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In a range of meaningful contexts: 25 years of struggle for meaning in mathematics teaching

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The use of meaningful contexts has been a given in New Zealand's mathematics curricula for the last 25 years. They hold a privileged position, but there has been little examination of why they are given this position either nationally or internationally, even though there is solid evidence that the use of contexts and word problems in mathematics is not without implications for equitable access to mathematics, student learning, and assessment of learning. So what are the affordances and constraints of taking the meaningful context approach to mathematics? What has been the impact of taking this approach on student achievement and learning? These are important questions given The New Zealand Curriculum is ten years old and a curriculum review is looming. These questions are being raised to start an essential debate for mathematics education in New Zealand, one that needs to take place prior to any curriculum review so an informed decision on the place and nature of meaningful contexts in future mathematics curricula can be made.

Keywords: Mathematics education, word problems, contexts, problem-solving, assessment.

Introduction

The issue of using contexts or word problems in mathematics is complex (Boaler, 1994). Word problems have constituted an important part of school mathematics worldwide since antiquity (Swetz, 2009) and there are a number of rationales for their use (Verschaffel, Depaepe, & Van Dooren, 2014). In this paper, their use in mathematics education in New Zealand will be examined in some detail. In the first sections, the background of New Zealand's use of meaningful contexts over the last 25 years will be set. Following this, different streams of the international literature on the use of contexts will be explored. A discussion will then sum up the current position and identify questions that need to be addressed if we are to go forward. A brief conclusion follows. As meaningful contexts relate to mathematics taught from Years 1 to 13, and are common throughout mathematics teaching around the world, a broad range of literature will be drawn upon to frame the discussion.

In this paper I present evidence that indicates the way the phrase *meaningful contexts* is interpreted has consequences for learners. This evidence indicates that while the use of meaningful contexts can be beneficial for learners, not all research points to their use being positive in all situations, with how they are used in assessment being particularly problematic. The unregulated use of meaningful contexts may even contribute to systemic underachievement in mathematics by Māori and Pasifika students. I argue that, rather than being a required element in all mathematics teaching, learning, and assessment, the status given to meaningful contexts in *Mathematics in the New Zealand curriculum* (*MiNZC*; Ministry of Education [MOE], 1992) and *The New Zealand curriculum* (*NZC*; MOE, 2007a) should be reconsidered and their use, particularly in assessment, be made the subject of effective practice guidelines.

Background

Meaningful contexts and New Zealand curricula

"In a range of meaningful contexts, students will be engaged in thinking mathematically and statistically. They will solve problems and model situations that require them to…" (MOE, 2007a, n.p.). This phrase is the root of every mathematics achievement objective in *NZC* and sets the expectation that students should learn all mathematics by solving problems and modelling situations, and that these problems and situations should involve meaningful contexts. By stipulating that this pedagogical approach is essential to learning mathematics, the subject is unusual in *NZC*.

The origins of the *meaningful context* phrase can be traced to the previous mathematics curriculum document *MiNZC* (MOE, 1992). In *MiNZC*, a similar but simpler root was used: "Within a range of meaningful contexts, students should be able to:" (e.g., p. 32). *MiNZC* was the first subject developed as part of *The New Zealand Curriculum Framework* (MOE, 1993), the first overhaul of the national curriculum since the 1940s and which had as a major goal to "raise the achievement levels of all students" (p. 3). *MiNZC* emphasised that students needed to be prepared for an increasingly technological and information rich world in which solving novel problems would be the norm. *MiNZC* also clearly stated why meaningful contexts should be used in mathematics:

> In many cases in the past, students have failed to reach their potential because they have not seen the applicability of mathematics to their lives and because they were not encouraged to connect new mathematical concepts and skills to experiences, knowledge, and skills which they already had. This has been particularly true for many girls and for many Māori students, for whom the contexts in which mathematics was presented were irrelevant and inappropriate. These students have developed deeply entrenched negative attitudes towards mathematics as a result. (MOE, 1992, p. 12)

As such, the use of *meaningful contexts* was being stipulated for reasons of equity. They were intended to allow students both to access their prior knowledge when learning mathematics in the classroom and to become proficient users of mathematics in their daily lives.

The influence of learning theory on the use of meaningful contexts

Word problems are a cultural device that reflect a theory of learning; they are epistemological, cognitive, and social accounts deeply embedded in social thought (Lave, 1992). Their use as 'realistic' contexts in current mathematics education builds on the work of Piaget and constructivist theories of learning (Boaler, 1994).

When *MiNZC* (MOE, 1992) and *NZC* (MOE, 2007a) were written, constructivist learning theories based on the ideas of Piaget (e.g., 1953, 1968) and the more recently translated work of Vygotsky (1978) were having a big impact on mathematics educators (Cobb, Yackel, & Wood, 1992). The theoretical perspectives of both Piaget and Vygotsky emphasised that rather than being empty vessels to be filled with teachers' knowledge (Schoenfeld, 1988), students actively construct their own understanding (Cobb, 2007; Hodgen & Wiliam, 2006; Piaget, 1968; Vygotsky, 1978). In Piagetian terms, students learned mathematics through interacting with the world via the processes of assimilation or accommodation – new information was added to one's understanding if it was compatible with what was already known, or caused what was already known to be adapted to cater for the new ideas (Van de

Walle, Karp, & Bay-Williams, 2013). In Vygotskyan terms, students could be inducted into the community of mathematicians through social interaction with a more knowledgeable other in the learners' zone of proximal development – that space in which someone acting as a teacher could help learners grasp new ideas that would be just beyond their reach if working on their own (Van de Walle et al., 2013). From both perspectives, information that could not be linked to what was already known was largely not learned (Piaget, 1953; Van de Walle et al., 2013), hence the importance of meaningful contexts to the learning of mathematics.

In general, three broad rationales are commonly given to justify using 'real' contexts in modern mathematics, the roots of which can be traced to constructivist learning theories. First, using familiar contexts helps make learning more accessible to students and allows them to bring their informal mathematical knowledge into the classroom. Second, they impact on student motivation and interest. Third, they enhance the transfer of learning between school mathematics and the real world (Boaler, 1994; Mack, 1993; Verschaffel et al., 2014). Cockcroft (1982) also indicates that meaningful contexts suit students' needs better as future consumers or workers, thus sending the message that students really will need the mathematics they are learning in school when they grow up (Lave, 1992), the intention being to give meaning to the mathematics so that understanding from outside the classroom could be used "to ground the new mathematics in 'reality.' … This approach has developed as a direct challenge to the traditional idea of simply developing (possibly meaningless) algorithms" (Pirie & Martin, 1997, p. 163). As such, the use of meaningful contexts was closely tied to the reform of mathematics teaching – away from getting students to memorise procedures towards learning mathematics with understanding – and by emphasising the use of meaningful contexts, *MiNZC* (MOE, 1992) and *NZC* (MOE, 2007a) were reflecting an emphasis on contexts found in other influential mathematics education documents of the time (e.g., National Council of Teachers of Mathematics [NCTM] 1989, 2000).

