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Numeracy in paramedicine education: a literature review

Andrew Bell
University of Southern Queensland
Ipswich Campus, Australia
<Andrew.Bell@usq.edu.au>
Linda Galligan
University of Southern Queensland
Toowoomba Campus, Australia
< Linda.Galligan@usq.edu.au>
John Latham
University of Southern Queensland
Ipswich Campus, Australia
< John.Latham@usq.edu.au>

Abstract

The introduction of paramedical science into universities has led to unprecedented enrolment numbers in Australian undergraduate paramedical science programs. At the same time however, there has been an associated increase in complexity of student learning expectations and requirements. One area of paramedical education that is proving challenging for universities is the numeracy preparedness of students and how to best support students in this area.

To examine how universities may begin to address the current challenges related to improving the numeracy of paramedical science students, this paper investigates the literature on the numeracy of paramedics and the underlying mathematical skills required for their programs of study. It also reviews the support programs that are available at university and considers how much these are reflecting effective pedagogies. The aim of this review is to identify ways numeracy and numeracy teaching in paramedical science may be improved and highlight possible directions for future research in this area.

Key words: paramedicine; paramedicine education; clinical education; numeracy; curriculum.

Introduction to paramedicine research

Since the turn of the century, paramedicine in Australia has gone through a professional transition. As is occurring in other Western nations, such as the UK, US and Canada, the education of paramedics, once administered through ‘in-house’ (adult) vocational training programs, is now administered by universities through specific paramedical science degree programs (Devenish, 2014; O'Meara, Maguire, Jennings, & Simpson, 2015; Thompson, Grantham, & Houston, 2015). This educational transition has also invariably influenced the scrutiny of what has now become a ‘professional practice’, with the concomitant development of a specific research agenda arising to examine the practices of the profession and guide the development of education programs that address both contemporary university student needs and contemporary community health issues.

As paramedical education has moved into the realm of universities, the curricula have been evolving to ensure academic rigour while at the same time seeking to meet a distinct set of industry practice needs. This includes accurate use of numeracy skills particularly in the area of drug calculations, where accuracy of 100% is the industry expectation. Tertiary education providers have, for example, in recent years increased the depth, breadth and consistency of curricula, with delivery by subject experts who have training in education and applied clinical health (Thompson et al., 2015). Indeed, the introduction of paramedical science into universities and the ongoing development of curricula to address contemporary health and education needs has led to unprecedented enrolment numbers in Australian undergraduate paramedical science programs (Thompson et al., 2015). Recent research suggests that the commencing paramedical science student population is dominated by young adults under 25 years of age, with a high proportion of dual qualified students, whether studying concurrently with nursing or those who have qualifications from previous tertiary studies (Hallam et al., 2016; Laing, Devenish, Lim, & Tippett, 2014; O'Meara, Williams, Dicker, & Hickson, 2014; Williams et al., 2013; Williams, Fielder, Strong, Acker, & Thompson, 2015). The authors have also observed that there is also a smaller population of students that are returning to study as mature aged students or transferring from allied industries such as nursing. With this increase in student numbers, however, there has been an associated increase in complexity of student learning expectations and requirements, and the related challenges of producing work-ready graduates within traditional academic curricula frameworks. Indeed, one area of paramedical education that is proving challenging for universities is the numeracy readiness of students and related numeracy education.

In the development of mathematics-related curricula for paramedical science, some educational elements that have proved successful in other areas of health care areas may also be applied to paramedicine education as there are many parallels between these other areas and paramedic practice. For example, like other medical professionals, paramedics perform a range of physically invasive treatments to their patients, such as drug administration which involves a degree of applied numeracy and associated drug calculation error risk (Bell & Latham, 2018). At the same time, however, the context in which paramedics operate is relatively unique and this means there is also a need to design curricula that recognises and responds to this unique context. For example, while most other disciplines are predominantly seen as ‘in-hospital’ based, paramedicine is unique in that it embodies ‘pre-hospital’ clinicians (Williams & Webb, 2015). This ‘pre-hospital’ context means the pressures on paramedics differ from those of other health care professionals. In treating patients, paramedics are frequently required to make rapid decisions under time critical, high-pressure circumstances where delay in treatment could have adverse effects for the patient. In this uncontrolled, dynamic environment, distractions such as bystanders, loud noise, poor lighting and other situational stresses are also often compounding factors, and diagnostic information, clinical support and resources may be limited (K. J. Eastwood, Boyle, Kim, Stam, & Williams, 2015; Williams et al., 2015). In the administration of drugs in the applied pre-hospital setting, such as the side of the road at a motor vehicle incident, calculations involving the use of set formulae are regularly performed without the aid of a calculator; and mistakes in the dose/volume can be the difference between life and death of the patient, or may lead to the unnecessary prolonging of pain (Bell & Latham, 2018).

