Exploring the Impact on Practice of Secondary Teachers' Beliefs and Attitudes Towards 21st Century Skills and Mathematical Proficiency

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In this paper we report on an aspect of the findings of a larger three-phase study exploring the factors that influence teachers implementing pedagogies that cultivate students' STEM capabilities and 21st century skills. Data were collected through an online questionnaire, semi-structured interviews, focus groups and case studies. This paper will focus on the findings from the first phase of this study and initial analysis of focus groups and semi-structured interviews data. Preliminary findings show that participants hold mixed beliefs concerning student proficiency in mathematics and there are common factors that influence decisions concerning the use of pedagogical practices that support students' mathematical proficiency and the development of students' 21st century skills. These factors include teachers' personal beliefs and attitudes, perceived time and curriculum constraints, student behaviour and students' academic ability.

For more than two decades, policy makers, industry representatives, academics and key stakeholders in education have promoted 21st century skills as an essential component of what students need to learn to be successful in a global society (Goos et al., 2017; Griffin et al., 2012; OECD, 2018, 2019, 2021; Trilling & Fadel, 2009). International mathematics curriculum documents and assessment frameworks such as PISA (OECD, 2018b) and TIMSS (Thomson et al., 2021) have explicitly referenced the importance of providing learning and assessment opportunities for students to demonstrate proficiency in mathematics, especially emphasising their mathematical thinking, reasoning and problem-solving skills (OECD, 2018b; Siemon et al., 2014; Siemon et al., 2018).

Mathematical proficiency is a key aspect of the Australian Curriculum: Mathematics (ACARA, 2022; ACARA, 2017a; Siemon et al, 2018) and refers to a person's ability to understand, communicate and apply mathematical concepts and procedures flexibly, to reason with and solve problems in a variety of contexts (Siemon et al., 2018; Sullivan, n.d.). The National Research Council define mathematical proficiency in a holistic manner including five interrelated components: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition; describing these as the interrelated strands of proficiency (ACARA, 2022b; Kilpatrick et al., 2001). The revised Australian Curriculum: Mathematics Version 9.0, emphasises the importance of all students developing proficiency with the mathematics they are learning, with an expectation of proficiency embedded into content descriptions and achievement standards (ACARA, 2022b).

The term 21st century skills has been universally used to describe the set of abilities and competencies that are essential to thrive in the modern world (Bialik et al., 2015; Trilling & Fadel, 2009; OECD, 2018a; Whitney-Smith et al., 2022). There exist many frameworks through which to define these skills but essentially, they hold much commonality (Bialik et al., 2015; Greenstein, 2012; Griffin et al., 2012; OECD, 2021; Whitney-Smith et al., 2022). Most existing frameworks include reference to the key skills of critical thinking, creativity, collaboration, and communication, coined the 4Cs of 21st century Skills (Greenstein, 2012; OECD, 2021). Several frameworks also include reference to problem-solving, digital literacy, global citizenship and meta-cognition (Bialik et al., 2015; Griffin et al., 2012. 21st century skills are encompassed within the Australian Curriculum: General Capabilities (AC: GC) (ACARA, 2022; Whitney-Smith et. al., 2022). The capabilities encompass more than knowledge and skills, they include behaviours and dispositions (ACARA, 2017b, 2022).

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Teacher beliefs and attitudes towards mathematics can be influenced by the philosophical beliefs they hold about education and impact on decisions made in the planning, programming, and practice of teaching, mathematics (Beswick, 2012, 2016, 2019; Marshman & Goos, 2018; Martinez-Sierra et.al., 2019; Siemon et. al., 2014). There is no consensus on a universal definition for what is a belief (Beswick, 2019; Martinez-Sierra et.al., 2019). For this study, a belief was defined as a set of attitudes, opinions, or convictions that an individual holds to be true about the world, themselves, or others (Martinez-Sierra et. al., 2019). Teacher beliefs about mathematics and mathematics education have been researched extensively (Beswick, 2012, 2019; Marshman & Goos, 2018; Martinez-Sierra et. al., 2019) and play an influential role in the decision-making processes associated with classroom practice (Beswick, 2019; Martinez-Sierra et. al., 2019).

This paper will focus on the specific research questions of the wider study that investigate teachers' beliefs and attitudes towards mathematical proficiency, the role of mathematics in the development of students' 21st century skills, and how teacher beliefs and attitudes, along with other influential factors, impact on teachers' practice.