Meaningful contexts and written mathematics

When developing texts, resources, and assessments based on *MiNZC*, developers were faced with the challenge of being limited to print media yet needing to rewrite material to reflect this new emphasis. *MiNZC* stated "(s)tudents learn mathematical thinking most effectively through applying concepts and skills in interesting and realistic contexts which are personally meaningful to them. Thus mathematics is best taught by helping students to solve problems drawn from their own experience" (MOE, 1992, p. 11), but what does a realistic context look like for 30 children or teenagers sitting in a classroom? Or several hundred sitting in an examination hall?

Boaler (1993) points out that from constructivist principles, individual construction of understanding implies it is inappropriate to assume that all students will be familiar with or have similar understandings of a particular context. Sullivan, Zevenbergen, and Mousley (2003) also warn that "(t)he use of relevant situational contexts is an example of a commonly accepted aspect of mathematics teaching that, if not used carefully, has the potential to restrict the mathematical development of some students" (p. 109). This is due to the appropriateness of the task to the socio-cultural background of the student (ethnicity, socio-economic status (SES), gender, personal beliefs, and values). Student interest in the context is also a factor. Mack (1993) gives the example of a student not liking pizza but being happy to engage with a problem if the context was ice cream. Yet these are not all of the potential problems as the specific difficulties of a particular context are not often obvious at the time of writing (Sullivan et al., 2003). Thus there is a "major problem attached to the whole idea of 'real life' associations in mathematics" (Pirie & Martin, 1997, p. 163).

To alleviate these problems, Hill and Edwards (1991) advise that teachers trying "to construct 'real life problems' … need to be careful not to confuse students who already have known methods for working out topics" and suggest it may be better "to select genuine 'real life situations' and ask what mathematical ideas are incorporated, rather than construct and shape the problem to fit the maths idea" (p. 6). Sullivan et al. (2003) suggest items should be trialled for their mathematical suitability, their interest or relevance to the students, their potential motivational impact, and the possibility of negative consequences on or tendency to exclude some students. However, the purpose for using meaningful contexts should also be considered. Restricting contexts to those that can draw out informal knowledge and link mathematics to students' everyday lives can serve "to limit the horizons of those whose horizons are already limited by age, ignorance and context" (Watson, 2004, p. 371). Conversely, if they are to help link mathematics to the real world, the lack of experience with or interest in the situations being provided may mean the students do not or cannot engage at an adequate level. For example, they can be "stumped" when examples require "background general knowledge" that a student does not possess (Hill & Edwards, 1991, p. 28).

This strand of research suggests that contexts need to be carefully considered if they are to support learning or assess what students actually know. However, when writing a book to be used in a classroom or an assessment to be sat in a school hall, the writing process is often constrained to start from a particular piece of mathematics and constructing a context to wrap it in rather than starting from the exploration of genuine situations and the real use of mathematics. This can lead to contexts that are not properly formed, perhaps because the writer does not have a deep understanding of the context they are writing about, or because the real situation is too complex if used realistically, or the creation of contexts that may link better to the life of the writer than to the lives and imaginations of students. In the next section we go on to consider the use of meaningful contexts in assessment in New Zealand.

Meaningful contexts and assessment in New Zealand

New Zealand's first attempt to overhaul its norm-referenced senior secondary school examination system was the introduction of *unit standards* and the *National Certificate* in the 1990s. Instead of sitting exams in Years 11 and 13, and an exam-referenced internally assessed qualification in Year 12, students were supposed to sit a suite of internally assessed competence-based assessments across each of the three years. The mathematics standards, developed to replace the School Certificate exam, Sixth Form Certificate, and the University Bursaries exam, were all based on *MiNZC* (MOE, 1992), so inherited the need to use meaningful contexts. However, rather than providing model assessments, the New Zealand Qualifications Authority (NZQA) charged each school with the responsibility of developing their own assessments and submitting these for moderation prior to their use. Unfortunately, many of these early submissions were rejected during pre-moderation, a common reason being that tasks were not set in meaningful contexts – or in the language of unit standards, they did not require the students to "solve problems". The definitive attempt to resolve this confusion came in 1998, when Sylvia Bishton, the then national moderator for mathematics unit standards, issued the following clarification:

> Solving a problem involves both **choosing** the skills or techniques to apply, AND **applying** them correctly.
>
> Therefore:
>
> - Questions should be in context; these may be real, artificial or mathematical
> - <u>Explanation:</u> *It is important that contexts are accessible to students. Real practical contexts are ideal, but if they are difficult to interpret, artificial contexts are appropriate and acceptable. Mathematical contexts are equally appropriate for unit standards where real contexts are inaccessible and artificial contexts are unduly contrived.*

For new NZQA moderators at the time, myself being one of them, this statement was explained to mean that for practical purposes *real, practical contexts* should be used wherever possible, which in most situations meant that the students needed to be answering word problems for which no method of solution was indicated. That these problems should be interesting and personally meaningful to students, according to *MiNZC* (MOE, 1992), was lost in translation.

This approach to the use of contexts seems to have dominated assessment since then, and was included in New Zealand's second attempt to overhaul the senior secondary assessment system – the introduction of the *National Certificates of Educational Achievement* (NCEA). In this round of reform, senior secondary exams were replaced with a suite of achievement-based *achievement standards*, some of which are internally assessed while others are externally assessed through exams. The pervasive influence of contexts under this system can be best illustrated by two recent and controversial examples. For the first, the managing national assessment review for Parliament's Education and Science Committee notes that the graphing standard (standard number 91028) "has caused problems for years as it has moved from a primarily algebra-based assessment to a primarily contextually based assessment. Getting a relevant and understandable context for an average 15 year-old is not easy" (2015, pp. 41-42). For the second, NZQA changed the style of the questions in the NCEA level 1 mathematics common assessment task (MCAT), an assessment that had previously been focused on measuring students' algebra manipulation skills at the achieved (or pass) level, so it was no longer possible to achieve the standard without applying algebraic procedures in solving problems (NZQA, 2015a):

> To meet the requirement of the standard with respect to solving problems, candidates will not be able to provide evidence by following a direction to solve factorised quadratics, factorise, expand, write or solve a linear equation, or simplify an expression involving the collection of like terms in response to being told to. One part in each question may direct the student to perform such procedures; but without further evidence at Achievement level, this will not be sufficient for the award of the standard. Utilising procedures such as factorising, in simplifying a rational function, or writing an equation from a word problem will provide evidence of solving a problem. Candidates must know that given a word problem, they will be required to write equation(s) and demonstrate consistent use of these in solving a problem.

This tightening of direction for NCEA mathematics assessments was then codified in the 2017 versions of the mathematics achievement standards and supporting documents, with clear statements being made about the centrality of following the intent of the curriculum:

> The style of question needs to be in line with the intent of the curriculum. This involves moving from the previous question style of directed skills application to solving problems that involve selecting and applying the procedures listed in EN 4. This is consistent with the direction of the curriculum document. (NZQA, 2017a)
>
> Problems are situations that provide opportunities to apply knowledge or understanding of mathematical concepts and methods. The situation will be set in a real-life or mathematical context. (NZQA, 2017b)

Table 1 provides examples of real life and mathematical contexts drawn from one of the 2015 MCAT papers, the first paper to incorporate the changes.