The need to develop specialised curricula and a separate research agenda that reflect the nuances of the field which are distinct from, but complementary to, other medical disciplines has been recognised internationally through efforts to advance out-of-hospital and educational research agendas in Australia, Europe and North America (Devenish, 2014; O'Meara, 2011; O'Meara et al., 2015). Compared to other health professions, however, that have developed distinct bodies of professional knowledge and theory to help guide their members, the literature relating to paramedical education and practice is still in its infancy. This immature educational development includes the use of numeracy in the clinical setting and its ongoing development is seen as an essential component of the skill set of a professional paramedic. To examine how universities may begin to address the current challenges related to improving the numeracy of paramedical science students, this paper investigates the literature on the numeracy of paramedics and the underlying mathematical skills required, and reviews what programs are available at university and how much these are reflecting effective pedagogies. The aim of this review to identify how numeracy and numeracy teaching in paramedical science may be improved, thus highlighting directions for future research in this area.

Numeracy skills of paramedics

Numeracy is an umbrella term that means to be literate in mathematics (Wilkins, 2016). While the words *mathematics* and *numeracy* are often used interchangeably, they are not the same thing. Evans, Wedege & Yasukawa, (2013) contend that it is not easy to discriminate between the different notions of numeracy and that in fact numeracy can provide a connection between mathematics and adult life. Dalby (2017) also concludes that numeracy does not refer to just a simplified presentation of mathematics but is defined further by the way a person utilises it. Johnston states (1994, p. 34), "numeracy is a critical awareness which builds bridges between mathematics and the real world, with all its diversity… In this sense … there is no particular 'level' of mathematics associated with [numeracy]". In the academic context, teaching numeracy thus requires that students are able to, in a given situation (such as a paramedical scenario), choose suitable mathematics to use and at the appropriate level as required by the context/situation, apply the mathematics competently and confidently, and ensure that the solution fits the situation (Galligan, 2011; Wilkins, 2016).

To be effective health care workers, paramedics must feel confident in their abilities to work in highly stressful and unpredictable scenarios; and this includes being able to accurately complete mathematical calculations whilst under pressure. Indeed, while it has been acknowledged that nurses need to be numerate under pressure (Coben et al., 2008), paramedics' numeracy is more specific in a time critical, high stress decision making environment (Bell & Latham, 2018). Laying the groundwork in numeracy during the undergraduate programs thus plays a crucial role in preparing paramedics for professional practice. Paramedicine education programs need to ensure students are able to successfully negotiate medical calculations by applying a range of basic mathematics skills, including mental operations (addition, subtraction, multiplication, and division), fractions, percentages and decimals, ratios and proportions, algebra, unit conversions and worded problems. The poor performance in mathematical calculations demonstrated by practicing paramedics and paramedical science students indeed highlights a need for greater – and potentially more effectively designed – mathematics education during undergraduate paramedical science degrees (Boyle & Eastwood, 2018).

An ability to accurately perform mathematical calculations without assistance from technology or calculation tools, as well as in a manner that is appropriate to the situation is an essential skill for all health professionals undertaking patient management. Indeed, the inability to perform accurate calculations may result in a compromise of patient safety, potentially leading to an under-dosing, over-dosing, or a major adverse event, such as death. As with other areas of health care, mathematical calculations are a fundamental component of paramedic practice, used to determine, for example, factors such as joules for defibrillation, endotracheal tube size, fluid resuscitation volumes, laryngeal mask size, and dosage requirements as based on a person's age, weight, or vital signs (Boyle & Eastwood, 2018; K. J. Eastwood et al., 2015). It is assumed that when paramedics administer drugs to patients, their drug dosage calculation are always 100% accurate (K. Eastwood, Boyle, & Williams, 2012); however the often uncontrolled and dynamic conditions within which paramedics typically operate can complicate the ability to provide accurate assessments as high stress environments can exacerbate mathematical deficiencies (K. J. Eastwood et al., 2015). For these reasons it is critically important that students studying paramedical science achieve mastery over the mathematics required to perform paramedical-related calculations, as well as confidence in applying the mathematics appropriately as required by the situation. Goliath (2007), concludes that champions of mastery learning such as Keller and Bloom consider that learners benefit maximally from instruction under conditions of good, qualitative instruction that is varied in relation to the learners' pace. Furthermore, although calculation aides or aide-memoire (such as calculators, mobile phones, calculation charts and paediatric tapes) may be used to support mathematical calculations, paramedics in the field regularly encounter situations where these aides may not be readily accessible or suitable (Bell & Latham, 2018; Boyle & Eastwood, 2018). As such, paramedics need to be able to conduct mathematical calculations without computational aides and to high standards of accuracy.