Methodology

This study involves the integration of both quantitative and qualitative methods adopting an explanatory sequential mixed methods design structure (Creswell, 2015; Creswell & Plano Clark, 2011), through the three phases, using the following approach, as seen in Figure 1. The adoption of a three-phase design was driven by the study's aim to explore and explain teacher beliefs, attitudes and practices towards the role mathematics plays in developing students' STEM capabilities and 21st century skills.

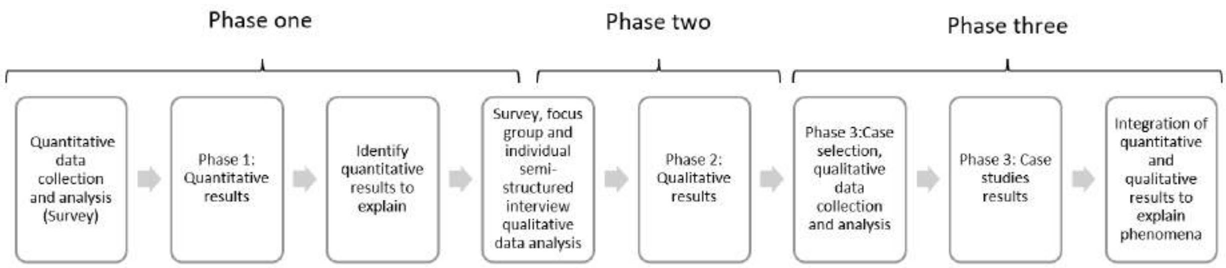

Figure 1. Mixed methods procedural diagram adapted from Creswell (2015).

Data Collection

The data being reported on in this paper were collected in Phases one and two through the following means.

- Phase one: involved an online questionnaire which provided a representative sample (*n*=60). The survey tool consisted of 19 questions, seven relating to teacher background information, six using a five-point Likert scale to elicit ordinal responses and six yes/no responses that provided opportunity for qualitative explanation for the participants' response.
- Phase two: involved purposefully selected semi-structured interviews (*n*=2) and focus groups (*n*=4). Both interview and focus group participants were asked a series of 14 questions about their beliefs, attitudes and practices towards mathematics education.

Participants

This study was conducted in Western Australia involving both regional and metropolitan teachers of Years 7-10 mathematics.

Table 1

Teaching Background of Phase One Survey Participants (N=60)

	Responses			
Current teaching position	Classroom teacher (mathematics)	Head of department (mathematics)	Head of department (other)	No response
	45 (75%)	12 (20%)	1 (1.7%)	2 (3.3%)
Teaching experience	<2 years	3-10 years	11-20 years	21 + years
	8 (13.3%)	23 (38.3%)	13 (21.7%)	14 (23.3%)

Note. One participant was currently teaching mathematics at TAFE and was therefore excluded from the data set in any further analysis.

Focus groups were recruited via the survey instrument and through responses to the original recruitment emails sent to school principals. They consisted of four to six participants, consistent with the recommended focus group size (Creswell, 2015), three involving teachers from the same school and one involving teachers from two neighbouring schools from the same region of Western Australia. Being unsuccessful in recruiting further participants from two participating schools, two independent semi-structured interviews were conducted. The background of focus group and interview participants varied from highly experienced heads of learning area, to graduate, early career and out of field teachers. The school demographics of the participating teachers included both metropolitan (n=4), and regional (n=3); high (1186) and low (895) Index of Community Socio-educational Advantage (ICSEA); selective (n=2) and non-selective (n=5) and schools with a significant number of students from First Nations (27%) and non-English speaking (26%) backgrounds.

Data Analysis

Initial findings from each phase informed the next in a quantitative (Phase one) → Qualitative (Phases two & three) sequential design (Creswell, 2015). This paper focuses on the quantitative analysis of survey data and preliminary findings of Phase two that draw on the analysis of qualitative survey data, focus group and semi-structured interview data using qualitative methods such as thematic analysis (Teddlie & Tashakkori, 2009). For the focus groups and semi-structured interviews, this involved systematically transcribing audio recordings, collating responses into tables and identifying patterns and themes. Codes or labels were identified for an idea or phenomenon such as “time constraints”, “students' academic ability” and “student behaviour”. Codes were mapped to aspects of participants responses and used to facilitate the identification of patterns, themes and meaning (Jackson & Bazeley, 2019; Krueger, 1998).