Table 1

Examples of problems set in real-life and mathematical contexts

Real-life context	**Mathematical contexts**
Five people on a camp have a stomach bug. The bug spreads at a constant rate *r*. At the end of 3 days, 320 people have the bug. This can be modelled by: $320 = 5r^3$ Find the rate, *r*, at which the bug is spreading (NZQA, 2015b).	Give the coordinates of the points where the graph of $y=x(x+3)$ cuts the *x*-axis (NZQA, 2015b). The volume of a cylinder is given by $V=\pi r^2 h$ and that of a cone is given by $V = \frac{\pi}{3}r^2h$. A cylinder has the same radius as the base of a cone. If the volume of the cylinder is twice that of the cone, give an expression for the ratio of the height of the cylinder to the height of the cone (NZQA, 2015b).

It seems that when examining mathematics in NCEA, NZQA effectively mandates that solving problems means the use of word problems, even though there are no published guidelines about what would make a context meaningful for students. As such, when writing exam papers it seems likely that it is up to individual examiners to make this determination, which can have unfortunate consequences (for example, the "outrage over the level 1 MCAT algebra exam" which left some "students reduced to tears" and others with their "confidence shattered" (Hendery, 2016, p. 1). Can it be said that under such circumstances the 2016 MCAT allowed a valid measurement of all students' understanding? Or that the students were working with contexts that were interesting and meaningful to them?

Word problems are not only a central element of NCEA assessment, but are also heavily featured in other mathematics assessments in New Zealand. They were common in the exemplar tasks in the National Standards (MOE, 2009), and are common in the tasks in the Assessment Resource Banks (New Zealand Council for Educational Research; NZCER, 2016a), the numeracy diagnostic interview (MOE, 2005), and derived assessments like GLOSS (Global Strategy Stage; NZmaths, 2016), as well as in the National Education Monitoring Project (e.g., Flockton, Crooks, Smith, & Smith, 2006), the National Monitoring Study of Student Achievement (MOE, 2015), the Assessment tools for Teaching and Learning (MOE, 2016), and Progressive Achievement Tests (NZCER, 2016b). It seems that students' achievement in mathematics is heavily dependent on their ability to deal with word problems.

Meaningful contexts and international comparative assessment

New Zealand also participates in a number of international comparative assessment programmes that heavily feature word problems. These include:

- the Programme for International Student Assessment (PISA), which is run every three years and assesses the knowledge and skills of 15-year olds in reading literacy, mathematical literacy, and scientific literacy (MOE, 2004);
- the Trends in International Mathematics and Science Study (TIMSS) which is run every four years and measures trends in mathematics and science achievement at fourth and eighth grade (Caygill & Kirkham, 2008); and
- the Adult Literacy and Life Skills (ALL) survey. This survey investigated the distribution of certain skills (such as numeracy and document literacy) among the adult population aged 16 to 65. ALL was a follow-up of the International Adult Literacy Survey) conducted in 1996 which was also run in New Zealand (MOE, 2007b), but did not include numeracy measures.

PISA focuses on measuring "students' capacity to formulate, use and interpret mathematics in a variety of contexts" (Organization for Economic Cooperation and Development [OECD], 2013a, p. 25) as the purpose of mathematical literacy is to assist individuals in recognising the role that mathematics plays in the world, and in making well-founded judgments and decisions needed to be constructive, engaged and reflective citizens (OECD, 2016). To this end, most PISA mathematics units make reference to real-life contexts (OECD, 2016); can students apply what they have learnt in school to non-school environments? (OECD, 2013a). The ALL survey data consider document literacy (discontinuous text, such as graphs, charts, and tables), numeracy (mathematical and numerical information) and problem solving (analytical thinking, reasoning, and logic). This information is typically collected through a respondent providing an answer to a written task set in a practical context (Satherley & Lawes, 2007). TIMSS typically uses a mix of symbolically expressed problems as well as problems expressed in word form (e.g., Garden, 1996).

New Zealand's participation in, and results from such comparative studies are of interest when designing educational policy as we seek to "build a world-leading education system that equips all New Zealanders with the knowledge, skills and values to be successful citizens in the 21st century", and help measure progress towards reducing underachievement in education (May, Cowles, & Lamy, 2013, p. 6). English-based literacy and numeracy, known to be related to higher wages (Earle, 2009), "provide the base for building a competitive, highly skilled and productive workforce" (Tertiary Education Commission, 2009), one able to engage with a knowledge economy and society (Satherley & Lawes, 2009a), a society in which the proportion of unskilled jobs is falling (Parsons & Bynner, 2005):

> The labour-force demands of a modern economy are becoming increasingly complex. If New Zealand is to improve or maintain its position in the world economy, it must develop a workforce with high levels of generic and technical skills. The ALL survey provides an insight into our current skill levels. (Satherley, Lawes, & Sok, 2008, p. 4)

However, at the same time as there is growing international demand for science, technology, engineering and mathematics (STEM) professionals, the number of people studying STEM subjects internationally has been on the decline (Fairweather, 2008; Jolly, 2009). Hence, to help better equip students with high levels of mathematics and science, increased attention is being devoted to understanding why some countries are better at advancing mathematics and science achievement than others (Foley et al., 2017).

It seems that building all learners' understanding of mathematics is an economic imperative. Now the background to our use of meaningful contexts has been set, the next sections move on to consider what various streams of literature have to tell us about meaningful contexts and their use.

Literature

Meaningful contexts as the use of concrete materials or manipulatives

The notion of a meaningful context does not necessarily have to involve a real situation or a word problem. In the Numeracy Development Projects (NDP), new mathematical concepts were intended to be introduced through the use of manipulatives, such as place value blocks or craft sticks. In taking this approach, the NDP was building on the work of Piaget who emphasised the importance of personal exploratory contact with concrete objects for the development of logical thought patterns (Good, 1972). However, the intent of using materials in the NDP was to provide a tool to support and guide students' thinking, which could happen in a number of ways (Higgins, 2005). Firstly, mathematical equipment could act as an external representation of the thinking process when a problem is being solved, so could help a teacher model a way of answering a particular question or a student demonstrate and articulate their strategic thinking. Secondly, equipment could be chosen by a teacher to highlight a critical aspect of a new concept, such as how a tens frame helps structure students' thinking when learning the notion of adding by bridging through ten. Thirdly, equipment could be used as a dialogical support in the negotiation of meaning and in mathematical justification (Higgins, 2005).

By being a visual and external representation that can be touched, manipulated, and talked about, equipment can provide experientially real situations that scaffold mathematical thinking and that can help students understand the concepts behind how mathematical symbols are manipulated (Swan & Marshall, 2010). Use of manipulatives by teachers skilled in their use is also associated with increased student achievement (Carbonneau, Marley, & Selig, 2013; Sowell, 1989) and improved attitudes to mathematics (Sowell, 1989), when compared to symbol-based instruction. In summary, their use is built on constructivist principles, meets at least one of the purposes for using meaningful contexts identified by *MiNZC* (MOE, 1992), and can become meaningful mathematical objects even if they are not familiar to students when first introduced (e.g., place value blocks, pipe decimals. Note: Animations of how many pieces of mathematical equipment can be used to support the learning of mathematical concepts can be found at https://nzmaths.co.nz/equipment-animations). Thus a word problem is not an essential component of a meaningful context when learning mathematics.

