & Dunekacke, 2021, Theoretical Framework section, para 9). Maxwell et al. (2001) also reported that a lack of quality early childhood practicum sites as a challenge for teacher educators.

Limitations

The research study's limitations are important to understanding the scope and applicability of the findings, as well as guiding future research in this area. Firstly, one potential limitation is the sample size and diversity. Educational research often faces the challenge of ensuring that study participants represent a wide range of backgrounds, teaching disciplines, and educational contexts. This diversity is crucial for the generalizability of the findings. Studies focused on numeracy in ITE, such as those by Goos, Geiger, and Dole (2012), and Hill, Rowan, and Ball (2005), typically involve a specific cohort of pre-service teachers or teacher educators. The results, while insightful, may not fully capture the experiences and challenges of all pre-service teachers across different educational settings, disciplines, and geographical locations.

Secondly, the methodological approach can also be a limitation. Qualitative research, while offering deep insights into participants' experiences and perceptions, may not easily lend itself to quantification or generalization across broader populations. A reliance on interviews, focus groups, or case studies means that findings may be more influenced by the researchers' interpretations. Additionally, the cross sectional nature of this research study does not account for longitudinal insights.

Thirdly, the focus on numeracy within ITE research may overlook the broader educational ecosystem, including curriculum requirements, institutional support, and policy frameworks. While this study highlighted the importance of motivation and self-efficacy to teach numeracy from teacher educators’ perspectives it did not fully address the potential systemic barriers to achieving this goal. The integration of numeracy teaching strategies into diverse disciplinary contexts is complex and requires more than just adjustments at the level of ITE, it may also necessitate a holistic approach that considers the entire educational landscape.

Chapter Summary

The concluding investigation within this thesis aimed to complement the insights developed from the second and third studies by adopting a qualitative methodological approach. While the prior studies utilized self-report measures to measure the numeracy teaching motivation and self-efficacy among pre-service teachers, this final study employed interviews to capture the perspectives of teacher educators. The findings, articulated through seven identified themes, were then discussed in accordance with the research aims.

The analysis yielded several critical insights. From the perspectives of teacher educators, there exists a low level of both the motivation and self-efficacy levels of pre-service teachers concerning numeracy teaching. This observation is significant, particularly when numeracy is construed in its everyday applicability, suggesting some disparity between personal numeracy skills and the capacity to teach numeracy. Furthermore, the teacher educators themselves were characterized by a robust sense of motivation and self-efficacy in fulfilling their pedagogical roles. However, this self-assessment was despite the acknowledgment that their principal responsibilities do not always explicitly concern instructing pre-service teachers in numeracy teaching or developing their pedagogy regarding numeracy.

Additionally, the research highlighted the significant impact of prior experiences in mathematics education on shaping the motivation and self-efficacy of pre-service teachers towards numeracy. This factor, coupled with the challenges imposed by constrained timelines, varied placement experiences, and individual learner differences, increases the complexity of developing numeracy educators who are both motivated and self-efficacious. Such findings underscore the difficult nature of teacher education, particularly in the realm of numeracy, highlighting the interplay between educator perspectives, pre-service teacher motivation and self-efficacy, and the broader educational environment.

Finally, this analysis not only contributes to the literature on numeracy education within the context of teacher education but also offers qualitative insights from teacher educators to inform future curricular and pedagogical strategies. By exploring the perceptions of teacher educators, this study contributes valuable understandings to complement those derived from self-report methodologies in chapters three and four, thereby enriching the thesis with a balanced and multi-dimensional exploration of numeracy teaching motivation and self-efficacy among pre-service teachers. Some of the implications of these findings point to the necessity of targeted interventions and support mechanisms aimed at developing the numeracy teaching capabilities of future educators, while also considering factors that influence levels of teaching motivation and self-efficacy in this critical area.

Chapter Seven: General Discussion

This general discussion chapter of the thesis seeks to integrate findings from the three studies to advance understanding of the levels of pre-service teacher motivation and self-efficacy in numeracy teaching within the context of initial teacher education. This synthesis takes the form of a comparative analysis between the pre-service teacher and teacher educator perspectives. An examination of these perspectives reveals points of convergence and divergence in perceptions of numeracy teaching. The chapter also seeks to discuss the studies' results in relation to existing empirical data and theoretical constructs, to contribute to research on numeracy teaching and its implications for teacher education programs.

The primary aim of this thesis comprised the following three sub-aims: to describe pre-service teachers' current levels of motivation and self-efficacy, to analyse the dimensions of numeracy teaching, and to identify potential factors influencing these levels. These sub-aims facilitated a detailed investigation of the state of numeracy teaching in ITE and also align with the broader objectives of improving teacher quality. The mixed-methods design applied across the research studies aimed to provide a greater level of nuance than would otherwise be achieved through either a solely quantitative or qualitative approach.

Prior to addressing each sub-aim in detail, an overview of the key findings in relation to each will provide beneficial context. Regarding the first sub-aim, the studies have revealed insights into the current state of pre-service teachers' levels of motivation and self-efficacy, underpinned by a critical examination of numeracy as a construct and its implications for teaching practices. This exploration, informed by Goos et al. (2020) rich 21st century model primarily revealed an alignment between this conceptualization of numeracy and the resulting factor structure of the MSETN, underscoring the importance of embedding aspects such as critical thinking within numeracy teaching. Such findings not only provide validation of the conceptual framework employed but also highlight the complexities surrounding numeracy's definition and its pedagogical implications.

The second sub-aim interrogated the dimensional components of numeracy teaching, drawing attention to the relationship between personal and pedagogical numeracy proficiency as well as motivational and self-efficacy aspects. The key findings build upon Shulman's (1987) pedagogical content knowledge framework, emphasizing the necessity but also insufficiency of solely possessing content knowledge for effective numeracy teaching. While personal numeracy forms a vital component of pedagogical content knowledge, its influence on numeracy teaching motivation and self-efficacy is mediated by various contextual factors.

The investigation of levels and structure of numeracy teaching forms a basis for the third sub-aim of analysing the factors that might influence pre-service teachers' motivation and self-efficacy. The results here reveal a variety of demographic variables, ranging from previous mathematical education to personal beliefs and pedagogical experiences, demonstrated effects upon pre-service teachers' levels. These findings, corroborated by Rovan, Gracin, and Trupcevic (2021), Forgasz (2017), Bennison (2022), and Goos (2015), affirm the pivotal role of teacher education programs in addressing these as a means of improving pre-service teachers' preparation for teaching numeracy.

In synthesizing these findings, this chapter now analyses the convergences and divergences between pre-service teachers' self-perceptions and teacher educators' perspectives. This evidence will contribute towards a comprehensive picture of levels of motivation and self-efficacy within the domain of numeracy teaching.

Sub-aim 1: Describing current levels of pre-service teachers' motivation and self-efficacy to teach numeracy

Sub-aim one explores the current levels of pre-service teacher motivation and self-efficacy to teach numeracy from both pre-service teacher and teacher educators' perspectives. A pre-condition for this sub-aim was a conceptual understanding of what numeracy teaching is. The results across the three studies provide a current cross-sectional view of pre-service teachers' levels, and also allow for an assessment of current conceptualisations of numeracy teaching.

Similarities regarding numeracy teaching

A comparison of results from across the studies contributes to the substantiation of the conceptualisation that numeracy teaching involves a critical aspect as developed from Goos' framework (Goos et al., 2020). Teacher educators saw numeracy as involving an everyday type of maths (Theme 1) but gave particular emphasis to numeracy teaching as requiring a level of critical thinking (Theme 3). From pre-service teacher perspective, the mean of the Numeracy concept factor was 71 and the associations between it and the personal numeracy and contextual numeracy factors were .63 and .58. This is also consistent with the concept of numeracy teaching as involving personal and contextual elements. Furthermore, the contextual numeracy factor overlaps with the concept of critical thinking since it is here that pre-service teachers need to judge how to best implement numeracy in particular contexts. Within the literature, many definitions of numeracy include a critical aspect. The results of this research indicate that the critical aspect of being numerate also applies to the teaching of numeracy. This recognition of sharing an element of critical thinking between numeracy and numeracy teaching highlights a crucial alignment between the goals of teaching and intended numeracy outcomes. Explicitly prioritising this alignment may therefore lead to more effective and intentional educational practices. It also reinforces the potential for emphasising the cross-disciplinary nature of numeracy teaching offering a common basis of agreement for teachers of all learning areas (Goos et al., 2020; Steen, 2001).