Results

The following results stem from the analysis of Phase one and an initial analysis of Phase two data as part of the larger study. An analysis of the survey data, including qualitative responses, produced interesting findings regarding teacher beliefs and practices. When asked about their beliefs concerning whether all students are capable of learning mathematics, most 51 (91.1%) participants responded agree or strongly agree, with five (8.9%) participants responding they were undecided or disagreed. In response to whether they believed all mainstream students are capable of reasoning mathematically, most 48 (84.2%) participants agreed or strongly agreed, with six (10.5%) undecided and three (5.3%) disagreeing. Participants were also asked whether they believed that mathematical reasoning was a crucial component of being considered proficient in mathematics, 45 (81.8%) either agreed or strongly agreed, two (3.6 %) disagreed and eight (14.5%) were undecided. Thirty-seven (62.7%) responded "*Yes*" and 22 (37.3%) responded "*No*" when asked whether they taught mathematics content to all their classes through the proficiency strands of conceptual understanding, procedural fluency, authentic problem-solving and mathematical reasoning. Table 2 provides a sample of the qualitative responses given for some of the participants Yes/No responses and their assigned code.

Table 2

Do You Teach Mathematical Content Through the Proficiency Strands with all Your Classes?

Y/N	Please explain your response	
No	The foundational level class would struggle with higher order thinking	A
No	It is easier with students who are motivated	SB
No	Some topics I run out of time to accurately move through each task, often only hitting understanding and fluency and not getting to the rich tasks	T, TS
No	I have a bottom Year 8 and we are really focussed on understanding and fluency	A
No	I look at the content descriptors as a first point of call as this is what the judging standards refer to. The content is packed and it is hard to review everything	CCC
Yes	I try to, it can be a challenge as to which behaviours you are observing and developing	SB
Yes	Attempt to do so but not always successful especially with my lower ability levels	A
Yes	Time constraints sometimes force me to jump to procedures and return to understanding if we have time (especially with classes with more gaps in their foundational understanding)	T, A
Yes	Although I would like to achieve a level of reasoning in all of my classes it can often be hard to achieve with some students as they are still trying to understand the concepts. I usually try to encourage my lower-level classes to feel proficient in the basics of a topic and then we can explore some problem-solving or real-world applications. Not every student will gain the understanding behind the problem-solving task, but some mathematical reasoning is at least being introduced to them.	A
No	I don't do this consciously or explicitly. If it occurs, it is incidental based on the questions in the textbook.	R
No	Conceptual understanding, procedural fluency Yes. Authentic problem-solving, mathematical reasoning, No.	TS

Note. A=Academic; SB=Student Behaviour; T=Time; CCC=Curriculum Content Coverage; R=Resources; TS=Taught Separately.

Question 14 asked whether the mathematical ability of students influenced the pedagogical approach teachers adopted, with 48 (80%) participants responding "*Yes*" and nine (15%) responding "*No*". Qualitative responses supporting a response of "*Yes*" included reference to using more practical activities and concrete materials with low ability classes, with several responses claiming more behaviour problems existed in their streamed low ability classes, causing a reluctance for adopting more innovative teaching practices. One participant responded, "*For example, it's easier to do more problem-solving/rich tasks and group work with extension class because students are interested, motivated and enjoy these type of lessons and tend to take lesser time than students who need to be taught how to work together and work things out*." Another responded, "*low ability students need more Explicit Direct Instruction (EDI) and use concrete materials. They are unlikely to benefit from things like flipped classroom*." This response was similarly presented by a number of respondents such as, "*Weaker classes I use more manipulatives and more able classes more* *modelling and simulation activities*", "*I would use more hands-on materials with students who are struggling and more direct instruction breaking things down*" and "*Lower ability students spend more time learning skills rather than having a discussion or working with how they understanding these skills*." One "*Yes*" response provided the explanation, "*the more mathematical knowledge a student has attained, the less it is necessary to motivate their learning by demonstrating explicitly how the mathematics they are learning is used in the real-world, they begin to appreciate the power and beauty of abstract mathematics*".