Meaningful contexts as a literary genre

"Mathematical word problems are common school devices intended to help students apply classroom learning to the 'real world'" but have not lived up to their promise (Wiest, 2001, p. 74). An example is the common finding that students respond by "unthinkingly applying arithmetic operations suggested by the described situations", even when the situation does not warrant it (Greer, Verschaffel, Van Dooren, & Mukhopadhyay, 2009, p. ix).

One of the reasons for this lack of delivery is that the successful solving of a mathematical word problem requires both mathematical skills and reading comprehension skills (Boonen, de Koning, Jolles, & van der Schoot, 2016; Wijaya, van den Heuvel-Panhuizen, Doormana, & Robitzsch, 2014). Unlike "bare" mathematics problems in which the mathematics can be tackled directly, word problems require additional processing, including working out what mathematics is appropriate to use to solve the problem (Baranes, Perry, & Stigler, 1989). This processing can be best addressed through a four (OECD, 2013a) or a six step (Verschaffel, et al., 2014) modelling/problem-solving approach. In the OECD model, students need to (1) comprehend the task, (2) transform it into a mathematical problem, (3) solve the problem mathematically, and (4) interpret the mathematical solution in relation to the original task (OECD, 2013a; Wijaya et al., 2014). However, a study of errors made by Indonesian students on released PISA 2012 items found that 38% of their errors had to do with understanding the meaning of the tasks so were comprehension errors, while 42% of errors related to transforming the contextual task into a mathematical problem. Relatively few errors related to difficulties using the chosen mathematics (17%) (Wijaya et al., 2014). A different study of bilingual German-Turkish children also found that students' proficiency in the language of testing is predictive of their performance on mathematical word problems, with language proficiency explaining as much of the variation as arithmetic skills (Kempert, Saalbach, & Hardy, 2011). Many of the errors made by children in their study related to creating the mathematical problem to solve, which may have been because the questions asked only used high frequency words and simple grammatical structure (Kempert et al., 2001).

The significance of reading comprehension has also been demonstrated by other studies. For example, the New Zealand 2014/5 TIMSS Year 5 results indicate that average mathematics achievement is higher among students who read every day or almost every day (Caygill, Singh, & Hanlar, 2016). However, even students classed as effective solvers of word problems have been shown to have low performance when the problems are semantically complex (Boonen et al., 2016).

This could explain why using a mathematical modelling approach alone is not enough to help students solve word problems (e.g., Depaepe, De Corte, & Verschaffel, 2010), especially as they progress through school and the problems they meet become semantically more complex (Boonen et al., 2016). In another stream of research, Donaldson (1978) and Lamon (1996) have demonstrated that even minor changes to the wording of a problem, one that does not change the mathematics of the situation, can greatly change the proportion of students who answer it correctly. Moreover, teaching literacy strategies has limited effectiveness. For example, simply decoding the words or extracting an arithmetic operation is not enough (Barwell, 2011), and a key word search can result in the use of the wrong arithmetic operation (Boonen, van der Schoot, van Wesel, de Vries, & Jolles, 2013), or there may not be identifiable word cues in a problem. Rather, students need to develop an appreciation or understanding of the underlying mathematical structure of the various classes of problems they can meet (e.g., the various conceptual structures that underpin multiplication problems) (Barwell, 2011; Mason, Stephens, & Watson, 2009; Verschaffel et al., 2014).

A second explanation for word problems not living up to their promise to connect school mathematics to the real world is that mathematical word problems can be considered a literary genre in their own right (Gerofsky, 1996; Wiest, 2001), one that is “deficient in the rudiments of plot, character, dramatic tension, poetic use of language, moral or social theme” (Gerofsky, 1996, p. 39). Rather than framing real situations that mathematics can be used to solve, many word problems provide “pseudo-real contexts” which “encourage students to see school mathematics as a strange and mysterious language which is of no use to them in the real world” (Boaler, 1994, p. 554). In mathsland, this make-believe world of the school mathematics classroom, common-sense and real-world knowledge are not needed (Boaler, 2008); rather, students are expected to suspend their sense-making (Schoenfeld, 1991), pretend the outlined situation exists, ignore any real-world experience they may have of the situation, and use recently learned mathematics to solve it (Boaler, 1994, 2008; Gerofsky, 1996). This suspension of sense-making is a well-researched and accepted feature of students’ responses to word problems internationally (Greer et al., 2009). Even if the story is of interest to some students, such as a soccer league table, the interest of the student (e.g., knowledge of their favourite team and how it is doing) is likely to be different to the purposes of the teacher (to explore the mathematics of tables) (Nyabanyaba, 1999). The overall effect is that students learn that there is a gap between the artificial world of the school arithmetic problem and the real world (De Corte, Vershaffel, & Greer, 2000), with this student response not being due to cognitive deficit, or blind behaviour, rather students learning to act “in accordance with the ‘rules of the game’” (De Corte et al., 2000, p. 68). For students, it is the ultimate in sense-making, and results in good performance, praise, and minimal conflict (Greer et al., 2009; Schoenfeld, 1991). All they need to learn to do is ignore the context and work only with the numbers, a requirement that Boaler (2008) claims leads to students losing interest in learning mathematics.

Once again it can be said that the factors that affect students’ success with word problems are complex and are not well understood; however, we do know that students need to be taught more than mathematical skills if they are to be successful. The language and accessibility issues raised in this section also suggest that it is important for students not to be left to work on word problems alone or without scaffolding if the situations they are exposed to are intended to be meaningful and students are to have an opportunity to apply the mathematics they know to solve the problem.

Evidence from research: We construct our own understanding

The notion from constructivist learning theory that using familiar contexts helps make learning more accessible to students and allows them to bring their informal mathematical knowledge into the classroom has been widely researched, with the findings aligning closely to theory. For example, Carraher, Carraher, and Schliemann (1985) demonstrated that children working as street vendors in Brazil used different (mental) strategies to those taught at school, and that their achievement in problems embedded in this real-life context was superior to achievement on school-type word problems and context-free computations. There is also strong evidence that school graduates who routinely solve quantitative problems in their work and daily life do not use the mathematical algorithms taught at school; rather they use special-purpose strategies constructed within the specific context (Baranes et al., 1989). This evidence suggests that providing students with word problems does not necessarily help them to learn about how the mathematics they are learning can be applied in real life. Indeed "(h)ow children transfer knowledge between school and the outside world may be the central problem in education" (Baranes et al., 1989, p. 287).