When viewed through a more empirical lens, the corroboration of the critical aspect of Goos' numeracy framework with the specific construct of numeracy teaching employed in the measurement instrument signifies a significant step forward in the empirical validation of this conceptual framework. This alignment is particularly noteworthy due to the intricate nature of numeracy itself, which has posed challenges in developing a precise definition. As underscored by scholars such as Gizem Karaali, Edwin H. Villafane Hernandez, and Jeremy A. Taylor, the conceptualization of numeracy has proven to be a complex and multifaceted endeavour, giving rise to a variety of perspectives and interpretations (Karaali et al., 2015).

However, there were also areas of areas of nuance that emerged from this analysis which included the extent to which teacher educators with a mathematics background and pre-service teachers with a mathematics specialisation displayed differences to those without such qualifications. This distinction was most apparent when determining how much weight is given to the personal, contextual, or critical aspects of numeracy teaching. It is discernible across the studies that participants tended to give varying degrees of significance to these key aspects. For those with a mathematics qualification or specialisation, this divergence may be attributed to a nuanced understanding of mathematical concepts and the particular lenses through which they view numeracy education. They may, for instance, lean more towards the technical and analytical aspects, placing a heightened emphasis on personal numeracy, while possibly underemphasizing the contextual and critical dimensions. Bolstad’s study on the teaching of mathematical literacy by mathematics teachers found that there was a recurring emphasis on mathematical knowledge rather than developing a critical orientation (Bolstad, 2020). Gainsburg (2008) also found that mathematics teachers' main focus was on the development of mathematical skills and concepts. In contrast, those without mathematical backgrounds may exhibit a more balanced consideration of all facets, recognizing the value of a holistic approach to numeracy instruction. However, previous research has indicated that non-mathematics specialists or even non-STEM pre-service teachers tend to possess less self-efficacy to teach numeracy than their mathematics specialist of STEM based peers (Hall & Forgasz, 2020; O'Sullivan, 2022). Notably, the majority of conceptualizations of numeracy and numeracy teaching, as explored in Chapter 2 of the literature review, have come from scholars within the mathematics education community. However, the results of this research indicate a promising avenue for diversification and enrichment of this literature in further investigating non-mathematics educators' views of numeracy.

Differences regarding perceived levels of motivation and self-efficacy

One of the clearest differences emerges when contrasting the viewpoints of teacher educators and the quantitative data gathered through the newly developed self-report measure. This divergence is most pronounced in the evaluation of pre-service teachers' motivation and self-efficacy levels regarding numeracy teaching. Teacher educators, as conveyed by their qualitative responses, consistently portrayed a lower assessment of these levels, with some characterizing the levels of pre-service teacher motivation and self-efficacy as 'poor'. Averaging the quantitative estimations given by the teacher educators resulted in a value of 40% regarding pre-service teachers' levels (Theme 5). Their perspectives underscore perceived concerns or inadequacies within the preparation and training of future educators (Hall & Forgasz, 2020). In contrast, the quantitative findings, represented by the mean values of the self-efficacy and motivation scales, reveal a more positive picture. The average self-efficacy score was 72, indicative of a notably higher level among pre-service teachers than implied by the teacher educators' assessments. Similarly, the motivation scale resulted in an average score of 73, again indicating a relatively higher level of motivation for numeracy teaching than expressed by the teacher educators.

However, this divergence calls attention to the potential disparity between teacher educators' observations and pre-service teachers' self-report measures. There are a number of complexities in comparing data of different types arising from these different methods. These complexities are not just methodological but may also reflect difficulties in the nature of observations by teacher educators of latent constructs such as motivation, self-efficacy or other intrapersonal and subjective variables. For example, psychological research has consistently found judgement biases known as "actor-observer" effects (Fiske & Taylor, 1991; Sande et al., 1988). Regardless therefore of the particular reason, the research results highlight the importance of considering both pre-service and teacher educator perspectives regarding initial teacher education issues.

Another plausible rationale for the observed divergence may lie in the possibility of pre-service teachers overestimating their levels of self-efficacy and motivation, reflecting a phenomenon similar to the tendency to overrate their personal numeracy capabilities, as found by other researchers (Hall & Forgasz, 2020; O'Sullivan, 2022). This possibility toward overestimation may result from a combination of self-perception biases, social desirability, or the inherent optimism often associated with beginning teachers entering into the field of education. This connection between overestimation including both personal numeracy capabilities and pedagogical attributes, underscores the need for a more comprehensive examination of the cognitive and motivational processes than has been addressed by this research. These cognitive biases may have significant implications for teacher preparedness and self-efficacy, affecting not only their own sense of readiness but also their effectiveness in delivering numeracy teaching. An in-depth exploration of these dynamics could offer valuable insights into the development of targeted interventions and support mechanisms for pre-service teachers, ensuring that their self-perceptions align more closely with the realities of their roles in numeracy education.

Finally, a further consideration is found in some of the teacher educators' views of the influence of anxiety towards mathematics as being a determinant of numeracy teaching motivation and self-efficacy (Theme 2). It is possible that teacher educators may be extrapolating from widespread views regarding mathematics anxiety and overestimating the impact it should have on numeracy teaching. As discussed above there does seem to be a significant influence of mathematics education and experience. Still, one of the key contributions of this research and its unique methodology is that there is a need to proceed with caution. Even given the influence of mathematics on the self-reported levels of pre-service teachers, those without a year 12 maths or maths specialisation resulted in a mean of 70 which is still higher than teacher educators' views. Mathematics does have a significant effect but perhaps not so significant as to undermine pre-service teachers' self-efficacy and motivation to *teach* numeracy.

Sub-aim 2: Analysing the dimensions of motivation and self-efficacy to teach numeracy

The examination of results from the perspectives of teacher educators and pre-service teachers yields inconclusive findings regarding the degree of independence between personal numeracy proficiency and numeracy teaching. This ambiguity is evidenced by the disparity between the thematic observations captured within Theme 3 and the stronger correlation observed between the personal numeracy factor and the factor associated with numeracy teaching in studies 1 and 2. These findings neither confirm nor reject the notion that personal numeracy and the effectiveness of numeracy instruction stand as entirely distinct constructs. Instead, it is possible that the discrepancy between thematic insights and quantitative data indicates a complex interplay between these elements, whereby personal numeracy may exert an influence on the capacity to teach numeracy. However, the exact degree of influence remains unknown, underscoring the need for further research to determine the exact relationship between personal numeracy proficiency and numeracy teaching. Overall, the results align with Shulman's work on pedagogical content knowledge (Shulman, 1987). Personal numeracy proficiency can be viewed as a subset of content knowledge, specifically related to numeracy. Shulman's framework reinforces that a teacher's content knowledge is a fundamental component of effective teaching. If personal numeracy proficiency significantly influences the ability to teach numeracy effectively, it aligns with Shulman's concept of CK. This connection frames the possibility that PCK in numeracy teaching may require a strong foundation in personal numeracy. However, Shulman's framework also acknowledges that PCK is a dynamic and multifaceted construct, and while personal numeracy can be a contributing factor to PCK in numeracy teaching the precise nature and extent of this relationship is governed by many contextual aspects. This has been outlined more clearly by O'Sullivan who concluded that three elements of teacher content knowledge were required to teach numeracy effectively; Subject Specific Knowledge, Numeracy Knowledge, and Pedagogical Content Knowledge (O'Sullivan, 2022). Such a conclusion also affirms that personal numeracy is not enough to teach numeracy well and is mediated by the quality of teachers' other sets of knowledge.

There are some further complexities between the two perspectives. Firstly, from the view of teacher educators, it was not simply that numeracy teaching was relatively independent of personal numeracy, there was also an emphasis on numeracy teaching as involving a critical aspect. Conversely, when considering the pre-service teacher perspective, a particular pattern emerged. A lack of significant difference in the means across each of the factors, highlights that pre-service teachers see all aspects of numeracy teaching as equally meriting motivation and self-efficacy. This may imply that pre-service teachers view all aspects of numeracy teaching as interrelated or more or less equal significance or perhaps do not have a deep understanding of numeracy. Hall and Forgasz for instance found that approximately 22% of the pre-service teachers they surveyed were unsure of or did not believe there were differences between mathematics and numeracy (Hall & Forgasz, 2020).