In terms of beliefs, attitudes and practices relating to 21st century learning, participants were asked whether they address the Australian Curriculum: General Capabilities within their mathematics teaching programs, 48 (85%) responded "*Yes*" and nine (15%) responded "*No*". Table 3 provides a sample of the qualitative responses given for some of the participants Yes/No responses and their assigned code.

Table 3

Do You Address the Australian Curriculum: General Capabilities Within Your Mathematics Teaching Programs?

Y/N	Please explain your response	
No	Try to. Numeracy is easier than most. Big focus in schools for literacy, very little for numeracy.	NA, L, N
No	Some of the capabilities in most lessons—literacy/numeracy, ICT but probably not all	NA, L, N
No	This is hard to explicitly do	C
Yes	Literacy and numeracy are a given	L, N
Yes	Some are much harder than others to address but I always looking for opportunities to link the lesson work to GCs	C
Yes	Numeracy is addressed when teaching maths	N

Note. C=Challenging; NA=Not All; L=Literacy; N=Numeracy.

Table 4 provides the Likert scale responses concerning the impact of certain factors on participants' pedagogical choices.

Table 4

What Impact do the Following Factors Have on your Pedagogical Choices?

	Extreme	Large	Medium	Small	Nil
Teacher beliefs and attitudes	12 (20%)	27 (45%)	11 (18.3%)	6 (10%)	4 (6.7%)
Behaviour management	9 (15%)	23 (38.3%)	16 (26.7%)	6 (10%)	4 (6.7%)
Students' academic levels	11 (18.3%)	26 (43.3%)	16 (26.7%)	3 (5%)	4 (6.7%)
Time constraints	16 (26.7%)	25 (41.7%)	14 (23.3%)	1 (1.7%)	4 (6.7%)
Curriculum Year level	8 (13.3%)	21 (35%)	18 (30%)	8 (13.3%)	5 (8.3%)

These findings from Phase one, influenced the following Phase two focus group and interview questions, '*Do you believe that proficiency in mathematics is an achievable expectation for all students in junior secondary mathematics*?', '*Do you teach through the proficiency strands with all of your mathematics classes and why or why not*?', '*Who or what influences decisions when it comes to selecting a teaching and learning approach for teaching your lower secondary mathematics classes*?', '*What role do you see mathematics plays, as a school subject, in developing students' General Capabilities?'* and '*Do you consider all three-dimensions of the Australian Curriculum when planning, teaching and assessing students in your lower secondary mathematics classes?'* The initial analysis of Phase two data collected during focus groups and interviews show some emerging themes, consistent with themes emerging from the qualitative survey data such as, time constraints, curriculum and assessment implications, perceived student ability levels, and classroom behaviour management.

Conclusions and Implications

Teachers' beliefs and attitudes need to support the role of mathematics in developing students' 21st century skills and the provision for learning opportunities for all students to develop proficiency with the mathematics they are learning, if the curriculum is to be implemented as intended (ACARA, 2022; OECD, 2021). Given the larger study in which this research sits has adopted a mixed methods approach, findings from the qualitative data collected in Phases two and three of this study will be used to explain the quantitative results of Phase one (Creswell, 2015; Creswell & Plano Clark, 2011; Teddlie & Tashakkori, 2009). Phase one data showed that most teachers 53 (88%) pedagogical choices are influenced by the academic ability of the students in their class, which was also an emerging theme in participant responses during Phase two focus groups and interviews. In Phase one, although 53 (88.3%) surveyed participants responded that they agree or strongly agree mathematics is an integral part of 21st century learning, and 53 (88.3%) either agreed or strongly agreed that the use of real-world and authentic contexts is important, when asked how often they use real-world contexts 29 (48.3%) participants responded either sometimes or rarely and 45 (75%) participants responded that they either sometimes, rarely or never use authentic problem-solving (other than word problems). Time constraints, classroom behaviour, students' academic ability and the pressure of student assessment in mathematics are some of the early themes emerging from the Phase two analysis, in response to questions relating to the factors that influence participants planning and teaching of mathematics. Early findings from Phase two data analysis also show an apparent disparity between several of the respondents' beliefs and attitudes concerning what should happen to what happens in practice. This is consistent with findings from previous studies that suggest an inherent disparity between teachers' classroom practices and their perceptions of best practice (Beswick, 2012; Clark & Lomas 2016).

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