Similar findings were made in research into children's developing understanding of number, in that students were found to use a range of mental strategies to answer problems rather than resort to the formal algorithms they were being taught at school (e.g., Carpenter & Moser, 1983; Fuson, 1992; Steffe, 1988; Steffe, Cobb, & von Glasersfeld, 1988). From this research base a number of reform movements developed, including Cognitively Guided Instruction in the United States (Carpenter, Fennema, & Franke, 1996), Count Me In in Australia (Wright, 1998; Wright & Gould, 2000) and our own NDP. However, while the idea of learning mathematics with understanding has become widely accepted in the mathematics education community, less success has been had in designing teaching environments that enable this to happen: "achieving this goal has been like searching for the Holy Grail. … designing learning environments that successfully promote understanding has been difficult" (Hiebert & Carpenter, 1992, p. 65). Twenty-five years later, this statement is still true, with considerable effort being expended on the problem in the interim. Certainly in New Zealand, the NDP did not lead to the significant learning gains expected of it (Patterson, 2015), and the numeracy strategy in England was also not as successful as it was hoped.

One aspect of our personal construction of understanding that is directly relevant to solving word problems is the evidence that good solvers of word problems generally construct a visual representation or internal model of the problem to facilitate understanding of the problem situation (Boonen et al., 2013; Verschaffel et al., 2014). The production of a good visual-schematic representation is related to a person's spatial skills (skills related to the retrieval, retention, and transformation of visual information in a spatial context) and is grounded in the visual-spatial domain (Boonen et al., 2013). Visual-schematic representations integrate relevant text elements into a coherent mental or drawn visualisation of the problem, as opposed to a drawing sparked by a mental image of an element of the problem. For example, in a problem about a balloon flight, a visual-schematic representation would be an image of the path of the balloon, whereas a pictorial representation would be a picture of the balloon (Boonen et al., 2013).

It seems that mathematical word problems are not only often seen by students as a form of problem with their own special rules, they must also be solved using special mathematics – classroom mathematics, a form of mathematics that can have little relationship to maths in the real world.

Evidence from research: The use of word problems in assessment

"Word problems are a dominant genre in mathematics classrooms in assessing students' ability to solve problems from everyday life", even though research has revealed a range of persistent difficulties associated with their use (Hoogland, Pepin, Bakker, de Koning, & Gravemeijer, 2016, p. 22). Such statements are not new. Cooper and Dunne (2000) argue the taken for granted assumption that relevance and realism are important aspects of educational practice in mathematics that seem to be based "on a general sense of what might plausibly 'work' with children as a whole, or particular groups of children, as on any reference to evidence concerning what actually 'works'" (p. 195). Their review of the national testing system in England found that the use of realistic contexts created differences in achievement that were SES related and which did not exist when decontextualised tasks were used.

Over a 15-year period, a programme of research has indicated that there are issues with "invalidity and/or differential validity" (Cooper & Harries, 2009, p. 106) when using realistic contexts, with contextual items also being able to give false positives and negatives. These findings “should be taken seriously” (p. 108) due to the social class and gender differences in how students respond to contexts. For example, differences found between contextual and purely mathematical items were large enough to make a substantial impact on life chances had the tests studied involved high stakes (Cooper & Dunne, 2000). Girls (Boaler, 1994) and students from working class backgrounds were found to be more likely to use their everyday knowledge in ways not intended by examiners which “might impact on social justice” (Cooper & Harries, 2009, p. 93). Cooper and Harries go further to suggest that test developers would also do well to take cultural differences into account when making decisions about the nature of contextualised assessment items.

Other researchers have found that the type of context used causes different responses and differential levels of success. For example, Wiest (2001) showed that familiar contexts and fantasy contexts can evoke similar levels of achievement, but adult contexts lead to lower levels of achievement. However, the use of fantasy contexts could be controversial in that they could evoke strong negative emotions, especially from students and parents with conservative religious backgrounds.

These findings should be of concern for any country seeking to provide equal opportunities for all members of society.

Evidence from research: Comparative educational performance

The average mathematics score of New Zealand students in TIMSS 2014/5 at Year 5 has increased since 1994, but is not significantly different to those in 2002. Compared with other countries, New Zealand had a high proportion of low performers in 2014/5 (Caygill, Singh, & Hanlar, 2016). Average mathematics scores at Year 9 are statistically unchanged since 1994 (Caygill, Hanlar, & Singh, 2016). At both Years 5 and 9, Māori and Pasifika students had lower average achievement than other ethnic groupings, although this reduced when SES was factored in. Mathematics achievement was higher in schools with more affluent students at both Year 5 and Year 9, with the achievement differences between high and low SES groupings being greater than most other countries in the study (Caygill, Hanlar, & Singh, 2016; Caygill, Singh, & Hanlar, 2016).

The average mathematics score of New Zealand students in PISA has been declining since the country first participated, from 523 in 2003 to 495 in 2015, but is still above the international average (490) (May, Flockton, & Kirkham, 2016). In 2015, the proportion of New Zealand students performing below the level needed to actively participate in mathematics-related life situations (22%) was the same as the OECD average (23%), but was up from 15% in 2003, and there is a relatively high proportion of Māori (36%) and Pasifika (42%) in this figure. The proportion of top students has also declined from 21% (2003) to 11% (2015). New Zealand currently ranks 21st of the 72 nations involved (May et al., 2016). As in previous iterations, there was a large difference in the average scores between students from rich and poor backgrounds, equivalent to more than three years of schooling. Māori students had average scores roughly the same as the poorest 25% of students, while Pasifika students’ averages were lower (Radio New Zealand, 2016). Overall, the average mathematics score for low SES students has fallen from 473 in 2003 to 452 in 2015, although the average of students from high SES backgrounds fell more (from 579 to 540) (May et al., 2016).

ALL results from New Zealand show that English literacy and numeracy are related to a person’s overall educational level, and indicate around 40% of adults in employment have literacy and numeracy below the level needed in a knowledge society and information economy (Earle, 2011). The results also indicate that higher numeracy was related to higher hourly wages (Earle, 2009), whereas adults with low literacy and numeracy in comparison with their job demands were much less likely to have opportunities to undertake non-formal education and workplace training (Earle, 2011). In addition, those with low literacy skills (an amalgamated average across prose literacy, document literacy, numeracy, and problem-solving) are associated with lower physical well-being (Schagen & Lawes, 2009a). This suggests that people with low levels of literacy and numeracy not only have lower earning potential and physical well-being, but fewer opportunities to improve themselves.

ALL results also show that more than half of Māori (Satherley & Lawes, 2009b) and nearly two thirds of Pasifika (Lawes, 2009) did not have the skills for full participation in the knowledge society and economy. However, Māori aged 25-44 and Pasifika aged 25-34, and those who were employed were most likely to have the level of skill needed for such an economy and society (Lawes, 2009; Satherley & Lawes, 2009b). These statistics suggest that many young Māori and Pasifika adults may not have been well served by their mathematical education, and this may be affecting their ability to gain employment.

Overall, the results of these assessment programmes suggest that comparatively, New Zealand mathematics education has not been particularly successful in recent decades, and that the stated goal of raising the achievement of all students (MOE, 1992, 2007a) has not been met. Furthermore, the evidence suggests that mathematical achievement is linked to SES, with Māori and Pasifika being disproportionately represented in low SES statistics. This suggests a social justice issue is involved. However, the predominance of word problems in these assessments and how this might affect the results of Māori and Pasifika has not been considered in the reports, even though research reported above suggests that there is very likely to be an impact, with some causality.