Comparatively, the teacher educators' perspective appears to be a more hierarchical view of numeracy teaching centred on the aspect of critical thinking. However, the pre-service teachers' view appears to be more evenly distributed. One plausible explanation for this distinction could be the developmental trajectory of pre-service teachers as they progress through their initial teacher education programs. It is conceivable that as pre-service teachers advance in their understanding and classroom experiences, they undergo a maturation process that gradually refines their understanding of the relative importance of various aspects of teaching numeracy. Over time, pre-service teachers may come to appreciate that certain facets of teaching carry more weight in terms of their impact on student learning outcomes, classroom management, or instructional effectiveness. This would align with Bennison's embedder-of-numeracy framework which has shown that the identities of practising teachers change as they develop their capacity to “embed numeracy” into different learning areas (Bennison, 2022).

An alternative interpretation of these findings highlights that the critical dimension of numeracy teaching may be inherently more complex or challenging in comparison to the personal numeracy factor. This perspective posits that while personal numeracy proficiency focuses on an individual's mathematical skills and abilities, the critical component of numeracy teaching encompasses a broader and multifaceted set of skills, including the ability to foster critical thinking, adapt pedagogical strategies, and address diverse student needs. Bennison’s work has found some evidence that pre-service teachers without a mathematics specialisation possess a “narrower understanding of numeracy” with no evidence of “dispositions or a critical orientation as part of numeracy” (Bennison, 2022, p. 88).

When viewed from the lens of teacher educators, an additional rationale for the distinction between personal numeracy and the emphasis on critical thinking could be attributed to their professional roles and responsibilities. Teacher educators may perceive their primary duty as imparting pedagogical knowledge and skills to future teachers, rather than developing content expertise in specific disciplines, including numeracy. This perspective acknowledges that teacher educators may inherently value the ability to cultivate critical thinking in their pre-service teachers, as this skill is deemed indispensable for teaching across various content areas. Consequently, their judgment that critical thinking carries greater importance within numeracy teaching is influenced by their professional commitment to pedagogical knowledge and the development of effective teaching practices. This emphasis on pedagogical expertise, coupled with their role in teacher development, may shape their perspective on the relative importance of various aspects within the numeracy teaching domain. This would be consistent with the result from Theme 2 that teacher educators with a mathematics background were more likely to emphasise the role that content knowledge plays while non-mathematics teacher educators were more likely to emphasise the critical aspect.

Overall, the assessment of the results infers that they lend weight to both conceptual and empirical substantiation for the proposition that numeracy teaching maintains a degree of independence from personal numeracy. However, it is vital to acknowledge that the precise extent of this independence remains inconclusive and warrants further investigation and clarification. The findings underscore the nuanced relationship between personal numeracy proficiency and the practice of numeracy teaching.

A difference in teacher educator levels of motivation and self-efficacy

A notable divergence emerges with regard to the observation that teacher educators' self-reported levels of motivation and self-efficacy in teaching pre-service teachers exhibited a significant disparity in comparison to their perceptions of these attributes within the pre-service teacher cohort. Specifically, teacher educators, when self-evaluating their motivation and self-efficacy, consistently rated themselves at high levels, typically falling within the range of 90% to 100%. In contrast, teacher educators assessed the motivation and self-efficacy levels of pre-service teachers to be significantly lower, averaging at 40%. This disparity is also corroborated by comparison with the overall mean values of the measurement instrument, of 71%. These results reveal a distinct contrast between teacher educators' self-perceptions and their perceptions of pre-service teachers, indicative of a disparity in the judgement of motivation and self-efficacy within the context of numeracy teaching.

This variance in perception raises intriguing questions about the factors that contribute to the observed disparity, potentially highlighting the dynamics of teacher-student relationships, instructional expectations, and the extent to which teacher educators' personal levels of self-efficacy and motivation may influence their assessments of pre-service teachers. Firstly, an important consideration arises from a potential selection bias when evaluating teacher educators' motivation and self-efficacy. Teacher educators often emerge as individuals who have demonstrated exceptional levels of motivation and self-efficacy in their own teaching practices, as evidenced by their successful careers and expertise in pedagogy. Consequently, there exists the distinct possibility that this selection process results in a cohort of teacher educators who naturally possess and embody higher levels of motivation and self-efficacy compared to the broader population of educators. This selection bias raises significant questions regarding the generalizability of teacher educators' self-assessments, especially when extended to pre-service teachers. The inherent disparity in motivation and self-efficacy levels may not only be a result of the role these educators play in initial teacher education but also a reflection of their distinctive experiences and career trajectories. It prompts consideration of how the motivation and self-efficacy of this particular subgroup of educators may shape their perceptions of pre-service teachers.

Secondly, a key aspect of teacher educators' self-assessment of their motivation and self-efficacy requires further examination, particularly with regard to those educators without a background in mathematics. These educators took care to specify that their reported levels of motivation and self-efficacy in teaching pre-service teachers were contextually relative to their respective areas of expertise (Theme 7). Furthermore, it is important to acknowledge that their areas of expertise did not inherently encompass the domain of numeracy teaching. Within initial teacher education courses, it is a requirement that they demonstrate the teaching, practising and assessment of the AITSL standards throughout their units. However, it is a common practice for many teacher educators to specialize in teaching a specific subset of units that may not necessarily include AITSL standard 2.5, which directly pertains to numeracy teaching. Consequently, it is uncommon for any single teacher educator to offer instruction across the entire spectrum of AITSL standards, given the specialized nature of their respective expertise areas. These considerations frame a complexity of context. The comparison may demonstrate the difference in evaluating teacher educators' motivation and self-efficacy within the framework of their specialized domains of expertise as juxtaposed with pre-service teachers' motivation and self-efficacy in an area—numeracy—that may not inherently align with their individual expertise or chosen focus. All pre-service teachers are expected to teach numeracy, however it is not necessarily the case that all teacher educators are required to teach pre-service teachers to teach numeracy. This interplay of expertise, context, and the alignment of motivation and self-efficacy in teaching raises important questions regarding the potential impact of educators' specific domains of proficiency on their evaluation and guidance of pre-service teachers. This is further underpinned by Theme 6, which underscores the fact that teacher educators may not uniformly perceive numeracy teaching as an integral component of their professional roles. This introduces a layer of complexity to the interpretation of the results and prompts questions about the roles and expectations within teacher education programs. Pre-service teachers' motivation and self-efficacy towards numeracy teaching may be indicative of their awareness of the AITSL standards and the requirements of their teacher education. In contrast, teacher educators' varied stances may reflect a broader question concerning the definition and delineation of roles within the teacher education domain, especially regarding numeracy pedagogy. The implications of this observation extend to the development of more precise teacher education curricula and the establishment of clear role expectations for teacher educators.

Sub-aim 3: Identifying personal and background factors influencing numeracy teaching motivation and self-efficacy

Similarities regarding influential factors

A discernible degree of agreement emerges when considering the impact of mathematics education and prior school experiences, aligning closely with the foundational aspects of the numeracy framework upon which this research was developed. This shared perspective was not only highlighted in the qualitative observations (Theme 2) but also in the statistical significance MANOVA conducted on pre-service teachers' year 12 mathematics subjects. This statistical significance offers confirmation of mathematics as an indispensable component of numeracy, which is a core aspect of the framework developed by Goos et al. (2020).

However, the results also showed that previous mathematics education and school experience is mostly strongly associated with the personal numeracy factor and less so regarding the teaching of numeracy. On one hand, the strong association observed between prior mathematics education and personal numeracy underscores the impact of formal mathematical education on an individual's personal mathematical skills. It reinforces the notion that a robust mathematical foundation can be attributed, in large part, to prior educational experiences. Conversely, the weaker association between previous mathematics education and the teaching of numeracy implies a more complex dynamic. This observation demonstrates that while previous mathematical background is advantageous, it may not be the sole determinant of one's ability to effectively teach numeracy. This has also been highlighted by Bennison's embedder-of-numeracy framework. Previous mathematics experiences are an aspect of only one out of five domains; Life History, Knowledge, Affective, Social, and Context domains (Bennison, 2017). This nuanced perspective calls attention to the need for a broader pedagogical skill set and reinforces that successful numeracy teaching demands more than just personal mathematical proficiency. This pattern also reflects research arguing that teaching any subject requires much more than competence in that subject (Shulman, 1987).