Despite the central role that numeracy plays in delivering sound patient care in paramedical practice, research conducted both locally and internationally has revealed alarmingly low levels of accuracy in the unaided mathematical calculations performed by paramedics and paramedical science students (Bernius, Thibodeau, Jones, Clothier, & Witting, 2008; Boyle & Eastwood, 2018; K. Eastwood et al., 2012; K. J. Eastwood, Boyle, & Williams, 2009; Hubble, Pascal, & Sanders, 2000; Leblanc, Mcarthur, King, & Lepine, 2005). Such research has found that calculation errors are among the most prominent medication errors in paramedic science (Crossman, 2009). In fact, it has been suggested that in a classroom setting, calculation and drug administration errors are likely to occur in up to half of all dosage calculations (Boyle & Eastwood, 2018; K. Eastwood et al., 2012). Such findings indeed highlight a problem in the paramedical science discipline, particularly when compared to research from other health fields, such as nursing, where, for example, research has concluded that there is little evidence that medication errors in nursing practice are caused by errors in calculation (Sneck, Saarnio, Isola, & Boigu, 2016; Wright, 2010).

While dosage errors in paramedic practice may be a result of the high pressure environments in which paramedics operate, research has shown that such errors may also be a result of factors that include skills decay in practicing paramedics (the loss of the ability to undertake manual calculations over time) (Boyle & Eastwood, 2018), pessimistic attitudes towards mathematics (K. Eastwood et al., 2012; K. J. Eastwood et al., 2015) and confidence (Harris et al., 2017). In many cases, such pessimistic attitudes and confidence – or lack thereof – can manifest as a result of mathematics anxiety. Mathematics anxiety is a well-documented occurrence across science and health disciplines both at the university and practice level (Bull, 2009; Choudhary & Malthus, 2017; Glaister, 2007; Williams & Davis, 2016). It is a feeling of tension, apprehension, or fear that not only interferes with mathematics performance (for example it can lead to poor performance on mathematics achievement tests), but it can also have a profound, negative impact on the acquisition and comprehension of new information (Ashcroft, 2002; Caffey, Crane, & Ireland, 2016; Hembree, 1990) and has been found to contribute to medication errors conducted in practice (Bull, 2009; Caffey et al., 2016; Choudhary & Malthus, 2017; Glaister, 2007; McMullan, Jones, & Lea, 2012; Williams & Davis, 2016). From a paramedical science perspective, research has found that dosage and ratio calculations are two aspects of practice that students feel most anxious about (Caffey et al., 2016); and one of the biggest fears paramedic students have regarding the commencement of a career in paramedicine is making a clinical mistake (Holmes, Jones, Brightwell, & Cohen, 2017).

Perhaps one of the most worrying findings to emerge from research investigating numeracy in paramedic practice and paramedicine education is the finding that the majority of mathematical errors result from a fundamental lack of understanding of mathematics (Boyle & Eastwood, 2018; K. Eastwood et al., 2012; K. J. Eastwood et al., 2015; K. J. Eastwood et al., 2009). This means that these errors are not simply random errors that may occur when one is distracted (such as basic computational errors in addition, subtraction, multiplication and division). Instead, they arise from either the inability to formulate an equation (conceptual errors) or the inability to operate an equation (arithmetic errors). This further means that by their very nature – as a product arising from lack of mathematical understanding – these errors will occur every time a calculation is attempted (K. J. Eastwood et al., 2015).