Evidence from research: The influence of affect

As comments throughout this paper indicate, research on the affective elements of teaching and learning mathematics (the attitudes, beliefs, and emotions about mathematics and learning mathematics [McLeod, 1992] that are held by teachers, students, and parents) is also relevant to the use of word problems in mathematics. However, study of this domain is complex as aggregated data that do not separate out population subgroups such as ethnic group and grade tend to show weaker relationships than data that have been differentiated (Ma & Kishor, 1997). For example, when grade levels are combined, only weak relationships between attitudes to mathematics and achievement are found, but when grade levels are compared, the relationship found in the elementary school years is not strong, but becomes strong enough to have practical consequences for students by the secondary school years (Ma & Kishor, 1997). What is studied can also be quite varied. For example, Martino and Zan (2010) highlight how attitudes towards mathematics are related to perceived competence, and how changing the notion of success away from the production of correct and quick answers to the activation of meaningful thought processes can alter a person's emotional disposition to mathematics and their perceived competence. Likewise, Sullivan et al. (2009) identify that a student's sense of what they can achieve can affect their engagement in that students who lack strategies to engage with a task or do not know how to improve their learning can become disengaged. Students need both the will and the skill to engage (Pintrich & de Groot, 1990).

Research has also identified that confidence in one's mathematical ability correlates quite strongly with achievement and enrolment in elective mathematics classes (McLeod, 1992), while anxiety towards mathematics is negatively related to achievement (Hembree, 1990). PISA (2012) data show that for 63 of the 64 education systems reported upon, students reporting higher levels of maths anxiety displayed lower levels of mathematics achievement, that is, anxiety related to doing mathematics and mathematics achievement are negatively related around the globe (OECD, 2013b). Brain science is starting to explain the mechanisms of this. It appears that maths anxiety results in measurable changes in the brain – for example, the anticipation of doing mathematics – can cause greater activity in regions of the brain associated with visceral threat detection, and such worries deplete working memory so students either rely on using low-level but safe strategies or tend to make mistakes when using more advanced strategies (Foley et al., 2017). Maths anxious individuals tend to learn less over the year, and can have difficulty with basic maths tasks, whereas a poor grasp of basic tasks may predispose students to develop anxiety (Foley et al., 2017). Such anxiety may also be infectious, in that children interacting mathematically with maths anxious parents or adults show impaired performance (Boaler, 2015c; Foley et al., 2017).

Mathematical mindset has also been shown to have a large impact on achievement (Boaler, 2015a, 2017; McLeod, 1992). People who attribute success to effort (characterised as having a growth mindset; Boaler, 2015b) believe learning and understanding come through hard work and meeting challenges (Boaler, 2015b; McLeod, 1992). By comparison, people with a fixed mindset attribute success to ability (or lack of ability – I'm just not a maths person) (Boaler, 2015b). People with a fixed mindset tend to give up more easily, can make very limited progress over time (Boaler, 2015b), and can become prone to learned helplessness (McLeod, 1992). Again, brain studies are informing us that this is to do more with self-belief than science as it has been shown that anyone can learn to high levels, and that the brain adapts and grows to the demands put on it (Boaler, 2015a).

Finally, it seems there could be some merit in asking students to talk about what they like working on and doing in mathematics with the goal of creating lessons and learning that are more engaging and inclusive. For example, Sullivan (2010) asked students what type of task they learned best from. The synthesis of responses identified that they liked lessons that used materials and were connected with their lives. They liked lessons with games or had some practical aspect but were also clear that they would rather be given a variety of tasks than a uniform diet (Sullivan, 2010, 2011). It seems that to students, this is what is meant by the phrase *meaningful contexts*, which aligns well to many practices that constructivist theory has theorised as being effective practice for learning mathematics.

Discussion

Different streams of research seem to be telling us that the phrase *meaningful contexts* has a broad rather than a narrow definition, and can encompass the use of manipulatives, materials, games, and practical work – in addition to contexts that are imaginable and engaging or familiar to students. Such contexts have a lot to offer our learners. Certain pedagogies show promise for problems involving unfamiliar contexts, especially where the task is engaging and students can work on it collaboratively, and teachers use students' solution methods to scaffold the introduction of important mathematics (Sullivan, 2010, 2011). These elements reduce the risk of task unfamiliarity through the use of shared wisdom. Tasks with such characteristics are often called rich tasks, and give students the opportunity to develop both strategic competence and adaptive reasoning; they are the focus of classroom work and are deliberately designed to create a potential for learning (Sullivan, 2010, 2011). Another strategy that is potentially useful is to encourage students to read the problem and reflect on what the problem "looks like." Teachers could scaffold this by encouraging younger children to use manipulatives to model the problem or by asking older students "what do you see in your head for this problem?" or "can you make a diagram to show what is going on?"

However, there is good evidence that word problems based on unfamiliar contexts, ones with considerations of authenticity (Hoogland et al., 2016) and which require a suspension of sense-making (Schoenfeld, 1991), the kind that dominate our text books and assessments, can have a very damaging effect on mathematics learning. Maybe we should call them *meaningless contexts* to ensure they are not mistaken for contexts that can enhance learning (see Table 2 for an example). Contexts of this form do not align with the reasons for introducing meaningful contexts outlined in *MiNZC* (MOE, 1992), so perhaps their use should be subject to effective practice guidelines. Here are some simple guidelines for suitable contexts suggested by van den Heuvel-Panhuizen (2005) writing about assessment in relation to Realistic Mathematics Education in the Netherlands. These could provide a starting point for developing our own guidelines for writers and users of contexts. Problems must be meaningful to students, therefore accessible, inviting, and worthwhile to solve. They need to be transparent, and allow students to show what they know (so can be solved in a variety of ways at different levels). They need to provide both a good question and a good context.

Table 2. *An example of a meaningless context in action*

<table>
<tr><th>Meaningful context</th><th>Meaningless context</th></tr>
<tr><td>The maths is in a context in which the mathematics is useful and helps us understand/learn something more about the situation than we currently do.</td><td>Easy to respond to if we ignore the context and just do the maths.