Furthermore, these findings provide warrant for the assertion that teacher education programs hold an influential role in developing the motivation and self-efficacy levels of pre-service teachers with regard to numeracy teaching, even in the presence of varying past experiences and backgrounds. Rovan, Gracin and Trupcevic (2021) make a similar point regarding primary mathematics teachers, and the studies by Forgasz (2017), Bennison (2022) and Hall (2020) show improvements in pre-service teachers' understanding of and self-efficacy in numeracy after completing units focused on numeracy teaching.

An area of complexity however, arises when comparing the measurement-based results with the thematic insights. Importantly, the MANOVA result was derived from the significance of year 12 mathematics subjects and mathematics specializations as contributing factors, while Theme 2 was arguably concentrated on the dimension of previous mathematics education experiences. It is essential to acknowledge that although they are not precisely identical in their focus, these two findings are interconnected. For example, several classroom factors such as teacher relationships and classroom climate of school mathematics can decrease the likelihood of students studying mathematics in year 12 (Espino et al., 2017; Kirkham et al., 2020) or of choosing a mathematics specialisation (Ahmed, 2018). Thus, those with adverse experiences are also likely to be those without a year 12 mathematics subject or specialisation. Despite this complexity the results across the three research phases present evidence for the role that mathematics plays in the definition of numeracy teaching and differentially on the components of numeracy teaching.

Further similarities regarding influential factors

Some further areas of similarity between the results of the two perspectives include the factors which exert influence on pre-service teacher motivation and self-efficacy to teach numeracy. The identification of these shared factors presents a valuable opportunity for teacher education programs and curriculum designers to gain deeper insights into the drivers of pre-service teacher motivation and self-efficacy.

The insights derived from Theme 4 offer a perspective on the role played by teacher educators in guiding the development of pre-service teachers. Within this, specific elements emerged as influential mediators contributing significantly to the growth and preparedness of pre-service teachers. These influential mediators related to time, student placement, and the impact of personal beliefs. Results from pre-service teachers revealed statistical significance for variables such as year, interests (puzzles and programming, but not music), and type of degree (Undergraduate versus Masters). Some meaningful comparisons can be drawn between each of these findings. Firstly, ITE programs in Australia are intentionally crafted to offer a gradual experience for pre-service teachers as they progress through their course of study. In this context, teaching placements commence after a period of initial preparation and theoretical coursework, and their level of involvement in classroom teaching increases as the program unfolds. The statistical significance observed concerning the pre-service teachers' year level in relation to the measure presents an interesting case. While the data indicates that there is a significant association between the year level of pre-service teachers and their levels of motivation and self-efficacy, it is essential to exercise caution in interpreting this relationship. It is possible that this statistical significance may be tied to the timing and progressive nature of pre-service teacher placements within the ITE programs. This prompts consideration of whether the increased immersion in teaching experiences as pre-service teachers progress through their studies influences their motivation and self-efficacy levels, thus accounting for the observed statistical significance. If so, then there is evidence of agreement between the results of the measure and the identification of student placement as a key factor by teacher educators.

Secondly, it is possible to explore the comparison between a series of variables linked to the interests of pre-service teachers, with particular emphasis on the statistical significance observed in areas such as puzzles and programming, although the same significance is not observed in the context of music. These findings can be aligned with the thematic insights presented in Theme 4, which underscore the pivotal role played by personal beliefs in the development of motivation and self-efficacy among pre-service teachers.

Again, with caution, these converging perspectives from the measurement-driven findings and the thematic analysis lend support to existing studies that emphasize the significant role of personal identity in the development of motivation and self-efficacy among pre-service teachers (Narayanan et al., 2021). The insights from this research resonate with the broader educational literature, affirming the relationship between personal interests, beliefs, and the motivation in numeracy teaching. These findings, when examined collectively, underscore the interconnected nature of the factors that influence pre-service teachers' readiness for numeracy teaching. Further research in this area holds the potential to offer deeper insights into the intricate relationships at play and inform the development of targeted strategies and interventions within teacher education programs.

Lastly, some resonance emerges when examining the concerns expressed by teacher educators regarding the time required for the development or transformation of pre-service teachers' beliefs. This consideration overlaps with the statistical significance in outcomes observed between undergraduate and master's degree students and therefore some understanding of the divergent levels of motivation and self-efficacy exhibited by these two groups of pre-service teachers. Typically, individuals pursuing a master's degree have a more extensive background of educational and professional experiences, which includes both previous study and work (Rowston et al., 2021; Varadharajan & Schuck, 2017). This longer trajectory of development may afford masters students the time and opportunities needed to develop higher motivation and self-efficacy levels. In contrast, those beginning an undergraduate degree immediately after completing their secondary education may have a more limited timeframe to engage in formative experiences, both within higher educational settings and broader professional contexts. This shorter timeframe may impact the development of their motivation and self-efficacy in their initial teacher education course. This observation highlights the temporal aspect as a fundamental factor in the divergent outcomes between undergraduate and master's students. It underscores the significance of time in the development of personal beliefs such as motivation, and self-efficacy among pre-service teachers.

An initial interpretation of the convergence of factors encompassing beliefs and interests, temporal elements related to time and degree type, and the varying placement or year levels of pre-service teachers points towards support for the developed measure’s consistency with various theoretical frameworks outlined in Chapter 2: Literature Review. In each of these, factors of time, experience, and individual differences and beliefs are key considerations to the development of motivation and self-efficacy.

Limitations

As with any research study there are several key limitations that should be acknowledged.

Instrument Development and Validity:

The design and validation of a new self-report measure introduce questions about its reliability and validity. Addressing this limitation necessitated that rigorous steps were taken during the instrument development phase. A thorough literature review and consultation with experts in the field of education and psychometrics were conducted to ensure content validity. The measure underwent multiple iterations, and exploratory factor analysis was carried out to assess its reliability and internal consistency. Additionally, confirmatory factor analysis was performed to assess the fit of the proposed structure of the measure and assess construct validity. Despite these techniques however, some aspects of validity and reliability were not addressed. In particular, these included test-retest reliability, differential item functioning (DIF), convergent or divergent validity where measures are assessed against other known measures expected to be similar or different. The validity and reliability of measures can also be assessed using interventionist research studies to determine how well such measures perform as predicted. Lastly, there is the limitation of ecological validity where the measure is examined for how applicable it is to the situations in which it is intended.

Sample Size and Generalizability:

For each of the individual studies and taken together a key limitation relates to the sample sizes, potentially raising concerns about the generalizability of the findings to any broader population of pre-service teachers and teacher educators. It is worth noting that while the sample sizes may be described as modest, they were suitable enough in terms of size and variability to achieve the aims of the research. This aim was primarily a descriptive rather than predictive or explanatory project where generalisation was not the goal. Further research involving larger sample sizes however, would provide a stronger basis for credence in the results.

Response Bias:

Again, across each of the studies, there is the potential for response bias whereby pre-service teachers and teacher educators who volunteered to participate may have been more motivated or self-efficacious than their non-participating counterparts. The efforts made to mitigate this involved encouraging a wide range of participants to take part in the study and emphasising the informed consent procedures and assurance of anonymity for the survey responses. As with the comments on sample size, it is helpful to note that the studies' primary foci were on understanding the variations within the sample rather than making definitive claims about a larger population.

Social Desirability Bias:

As with response bias, participants might also provide responses that align with perceived social norms or expectations, particularly when discussing their motivation and self-efficacy. For interview questions, an attempt was made to ensure these were open-ended enough to encourage participants to share their genuine experiences and perspectives. Additionally, participants were assured of the confidentiality of their responses to promote honest answers.

Cross-Sectional Nature:

The study's cross-sectional design captured pre-service teachers and teacher educators at a specific point in time, limiting the ability to draw conclusions about changes or developments over time. However, this limitation is a feature of most initial and exploratory research and often a necessary one regarding the logistics of how much research can be carried out within a single project. Suggestions for future longitudinal research are provided in the final chapter, which could explore changes in these attributes over time.