Such findings highlight an insufficient level of understanding of basic mathematical principles across the paramedical science discipline. Yet, from an Australian context, perhaps these results are not surprising given that most universities in Australia do not have mathematics as a pre-requisite for entry into their paramedical science degrees. Of the fifteen universities that offer a degree program in paramedical science in Australia, eleven do not have mathematics as a pre-requisite; and while two other universities do include mathematics as a pre-requisite, it is only included in a list of subjects from which students choose their pre-requisites, meaning they do not actually have to select final year high school mathematics as a pre-requisite. In a small number of the degrees, mathematics is listed as a recommended subject (a subject in which students are recommended to have a passing grade prior to enrolment in the degree), assumed knowledge (a subject that a student is assumed to have passed in completing their year 11 and 12 high school certificate or Australian Tertiary Admission Rank) or as a subject which students should consider undertaking a bridging course prior to commencing their degree program. This means, given the current lack of emphasis being placed on the numeracy skills of potential degree candidates, there is potentially a large proportion of students who enter paramedicine degrees without a sufficient and current mathematics skillset.

As universities generally seem to assume that students entering their paramedicine programs will have some knowledge of mathematics beyond the basics, courses within these programs tend to focus more on further building on those assumed skills rather than re-teaching the basics (Bell & Latham, 2018). For students without those assumed, basic mathematics skills, it is often difficult to ‘catch up’ and disengagement and potential attrition from the program are inevitable consequences. Further compounding the problem is the apparent disconnect between students’ belief in their own mathematical abilities and their actual mathematical abilities, with many students overestimating their calculation abilities (K. Eastwood et al., 2012; K. J. Eastwood et al., 2015). This overestimation of one’s abilities potentially inhibits that person from being receptive to suggestions that they need to improve their skills or be involved in continued maintenance of those skills (Bell & Latham, 2018; K. J. Eastwood et al., 2015). In paramedic practice, the overestimation of one’s abilities has also been identified as a cause of diagnostic error, as overconfidence can lead to a decreased likelihood of consulting with colleagues, or with utilising tools, protocols or other practice guidelines (Harris et al., 2017).

Improving mathematics education in paramedical science

As the research into paramedical science education is in its infancy, research exploring the design of curricula and pedagogies that address the development of paramedical science students’ mathematical competencies are limited. Such research includes a study of the mathematical abilities of first year undergraduate paramedic students, in which K. J. Eastwood et al. (2015) found that the mathematics and drug calculation skills of the students improved significantly after participation in tutorials that were specifically designed to address the identified mathematical deficiencies. In a study investigating subject-related anxiety, Caffey et al. (2016) found that the anxiety students felt about performing simple dosage calculations was significantly reduced when authentic learning contexts such as case studies and simulated debrief sessions were incorporated into the pedagogy. The authors also found that the use of case studies led to increased student interest in, and understanding of the learning materials. In an attempt to help students enhance their mental arithmetic skills, Bell and Latham (2018) designed a mental calculation app that incorporates basic elements of gamification to address the development of a range of mathematical skills, from simple arithmetic through to contextualized applications of drug calculation problem solving utilising Australian industry standard drug therapy protocols. As the app was a support resource and not part of compulsory course content, however, take-up by students was low.

As paramedical science falls within the wider health science field, future research into paramedical science education needs to consider how interventions successfully implemented in the other health science disciplines may be adapted and adopted for use in the paramedical science field.

Indeed, because of the ongoing challenges universities face across all the health science fields with regards to declining mathematics skillsets and interest, there is significant research in this area in the health sciences (for reviews of the research see: Hunter Revell & McCurry, 2013; Stolic, 2014). While many of the interventions explored in the literature utilise diverse strategies, a number of pedagogical qualities can be seen to consistently contribute to the improvement of student outcomes in mathematics-related skill development. These include adopting a whole-of-curriculum approach where the numeracy needs of students is assessed from entry to the degree program and is characterised by consistency of approach and increase in depth of curricula and assessment and also incorporates active learning strategies into that curriculum, utilising online technologies to support learning (Elliott & Joyce, 2005). This whole-of-curriculum approach has been defined as, "An overall design of the numeracy expected at program level provides for continuity, so that each year level takes into account student autonomy and development, that is, from a high degree of structure or mastery of basic skills, to open inquiry and self-determined guidelines" (Galligan, 2017. p 741). Arguably, these approaches and strategies (a whole-of-curriculum approach, active learning, and online technologies) also need to be applied and explored in the paramedicine context and thus need to become a focus of future research and intervention design in paramedical science education.