For the stomach bug question (below), solving the provided equation to establish that $r = 4$ is relatively straightforward.</td></tr>
<tr><td colspan="2">Five people on a camp have a stomach bug. The bug spreads at a constant rate r. At the end of 3 days, 320 people have the bug. This can be modelled by: $320 = 5r^3$ Find the rate, r, at which the bug is spreading (NZQA, 2015b).</td></tr>
<tr><td colspan="2">Treating the problem as a real situation
Start by attempting to make sense of the situation and bring your existing knowledge to bear:
Is this for real? Huge camp. Never been on a school camp with more than 100 students at a time.
This outbreak has health and safety implications that we should research.
Bug seems to spread by human contact, and victims seem to become contagious very quickly.
What is the source of the infection? Did those 5 bring it with them – if so, this suggests an incubation period (which the provided equation seems to contradict). If on camp, then an additional source of infection may need to be found (which the provided equation seems to ignore).
How serious is the bug? Cramps and nausea? Vomiting and frequent toilet visits? Even with 20 victims (at the end of day 1) this could put a strain on the toilets and toilet paper supply.
320 victims after 3 days. Was nothing being done to contain the outbreak?
Camps are relatively closed eco-systems, so it should be possible to contain the outbreak.
With 320 victims after 3 days, the bug must be running out of new victims, so why is Liebig's law of the minimum not taking effect?
Next try to make sense of the mathematics:
The mathematics provided ($320 = 5r^3$) is not really a mathematical model. It would be better to say that the statistics collected on the number of cases could be used to create an equation to work out the bug's rate of spread.</td></tr>
</table>

- The initial condition (*t* = 0) is *n* = 5, which is where the 5 in the equation comes from.
- *r* is a rate of spread, so would have units of 'new cases per unit time'. The only time interval mentioned is days, so the cubed in the equation seems to come from the three days of the infection, creating the model: number of new cases = $5(4)^t$.
- It is not clear if existing victims continue to be infectious, in which case each victim is infecting an average of 3 people per day, or if they are only infectious for 24 hours, so are infecting 4 people per day. This has a big impact on the interpretation of the numbers the model creates.

Much of which seems to require an understanding of mathematics beyond the limits of standard 91027.

The research also makes it clear that mathematics teachers need not only to deal with teaching the subject, but also with students' emotions surrounding mathematics, their perceptions of the nature of mathematics, and their perceived competence (Martino & Zan, 2010). It seems likely that students struggling with mathematics, possibly due to reading comprehension or second language issues that may relate to low SES and/or immigrant backgrounds, may become disheartened by the prevalence of unfamiliar contexts and word problems in mathematics that do not make sense. For their parents, this could be an easily recognised experience of helplessness, acknowledgement of which may lead to generational transmission. The prevalence of such meaningless contexts in assessment could also come to be seen as an institutionalised and systematic policy of exclusion and marginalisation of certain groups.

The research on the use of contexts in assessment has particular implications for NCEA and high stakes assessment, and is strongly related to whether or not the context is familiar to students, and if familiar, to which students it is familiar. On one hand we could argue that if knowledge of a context is not likely to be fairly distributed, the use of unfamiliar contexts may create fairer questions in that fewer students will be advantaged (or disadvantaged) by knowledge of them. This would allow the use of adult contexts that could supposedly measure the ability of the student to transfer their classroom learning to the real world, as PISA aims to do. However, on the other hand, if we take this path (with any assessment, not just NCEA), we must expect that certain societal groups, such as second language learners and those from low SES backgrounds, will continue to be identified as low achievers, this being a reflection of the question style rather than any lack in the identified groups. Yet can such tasks provide a valid and reliable measure of mathematics achievement? Should mathematics assessment test what students can and cannot do or, given the argument that word problems tend to provide "pseudo-real" contexts that students need to take at face value (see table 2), should it measure the ability to transfer mathematics to unfamiliar word problems that may not be understood and are not perceived to relate to the real world? Such questions need to be openly debated and resolved if mathematics assessment is to become fairer.

It also seems important for writers of word problems to have a deep and connected understanding of the context in which they incorporate mathematics as well as have a clear understanding of the relationship between street mathematics and school mathematics if they are to create a problem that is meaningful and realistic for students. Maybe another example, one that could be turned into an NCEA question, can illustrate this point:

> Freda [an attempt to make the context gender neutral] is making a new gate for her front path, so wants to make sure the corners are right angles. To do this she is using mathematics [we cannot give a clue about using Pythagoras's theorem or other relevant mathematics even if this is in the title of the standard]; here are the measurements of the sides and diagonals of the gate, do some calculations help her prove (etc.).

This is a mathematically real use of Pythagoras' theorem from a mathematical point of view, and if the student used Pythagoras' theorem, they could be marked correct if this is one of the pieces of mathematics the standard is designed to assess. However, a builder's offspring would likely ask "why didn't she just say the diagonals of the gate are equal so the gate is square?"

Perhaps the real issue with the use of word problems in assessment is more to do with attempts to align assessment to curricula without fully understanding the intent of the curriculum. If meaningful contexts were and are promoted by the curriculum as they assist learning with understanding, what is their role in assessment? Should they have one and who should make this decision? If (certain types of) context have an important role, should all mathematics assessments require their use? Or should specific standards or assessments seek to measure the ability to work with meaningful contexts to avoid mathematics assessment degenerating into a repeated assessment of the same skill? (This latter situation already has a precedent. In the early years of unit standard assessment in mathematics, the pass/fail criteria often degenerated into a measure of the appropriate use of rounding and the use of measurement units rather than the intended mathematics in a standard. This was only overcome by designating specific standards for measuring these skills, and excluding them from consideration in others.)

All of these are important questions that may need to be addressed at a policy rather than at an implementation level because current evidence and practice point towards serious consequences for groups of learners when it is assumed that constructivist learning theory applies to assessment, especially high-stakes assessment.

To summarise, the use of word problems as meaningful contexts requires additional processing that can make the learning of mathematics less accessible (Baranes et al., 1989) and fair assessment problematic (Cooper & Harries, 2009). The research suggests that when addressing a word problem, students can be considered to be working with three independent but interacting elements: the written language (and its level of complexity); the problem situation (the context and how well it is specified); and the mathematics (which includes words with specialist mathematical meanings, the numbers and how they are related to each other, and the problem structure), all of which can be more or less familiar (Figure 1).

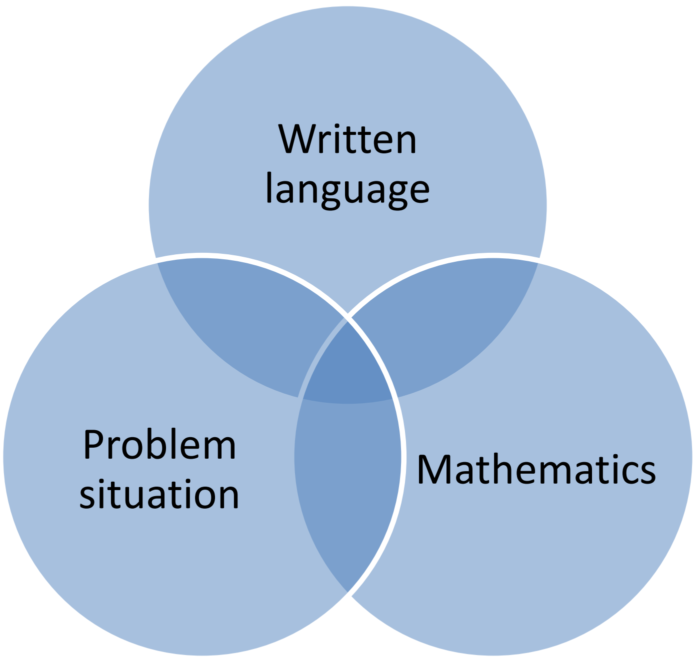

Figure 1. An interactional model for working on a word problem

However, the interaction of these elements is not well understood. For example, there is good evidence that the solution of word problems is dependent on reading comprehension (e.g., Boonen et al., 2016), which is part of the language variable; however, language learning strategies such as the key word strategy have limited value (e.g., Boonen et al., 2013; Verschaffel, et al., 2014). This suggests that the knowledge of an English teacher would be helpful in terms of developing reading comprehension, but would be of limited value when seeking to raise mathematics achievement. Rather, being able to unpack the interaction of the written language and the mathematics to identify the specific mathematical structure of the problem seems more significant (Boonen et al., 2013), a task better suited to a mathematics teacher. Even better would be to work in the intersection of all three to create a visual representation of the problem situation from the language in the problem, one that relates to the mathematical structure of the problem and supports the use of appropriate mathematics. However, it seems the mechanics of these aspects of responding to word problems have yet to be well studied and are certainly not covered in New Zealand's current textbooks.