Potential Researcher Bias:

The interviews with teacher educators might be influenced by the researcher's presence or the nature of the researcher’s position as both an academic and teacher, leading to potential interviewer bias. The attempt was made to ensure interview questions were carefully crafted to be open-ended and non-leading and transcripts and recordings were systematically analyzed to ensure that the data collected accurately reflected the participants' perspectives. There is also debate surrounding the extent to which being an insider versus outside research is beneficial to the conduct of interviews and analysis of subsequent data. On the one hand, familiarity and experience with the topics being asked provides the researcher with judgement that others would not have. On the other hand, being too familiar may lead one to miss novel insights. This situation occurs to some extent in all research and the primary means of addressing it within this thesis was the oversight of the researcher’s supervisors as part of the PhD process.

Lastly, while these limitations are acknowledged and have been addressed to some extent, the study's transparent approach to instrument development, data collection, and data analysis also assists in mitigating these limitations to ensure valuable insights into the complexity of levels of motivation and self-efficacy to teach numeracy can be gained.

Chapter Summary

This chapter discussed the investigation into pre-service teacher motivation and self-efficacy in numeracy teaching through a detailed analysis of the findings in relation to the aims of the thesis. The primary research aim was comprised of three interrelated sub-aims, each contributing to the overall understanding of the topic. The initial sub-aim sought to investigate the current state of pre-service teachers' levels of motivation and self-efficacy to teach numeracy. The second sub-aim focused on exploring the nature of the dimensions of numeracy teaching while the third sub-aim explored the factors influencing pre-service teacher motivation and self-efficacy, offering an in-depth analysis of the potential demographic variables that impact these attributes. This chapter then sought to discuss the convergences and divergences between the pre-service teacher and teacher educator perspectives, highlighting the contextual information they provide for initial teacher education programs. It incorporated the synthesized findings to present an overview of how these align with existing literature, therefore placing the research outcomes in the broader context of educational research. Drawing from the research findings and discussions, the chapter also outlined the key limitations of the research. The insights presented here contribute valuable knowledge accessible to educational institutions seeking to refine teacher preparation and support pre-service teachers in their numeracy teaching. The discussion of the contribution to the existing body of knowledge in teacher education aimed to offer a foundation for future research and practice the implications and recommendations for which will be further specified in the next chapter

Chapter Eight: Summary, Recommendations and Conclusion

The impetus for this research was framed by the acknowledgement of numeracy as a critical component within the educational landscape, with all teachers in Australia, responsible for its development (Geiger et al., 2015). Initiatives such as the Literacy and Numeracy Test for Initial Teacher Education (LANTITE) and the Australian Professional Standards for Teachers (APST Standard 2.5) aim to ensure pre-service teachers achieve a required level of numeracy and numeracy teaching proficiency (Australian Institute for Teaching and School Leadership [AITSL], 2014). However, research shows we do not know to what extent pre-service teachers are motivated or self-efficacious to teach numeracy, especially across various educational levels and specialisations. Addressing this gap is pivotal for enhancing Initial Teacher Education (ITE) programs to develop motivation and self-efficacy among pre-service teachers.

The primary aim of this research was to investigate pre-service teachers’ and teacher educators’ perspectives of the key aspects of motivation and self-efficacy to teach numeracy. To achieve this aim, the first two studies detailed the development and psychometric evaluation of the Motivation and Self-efficacy to Teach Numeracy (MSETN) instrument. The measure demonstrated robust validity and reliability across two separate studies. The use of both exploratory and confirmatory factor analyses substantiated the instrument’s factor structure, reinforcing its alignment with Goos' (2014) rich conceptualization of numeracy for the 21st century. The insights from the development of the MSETN contribute a valuable perspective from pre-service teachers, highlighting the various dimensions of teaching numeracy. This novel contribution forms the basis for further investigation and improvement of numeracy teaching within initial teacher education programs, providing a rigorous approach to assessing and developing the necessary skills, motivation and self-efficacy among future educators.

As any educational equation comprises both a student and a teacher, it was important therefore to also investigate the perspectives of teacher educators. The third study involved interviews with teacher educators from both mathematics and non-mathematics backgrounds regarding their perceptions on pre-service teachers' levels of motivation and self-efficacy to teach numeracy. Given the limited literature on this issue, this research has produced further knowledge that can contribute to improvements in the design and delivery of ITE programs. The resulting themes highlight the extent to which teacher educators see their job as developing pre-service teachers' motivation and self-efficacy to teach numeracy. The themes also give voice to what ITE teacher educators see as problematic and challenging regarding their capacity to develop pre-service teachers which can be used as suggestions for new policy or educational initiatives.

The discussion of the findings across each of the three distinct studies contributed further insight into the dynamics of pre-service teachers' motivation and self-efficacy in numeracy teaching, offering a comprehensive analysis of the similarities and differences between pre-service and teacher educator perspectives. Collectively, these studies progress the academic discourse by providing a detailed examination of the nature, levels and factors influencing pre-service teachers (Peters & Shoots-Reinhard, 2022). The comparative analysis of pre-service teacher and teacher educator perspectives also reveals that while both groups acknowledge the significance of mathematics education, there exists a notable gap in perceptions of pre-service teachers' levels of motivation and self-efficacy, suggesting areas for targeted intervention (Bolstad et al., 2017). This thesis, therefore, not only advances the definitional understanding of numeracy teaching within Initial Teacher Education (ITE) but also lays a practical foundation for developing strategies aimed at improving teacher education programs. Overall, the exploration of pre-service teachers' experiences and educator expectations reiterates the necessity for a more cohesive approach to addressing the challenges in numeracy teaching (Forgasz & Leder, 2016). Consequently, the contributions of this thesis can serve as a reference for developing future research directions and practical recommendations aimed at improving the quality of numeracy teaching in ITE programs.

Recommendations for Theory and Research

The MSETN instrument can serve as a basis for both further conceptual and empirical future research projects as follows. In particular, the instrument provides a reference point for progressing the study of pre-service teachers' preparedness in numeracy teaching. A first area of future research is the need for continuous review of the MSETN's reliability and validity, as it ensures the measure's robustness and applicability across the diverse educational contexts associated with numeracy (Cohen et al., 2018; O'Sullivan, 2022). Therefore, increasing the diversity samples of pre-service teachers and extending the instrument's application to international settings are critical steps which can contribute evidence supporting the MSETN. Such steps not only contribute to the psychometric refinement of the instrument but also facilitate a broader understanding of its utility in enhancing numeracy teaching competencies (Goos et al., 2014). Furthermore, by seeking larger and more diverse samples of pre-service teachers, research with the MSETN can uncover additional detail regarding the variables that influence levels of motivation and teaching efficacy and numeracy learning outcomes. For example, an international adaptation of the MSETN could present an opportunity to explore cultural and educational system variances in teaching numeracy, thereby broadening the scope of its applicability and relevance (Bolstad et al., 2017). This cross-cultural validation is essential for ensuring that the MSETN constructs are widely applicable and sensitive to different educational contexts and student populations.

Additionally, longitudinal studies employing the MSETN could yield valuable data on the evolution of pre-service teachers' self-efficacy and motivation to teach numeracy over time. Such research would offer insights into the effectiveness of teacher education programs in developing numeracy teaching skills and identify potential areas for curriculum design and development (O'Sullivan, 2022). These efforts could also be combined with qualitative methodologies, such as case studies or ethnographic research to provide contextualized understandings of the challenges and successes encountered by pre-service teachers as they progress toward becoming proficient numeracy educators.

The second set of recommendations for future research relates to intervention studies for both pre-service teachers and teacher educators. The MSETN can be used in evaluating the efficacy of pedagogical initiatives aimed at enhancing motivation and self-efficacy within ITE. For example, a pre and post-intervention application of the MSETN would enable a reliable assessment of changes in these key educational outcomes (Forgasz & Leder, 2016). One particular application could employ the “N” framework developed by O’Sullivan (2022). The “N” framework, offers a structure for embedding numeracy knowledge within initial teacher education (ITE) curricula. The potential of the “N” framework to impact numeracy teaching in ITE programs has been acknowledged, reinforcing its capacity to improve numeracy knowledge among pre-service teachers (Bennison, 2015). By facilitating a deeper understanding of numeracy and its pedagogical applications, the “N” framework provides a guide for pre-service teachers and teacher educators in planning and executing numeracy-rich lessons across the curriculum (Goos et al., 2014).Therefore, the implementation of the "N" framework alongside the MSETN in ITE programs would present a unique opportunity to examine the translation of this newly developed framework for numeracy knowledge into practical teaching self-efficacy and motivation.

Intervention studies derived from teacher educator practices also present a fertile ground for future research. This type of investigation holds potential to evaluate the impact of teacher educator practices on pre-service teachers' motivation and self-efficacy to teach numeracy. Measured increases in MSETN scores, could be correlated with the practices of teacher educators allowing for the identification of particularly effective ones. This identification could then act as a repository of expertise, guiding the development of pre-service teachers in numeracy instruction with a focus on enhancing both motivation and self-efficacy (Mononen et al., 2015).

A key aspect of intervention studies could also focus on incorporating control groups to more confidently determine the specific effects of teacher educator practices on MSETN scores. This methodological approach enables a more robust analysis of the relationship between educator practices and pre-service teachers' numeracy teaching efficacy (Bansilal et al., 2012). Lastly, extending the scope of intervention studies to investigations of the numeracy outcomes of primary and secondary school students provides a means to assess the impact of teachers' motivation and self-efficacy on students' numeracy learning outcomes. The MSETN, by differentiating between teachers of varying motivational and self-efficacy levels, could provide a lens through which the influence of teacher attributes on student numeracy achievement across different subjects and educational levels can be examined (Clarke et al., 2011).

Overall, in addition to further validating the MSETN, longitudinal and interventionist studies hold substantial promise for contributing to the field of numeracy teaching, especially within ITE. They not only provide potential for understanding effective numeracy teaching practices but also seek to bridge the gap between teacher preparation and student numeracy outcomes, ultimately fostering a more numerate student population (Bansilal et al., 2012; Clarke et al., 2011; Mononen et al., 2015).

Recommendations for Practice

There are also a number of recommendations arising from this research for Initial Teacher Education (ITE) programs to assist pre-service teachers and teacher educators with understanding and skills for numeracy teaching, while emphasizing the development of motivation and self-efficacy across all subjects and educational levels. In line with the recommendation by O'Sullivan (2022), ITE programs could integrate online numeracy modules which are designed to develop pre-service teachers' understanding and pedagogical approaches to numeracy. This would require a more comprehensive engagement with pedagogical and curriculum coursework in ITE, specifically tailored to numeracy teaching strategies.

Additionally, the MSETN as it stands constitutes a valuable self-assessment instrument, enabling pre-service teachers and teacher educators to identify areas in numeracy teaching that may require improvement. This approach encourages a reflective practice among pre-service teachers, focusing on enhancing their capabilities to teach numeracy rather than solely on their personal numeracy skills (Forgasz & Hall, 2019). Such reflective practice is vital, as it facilitates a deeper understanding of numeracy teaching, moving beyond mere content knowledge to include pedagogical content knowledge specific to numeracy (Goos et al., 2014).

Moreover, ITE programs could advocate for a collaborative model of numeracy education, wherein teacher educators across different disciplines work collectively to prepare pre-service teachers for the task of numeracy teaching. This collaborative approach could address the numeracy demands within various subjects and develop a comprehensive knowledge base for identifying numeracy learning opportunities, thereby ensuring a holistic preparation for pre-service teachers in numeracy education (Bansilal et al., 2012).

A further recommendation of this research would be to increase teacher educators’ professional development on how to best develop pre-service teachers’ motivation and self-efficacy to teach numeracy. This type of professional development would address how to embed numeracy teaching pedagogy and curriculum across all or the majority of units in initial teacher education courses. A framework of embedding across ITE curricula could parallel the situation in primary and secondary schools whereby numeracy is a cross-curricular priority and the responsibility of all teachers. It would require teacher educators from all subject backgrounds to coordinate efforts on integrating numeracy teaching across units as mentioned above.

One implication from the empirical results of this research arises from the disparity between teacher educators’ estimates and pre-service teachers’ self-reports of their levels of motivation and self-efficacy. This signals a need for both groups to develop a greater appreciation of the other’s perspective. It may be that pre-service teachers over-estimate their motivation and self-efficacy to teach numeracy, which then needs appropriate recalibration by experienced teacher educators. On the other hand, teacher educators may hold on overly pessimistic view of pre-service teachers’ motivation and self-efficacy, which may risk self-fulfilling practices. In both situations the MSETN could serve as a point of communication capable of facilitating closer alignment of perspectives. Furthermore, fostering an environment that encourages open dialogue between teacher educators and pre-service teachers about expectations, self-perceptions, and the realities of teaching numeracy can help align perspectives. Such discussions can be facilitated through mentorship programs, reflective teaching practices, and feedback mechanisms designed to support pre-service teachers in developing a realistic understanding of their motivation and self-efficacy to teach numeracy as measured by the MSETN.

ITE programs could also investigate the potential to develop teacher motivation and self-efficacy in numeracy teaching through the introduction of specialized numeracy credentials (Tatto, 2013). Institutions of higher education could explore implementing recognition of achievements in numeracy teaching, thereby acknowledging the specialized skills required for effective instruction in this area (Ingvarson & Rowe, 2008). Such recognition could become an additional certification for pre-service teachers, promoting their proficiency in numeracy teaching across various subjects, which in turn could serve as a significant motivator for pre-service teachers to engage in further numeracy-focused coursework (Beswick & Goos, 2012). Obtaining these certifications might also prompt teacher educators to allocate more resources towards numeracy pedagogy, including the provision of placements that emphasize or model best practice numeracy teaching strategies.

Conclusion

This thesis has contributed to and progressed the domain of initial teacher education (ITE), particularly addressing the relatively unexplored constructs of pre-service teacher motivation and self-efficacy to teach numeracy. Employing a mixed methods research design, the study facilitated a comprehensive empirical assessment of these critical affective variables. It provides valuable insights which broaden the conceptual understanding within this specialized field. The construction and subsequent validation of the Motivation and Self-efficacy to Teach Numeracy (MSETN) instrument provides a robust foundation for generating quantitative data. These data can be used to highlight the extent of variability in motivation and self-efficacy among pre-service teachers, and offer valuable information that could contribute to strategic improvements to ITE programs. Furthermore, the detailed thematic analysis derived from qualitative interviews with teacher educators produced new perspectives into the educational literature, highlighting areas for targeted intervention within ITE. These insights will be of value in refining curriculum design, optimizing placement experiences, and evolving pedagogical methodologies with a focus on developing numeracy teaching motivation and self-efficacy. The findings of this thesis reinforces the necessity for pre-service teachers to attain a required level of numeracy competence and knowledge and emphasizes the critical importance of fostering their motivation and self-efficacy to teach numeracy which is essential for effective numeracy teaching across diverse subject areas and educational stages. In essence, this research contributes a significant layer of empirical evidence and theoretical insights to the ongoing development of ITE programs.

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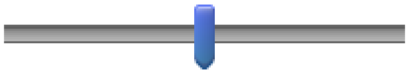
Appendices

A Questionnaire Items for PSTs (this is an export from Qualtrics and does not reflect actual appearance)

Q1 How confident are you that you can learn mathematical skills and concepts?

Not Confident Absolutely Confident

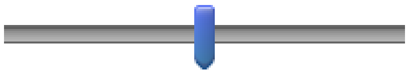
0 10 20 30 40 50 60 70 80 90 100



Q2 How confident are you that you can apply mathematics to tasks associated with your work as a teacher?