Another way of looking at the interaction of these three bodies of knowledge, one with strong explanatory power for how a student answers word problems, is graphically (Figure 2). In this model, zero knowledge is at the origin, and the solution of a particular word problem is located in three dimensional space, through finding the right balance between the bodies of knowledge, a balance which of course changes from problem to problem. However, as it is likely that, for example, a variety of mathematical solution techniques is possible for most problems, so the solution space is likely to be a region rather than a point in space. The model helps explain how a student with limited mathematics might rely strongly on their knowledge of the problem situation (e.g., Cooper & Harries, 2009); they are effectively solving the problem in two-dimensional space. In a more extreme case, a learner with limited knowledge of the problem situation and low reading comprehension is left with effectively guessing the mathematics to use for the problem (e.g., Greer et al., 2009).

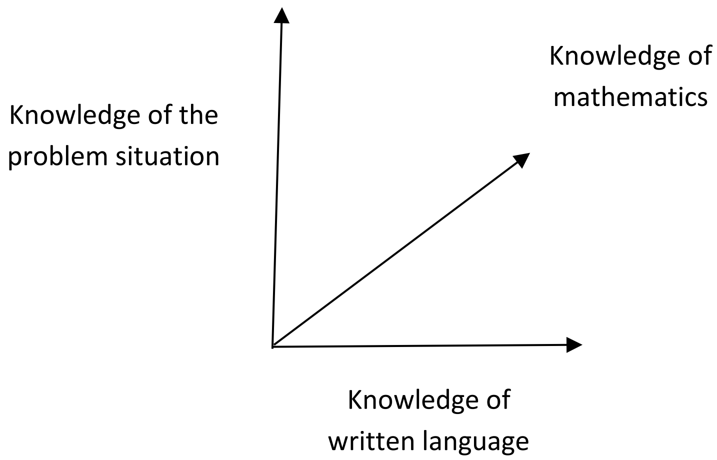

Figure 2. A graphical model for working on a word problem

One way forward may be to acknowledge that, when learning mathematics, not every problem needs a context (Meyer, Dekker, & Querelle, 2001). Certainly recording the numbers of a choral count in threes (e.g., see Averill, Anderson, & Drake, 2015), starting from three, and looking for patterns in the numbers is a deeply mathematical activity that helps students see the mathematical structure underlying the multiples of three and the power of looking for patterns in collections of numbers. And is developing students' number sense – their ability to look at numbers (such as 42 and 72) and see relationships and connections between them – not part of developing a mathematical mind? If we are always focusing on unpacking word problems, when do students, for example, get to explore prime numbers by working on the sieve of Eratosthenes?

Conclusion

The original intent for using meaningful contexts when teaching mathematics in New Zealand was a good one. They would help students learn and reduce inequity (MOE, 1992). However, there has been a lack of debate in New Zealand as to what comprises a meaningful context, which has made it possible for, over time, these purposes to be lost. There has also been a lack of New Zealand-based research into what constitutes a meaningful context, meaning no guidelines have been developed to help writers produce contexts that are meaningful for learners. Rather, a *laissez faire* approach has prevailed, with anything written in a word context being "good enough". Fortunately, a wealth of international research is available, especially from Dutch researchers whose mathematics education system is similarly focused on using contextual problems through Realistic Mathematics Education (Treffers & Beishuizen, 1999), some of which have informed the development of this paper.

The degree to which a context influences students' performance is widely underestimated (Boaler, 1993). There is now a body of robust empirical evidence that shows the disconnect between mathematical word problems and the real world (De Corte et al., 2000). Word problems have also been demonstrated to inaccurately measure a person's knowledge of mathematics and disadvantage particular groups, including students from low SES backgrounds, students with low language proficiency, second language learners, and girls. "The reported difficulties with word problems are so persistent" it has caused some researchers to seek an alternative (Hoogland et al., 2016).

New Zealand is fast becoming a part of a global multicultural society, one in which those with low educational outcomes are disadvantaged, marginalised and not able to fully participate (e.g., Earle, 2011; Satherley et al., 2008). Our participation in international comparative assessment programmes, which provide a measure of our preparedness for this new society, strongly indicate that Māori, Pasifika, and students from low SES backgrounds are persistently over-represented among our lowest achievers in mathematics (e.g., Lawes, 2009; Satherley & Lawes, 2009a), which has the effect of excluding them from many high-status careers, affecting their earnings potential and well-being, thus helping form a poverty cycle from which it is hard to escape.

Our participation in international comparative assessment programmes has also demonstrated that our approach to mathematics education has not led to the hoped for rise in achievement over the last 25 years (e.g., Caygill, Hanlar, & Singh, 2016), suggesting the fundamentals of that approach should be re-examined. Furthermore, the international results from PISA (2012) indicate that associations among all students:

> …regardless of their performance in mathematics … students who reported having been more frequently exposed to pure mathematics problems reported a greater sense of belonging, more positive attitudes towards school, greater perseverance, greater

> openness to problem solving, greater intrinsic and instrumental motivation to learn mathematics, greater mathematics self-efficacy, a higher self-concept, and lower mathematics anxiety. The relationship between experience with applied mathematics problems and students' engagement, drive, motivation, and self-beliefs is positive, but weaker than that estimated between experience with pure mathematics problems and students' engagement, drive, motivation and self-beliefs. (OECD, 2013b, p. 129)

Isn't the body of evidence surrounding the use of word problems in mathematics education enough for us now to question their unrestricted and indiscriminate use? Furthermore, in an educational environment that is promoting "achievement for all", and in light of the research presented above, is the maintenance of an assessment system that mandates the use of word problems in mathematics morally defensible? Can we categorically say that the current use of word problems in mathematics assessments is *not* a factor in Māori and Pasifika underachievement? Are we certain that our assessment practice is not affecting access to higher education for children from low SES backgrounds? For myself, I think now is the time for us to take a long hard look at this historical and "taken for granted" cultural practice, and consider how it may be contributing to our societal problems rather than alleviating them. In doing so, we may be able to truly develop a system of mathematics education that is more inclusive and which leads to everyone being able to become confident mathematicians.

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