Not Confident Absolutely Confident

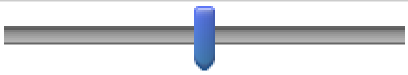
0 10 20 30 40 50 60 70 80 90 100



Q3 How confident are you that you can look for the mathematics present in your everyday work?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100



Q4 How confident are you that you can use a range of physical, graphical and digital tools to help your mathematical thinking, e.g. rulers, graphs, and/or computers?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q5 How confident are you that you can decide if and when mathematics is appropriate?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q6 How confident are you that you can identify the mathematical skills and concepts present in all the learning areas you teach?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q7 How confident are you that you can design real world tasks that require students to apply mathematics in all the learning areas you teach?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q8 How confident are you that you can create tasks that improve both students' numeracy and their understanding of a learning area e.g. English, or PE?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q9 How confident are you that you can identify what physical, graphical or digital tools are needed to help students' mathematical thinking e.g. rulers, graphs, and/or computers?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q10 How confident are you that you can use tasks to promote discussion about the societal importance of mathematics?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q11 How confident are you that you can ask students questions that promote their mathematical skills and knowledge?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q12 How confident are you that you can give feedback to students on how they should change their mathematical thinking when faced with a new situation?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q13 How confident are you that you can motivate students to persevere when applying mathematics to unfamiliar situations?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q14 How confident are you that you can demonstrate the use of physical, graphical and/or digital tools such as rulers, graphs and/or computers?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q15 How confident are you that you can assess students' ability to interpret mathematical information?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q16 How confident are you that you can reach out to other teachers for help with understanding mathematical skills and concepts?

Not Confident   Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q17 How confident are you that you can continually look out for new mathematical opportunities to use in each of the learning areas you teach?

Not Confident   Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q18 How confident are you that you can seek feedback on your willingness to apply mathematics in your work as a teacher?

Not Confident   Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q19 How confident are you that you can locate resources to improve your use of physical, graphical, and/or digital tools such as rulers, graphs and/or computers?

Not Confident   Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q20 How confident are you that you can use mathematical information and data to evaluate your own teaching performance?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q21 How confident are you that numeracy requires mathematical skills and concepts?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q22 How confident are you that numeracy means being able to apply mathematics to any situation?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q23 How confident are you that numeracy means wanting to see the mathematics present in everyday situations?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q24 How confident are you that numeracy requires being able to use a range of physical, graphical and digital tools to help mathematical thinking e.g. rulers, graphs, and/or computers?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

Q25 How confident are you that numeracy means deciding if and when mathematics is appropriate?

Not Confident Absolutely Confident

0 10 20 30 40 50 60 70 80 90 100

End of Block: Confidence

Start of Block: Motivation

Q1 How motivated are you to learn mathematical skills and concepts as a teacher?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q2 How motivated are you to apply mathematics to tasks associated with your work as a teacher?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q3 How motivated are you to look for the mathematics present in your everyday work?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q4 How motivated are you to use a range of physical, graphical and digital tools to aid your mathematical thinking?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q5 How motivated are you to decide if and when to use mathematics in your teaching?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q6 How motivated are you to identify the mathematical skills and concepts in all the learning areas you teach?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q7 How motivated are you to design real-world tasks that require students to apply mathematics in all the learning areas you teach?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q8 How motivated are you to create tasks that help improve both students' numeracy and their understanding of a learning area, e.g. English, or PE?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q9 How motivated are you to identify what physical, graphical or digital tools are needed to help students' mathematical thinking?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q10 How motivated are you to use tasks to promote discussion about the societal importance of mathematics?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q11 How motivated are you to ask students questions that promote their mathematical skills and knowledge?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q12 How motivated are you to give feedback to students on how they can change their mathematical thinking when faced with a new situation?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q13 How motivated are you to encourage students to persevere when applying mathematics to unfamiliar situations?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q14 How motivated are you to demonstrate the use of physical, graphical, and/or digital tools?

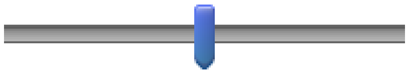
Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q15 How motivated are you to assess students' ability to interpret mathematical information?

Not motivated at all Totally motivated

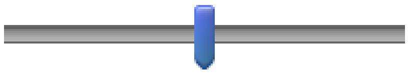
0 10 20 30 40 50 60 70 80 90 100



Q16 How motivated are you to reach out to other teachers for help with understanding mathematical skills and concepts?

Not motivated at all Totally motivated

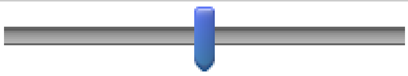
0 10 20 30 40 50 60 70 80 90 100



Q17 How motivated are you to continually look out for new mathematical opportunities that you can use in your teaching?

Not motivated at all Totally motivated

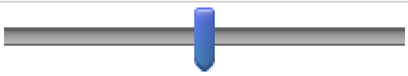
0 10 20 30 40 50 60 70 80 90 100



Q18 How motivated are you to seek feedback on your willingness to apply mathematics in your work as a teacher?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100



Q19 How motivated are you to locate resources to improve your use of physical, graphical, and/or digital tools, e.g. rulers, graphs and/or computers?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

Q20 How motivated are you to use mathematical information and data to evaluate your own teaching performance?

Not motivated at all Totally motivated

0 10 20 30 40 50 60 70 80 90 100

B Demographic Items for PSTs

Q2 Age?

Q3 Gender?

- ○ Male
- ○ Female
- ○ Non-binary

Q4 Which Australian Postcode do you currently live in?

Q5 Are you a Domestic or International student?

- ○ Domestic
- ○ International

Q6 Do you enjoy puzzles, or logic games such as sudoku or chess?

- ○ Yes
- ○ No

Q7 Have you ever tutored other people for Maths?

- ○ Yes
- ○ No

Q8 Do you enjoy programming with languages such as html, java, or c++, or using programs such as Scratch?

- ○ Yes
- ○ No

Q9 Do you enjoy playing a musical instrument?

- ○ Yes
- ○ No

Q10 Please select the maths subject(s) you studied in your final year of school (eg Year 12, VCE, HSC)? If you did not study a maths subject, select none. (To select multiple answers, hold down the cmd or ctrl button)

- ☐ I did not do a maths subject in my final year of school
- ☐ An Australian non-calculus based maths subject
- ☐ An Australian calculus based maths subject
- ☐ An Overseas non-calculus based maths subject
- ☐ An Overseas calculus based maths subject

Q11 Are you studying a Bachelor or Masters degree?

- Bachelor
- Masters

Q12 What level of education are you studying?

- Primary
- Secondary
- P-12
- Early Childhood
- Early Childhood + Primary

13 What stage of your course are you up to?

- First year
- Second year
- Third year
- Fourth year

Q14 What are your teaching specialisations? If none, select none. (To select multiple answers, hold down the cmd or ctrl button)

- ☐ None
- ☐ Generalist Classroom
- ☐ Maths
- ☐ Physics
- ☐ English
- ☐ EAL
- ☐ Student Welfare
- ☐ Special Ed/Disability studies
- ☐ LOTE
- ☐ Middle Years
- ☐ Health
- ☐ PE
- ☐ General Science
- ☐ Chemistry

- [ ] Biology
- [ ] Music
- [ ] Dance
- [ ] Drama
- [ ] Visual Arts
- [ ] Media studies
- [ ] Business studies
- [ ] Humanities
- [ ] Psychology
- [ ] Food Technology
- [ ] Design and Technology
- [ ] Wood Tech
- [ ] Outdoor Education
- [ ] English Literature
- [ ] History

- [ ] Geography
- [ ] Economics
- [ ] Politics
- [ ] Legal Studies
- [ ] Accounting
- [ ] Philosophy
- [ ] SOSE
- [ ] Religious Studies
- [ ] Environmental Science
- [ ] Engineering
- [ ] Visual Communication and Design
- [ ] Digital Technologies (ICT)
- [ ] Digital Media
- [ ] Business management
- [ ] Information and Communication Technology

- ☐ Home economics
- ☐ VET

C Interview questions for TEs

1. What would you consider to be any possible differences between mathematics and numeracy? (what do you think numeracy means?)

2. How would you describe the role that numeracy plays in relation to other subjects such as English etc.

3. What is your perspective of the expectation that all psts should demonstrate a required level of numeracy to become teachers i.e. through tests such as the LANTITE? (do you think psts are numerate enough?) Do you think higher LANTITE equals higher confidence and motivation?

4. What are your thoughts on personal characteristics or academic experiences that motivate ITE students in regard to their own numeracy skills? (interest for example)? Why are some more motivated than others when it comes to being numerate?

5. And for confidence? Why are some more confident than others when it comes to being numerate?

6. What are the key aspects of teaching numeracy that psts need to be able to do? What does teaching numeracy involve?

7. How would you describe the current levels of motivation and confidence of psts when it comes to teaching numeracy? Out of 100? What do you think they are most/least motivated/confident in doing?

8. What about ITE contributes to psts motivation and confidence to teach numeracy? What accounts for the differences in levels of motivation and confidence to teach numeracy among psts?

9. In considering ITE training do you have any thoughts on the type of assistance that psts should receive in becoming teachers of numeracy? What does it involve? What areas could be further developed/introduced? (what does teaching psts how to teach numeracy involve?)

10. How motivated and confident are you in giving psts this assistance? Out of 100?

11. On a personal level could you provide some detail on what might motivate you or give you confidence in helping psts teach numeracy.

D Demographic questions for TEs

Age/Gender: if you're comfortable, prefer but can decline

Experience - number of years of teaching ITE:

Academic background: sessional, online, ongoing, etc

Time at current institution:

Other institutions:

Do you have a maths background - degree, qualifications, teaching experience:

What maths (if any) ITE subjects have you taught:

What other ITE subjects have you taught:

Do any of these subjects have a learning outcome, assessment, content or activities that you think relates to numeracy:

E TE study information form

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

You are invited to participate

You are invited to participate in a research project entitled ***'Preservice teacher motivation and confidence to teach numeracy'.***

This project is being conducted by a student researcher David Clements as part of a PhD study at Victoria University under the supervision of Prof. Anthony Watt from the College of Arts and Education.

Project explanation

In Australia, all teachers are responsible for developing students' numeracy across the curriculum. However, not all teachers may share the same level of ability to teach numeracy. This project investigates to what extent preservice teachers feel confident and motivated to meet this responsibility. An online survey will ask participants to rate their confidence and motivation to teach numeracy and teacher educators will provide expert opinion on issues resulting from the survey.

What will I be asked to do?

Participation in this study is voluntary. As part of your involvement you will be asked to answer some demographic questions and participate in a one on one interview with the researcher to provide your views on preservice teacher confidence and motivation. This should take approximately 30 minutes.

What will I gain from participating?

There will be no direct benefit to you from your involvement in this research. However, your involvement could contribute to improved understanding and development of initial teacher education programs and thus future student numeracy outcomes.

How will the information I give be used?

The information will predominantly be used for the purpose of the student researcher's PhD thesis, as well as resulting publications. All interview data will be audio recorded, transcribed using pseudonyms to maintain confidentiality. Deidentified data will stored in accordance with ethics regulations at Victoria University.

What are the potential risks of participating in this project?

The potential risks of participating in this research are low and considered unlikely to occur. It is possible that participants may feel some unease when answering interview questions about their teaching practices. As mentioned above, the information and data provided in this project will remain confidential. You will also be provided with the opportunity to review the final draft report once completed if you desire by contacting the Chief Investigator, Dr Anthony Watt (9919 4119). If you experience any continuing concerns or anxiousness as an outcome of your involvement in the project, then you may contact registered psychologist Dr Romana Morda of Victoria University, who is available to discuss any of these issues (9919

5223, romana.morda@vu.edu.au). Alternatively, your participation is voluntary and you may withdraw from the research at any time without being penalised.

How will this project be conducted?

Participants will be invited by email, which will reiterate the project information. Consent will be confirmed again at the beginning of the interview.

Who is conducting the study?

Chief Investigator:	Prof. Anthony Watt College of Arts and Education Victoria University, Footscray Park Campus (03) 9919 4119 anthony.watt@vu.edu.au
Investigator:	A. Prof. Alasdar McAndrew College of Arts and Education Victoria University, Footscray Park Campus Email: Alasdair.mcandrew@vu.edu.au
Investigator:	Dr. Jean Hopman College of Arts and Education Victoria University, Footscray Park Campus Email: jean.hopman@vu.edu.au
Student Researcher:	David Clements PhD Candidate (Education) College of Arts and Education Victoria University, Footscray Park Campus david.clements@vu.edu.au

Any queries about your participation in this project may be directed to the Chief Investigator listed above. If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

F PST study information form

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

You are invited to participate

You are invited to participate in a research project entitled ***'Preservice teacher motivation and confidence to teach numeracy'.***

This project is being conducted by a student researcher David Clements as part of a PhD study at Victoria University under the supervision of Prof. Anthony Watt from the College of Arts and Education.

Project explanation

In Australia, all teachers are responsible for developing students' numeracy across the curriculum. However, not all teachers may share the same level of ability to teach numeracy. This project investigates to what extent preservice teachers feel confident and motivated to meet this responsibility. An online survey will ask participants to rate their confidence and motivation to teach numeracy.

What will I be asked to do?

Participation in this study is voluntary. As part of your involvement you will be asked to complete a demographics sheet and a questionnaire rating your confidence and motivation to teach numeracy. This should take approximately 10-15mins.

What will I gain from participating?

There will be no direct benefit to you from your involvement in the research. You may gain new insights into your own levels of motivation and confidence to teach numeracy. Your involvement could support the generation of new insights into improved understanding, and development, of initial teacher education programs and thus, future school student numeracy outcomes.

How will the information I give be used?

The information will predominantly be used for the purpose of the student researcher's PhD thesis, as well as resulting publications. All survey data will remain anonymous and stored securely at Victoria University.

What are the potential risks of participating in this project?

The potential risks of participating in this research are low and considered unlikely. It is possible that participants may feel some unease when undertaking the survey. As mentioned above, the information and data provided in this project will remain anonymous. You will also be provided with the opportunity to review the final draft report once completed if you desire by contacting the Chief Investigator, Dr Anthony Watt (9919 4119). If you experience any continuing concerns or anxiousness as an outcome of your involvement in the project, then you may contact registered psychologist Dr Romana Morda of Victoria University, who is available to discuss any of these issues (9919 5223, romana.morda@vu.edu.au). Alternatively, your participation is voluntary and you may withdraw from the research at any time without being penalised.

How will this project be conducted?

Participants will be invited by email with a link to an online survey, which will reiterate the project information and confirm consent.

Who is conducting the study?

Chief Investigator: Prof. Anthony Watt
College of Arts and Education
Victoria University, Footscray Park Campus
(03) 9919 4119
anthony.watt@vu.edu.au

Investigator: A. Prof. Alasdar McAndrew
College of Arts and Education
Victoria University, Footscray Park Campus
Email: Alasdair.mcandrew@vu.edu.au

Investigator: Dr. Jean Hopman
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Victoria University, Footscray Park Campus
Email: jean.hopman@vu.edu.au

Student Researcher: David Clements
PhD Candidate (Education)
College of Arts and Education
Victoria University, Footscray Park Campus
david.clements@vu.edu.au

Any queries about your participation in this project may be directed to the Chief Investigator listed above. If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

G Ethics clearance

Dear PROF ANTHONY WATT,

Your ethics application has been formally reviewed and finalised.

» Application ID: HRE20-165
» Chief Investigator: PROF ANTHONY WATT
» Other Investigators:
» Application Title: Investigating preservice teacher confidence and motivation to teach numeracy.
» Form Version: 13-07

The application has been accepted and deemed to meet the requirements of the National Health and Medical Research Council (NHMRC) 'National Statement on Ethical Conduct in Human Research (2007)' by the Victoria University Human Research Ethics Committee. Approval has been granted for two (2) years from the approval date; 01/10/2020.

Continued approval of this research project by the Victoria University Human Research Ethics Committee (VUHREC) is conditional upon the provision of a report within 12 months of the above approval date or upon the completion of the project (if earlier). A report proforma may be downloaded from the Office for Research website at: http://research.vu.edu.au/hrec.php.

Please note that the Human Research Ethics Committee must be informed of the following: any changes to the approved research protocol, project timelines, any serious events or adverse and/or unforeseen events that may affect continued ethical acceptability of the project. In these unlikely events, researchers must immediately cease all data collection until the Committee has approved the changes. Researchers are also reminded of the need to notify the approving HREC of changes to personnel in research projects via a request for a minor amendment. It should also be noted that it is the Chief Investigators' responsibility to ensure the research project is conducted in line with the recommendations outlined in the National Health and Medical Research Council (NHMRC) 'National Statement on Ethical Conduct in Human Research (2007).'

On behalf of the Committee, I wish you all the best for the conduct of the project.

Secretary, Human Research Ethics Committee
Phone: 9919 4781 or 9919 4461
Email: researchethics@vu.edu.au