In developing pedagogies to increase mathematical competence, research in the broader health science field has shown that adopting a whole-of-curriculum approach to the teaching of mathematics is more likely to provide a better means of improving applied numeracy skills than once-off, single interventions that are not linked to the wider degree curriculum (Choudhary & Malthus, 2017; Hunter Revell & McCurry, 2013; Jackson & De Carlo, 2011; Jarvis, Kozuskanich, Law, & McCullough, 2013; Sulosaari, Huupponen, Puukka, Torniainen, & Leino-Kilpi, 2015; van de Mortel, Whitehair, & Irwin, 2014). In adopting a whole-of-curriculum approach, research points to the importance of having a consistent mathematical formula teaching method adopted and demonstrated by all faculty within a given health science program. Such research has found that when mathematics is taught in individual clinical courses with no consistency in teaching methods, each course tends to exist in isolation (Hunter Revell & McCurry, 2013) thus potentially increasing confusion and the propensity for errors, while also reducing opportunities for scaffolding learning and for practicing the methods learned across different scenarios (Choudhary & Malthus, 2017). This does not discount the use of multi-modal, blended learning approaches within individual subjects, but rather indicates that the various modes of delivery are consistently utilised and developed throughout the curriculum.

In delivering a whole-of-curriculum approach, researchers also highlight the importance of teaching mathematics skills early in the curriculum, reinforcing those skills often throughout the curriculum, scaffolding the learning and providing learners with opportunities for reflection (Glaister, 2007; Rainboth & Demasi, 2006; van de Mortel et al., 2014; Zahara-Such, 2013). Ongoing mathematical mastery may be achieved, for example, by making mathematics classes mandatory every semester or through repeated testing of students' competence in numeracy over the course of an entire degree program. Bell and Latham (2018) note that there has been a recent trend towards integrating the numeracy components across all years of university study in an effort to improve student outcomes as few students are in the habit of maintaining their mathematical skills. In enhancing student outcomes and confidence, scaffolding of learning involves starting with simple calculations and anchoring learning in concrete representations, then slowly progressing through more complicated concepts, calculations and more abstract representations of a task. The sense of progression that scaffolding can create in students can thus lead to improved confidence, an increased likelihood that those students will attempt more complex tasks, and improvements in numeracy (Latimer, Hewitt, Stanbrough, & McAndrew, 2017; van de Mortel et al., 2014). To further consolidate their learning and encourage improved confidence in their mathematical abilities, research shows that students need to be provided with opportunities to engage in regular reviews and reflections of their learning (Caffey et al., 2016; Shelton, 2016). Such reflection is also an important process of active learning (Andres, 2017).

Also reflecting the wider literature on active learning, which promotes the use of real life examples and authentic experiences to situate learning, research in the health science area similarly emphasises the important role that tailored, contextualised, hands-on approaches to learning can play in improving the mathematical skills of health science students (Caffey et al., 2016; Choudhary & Malthus, 2017; Hou, Rego, & Service, 2013; Jarvis et al., 2013; Latimer et al., 2017; Ramjan et al., 2014; Sulosaari et al., 2015; Wright, 2009, 2012; Zahara-Such, 2013). This research suggests that the use of case-based teaching scenarios, real life examples, and simulated medication calculation and problem-solving scenarios that are embedded in authentic clinical practices can help to demonstrate the application of theoretical concepts and increase the relevance of the content to the learner. In addition, as mathematical competence from a professional perspective is situation-bound (contextual) (Dubovi, Levy, & Dagan, 2017; Wright, 2012), it is particularly important that the teaching and learning of mathematics takes place within the context in which it will be practiced. That is, students need to be provided with learning approaches that align mathematics to the ways they will use and experience mathematics in clinical practice, and testing needs to be completed through contextualised calculation tests and assessments rather than traditional ‘pen and paper’ tests (Hutton et al., 2010; Ramjan et al., 2014; Wright, 2008). Indeed, research has shown that when mathematics in the health science disciplines is situated in the clinical practice environment in which it will be practiced, for example through the use of case studies, students respond more positively to the learning environment, show increased understanding of the effects of medical treatment in real life, and are better equipped to practice decision-making in medication care (Caffey et al., 2016; Coyne, Needham, & Rands, 2013; Sulosaari et al., 2015).

In situating mathematical learning into the contexts in which it will be practiced and concomitantly increasing the propensity for active learning to occur, online technologies are playing an increasingly important role in health science education. Such technologies provide a cost effective and replicable way to enhance realism and improve authenticity in practical classes where opportunities to engage with actual clinical practice would otherwise be limited or unavailable (Clarkson, 2018; Hou et al., 2013). Technologies such as podcasts and videos with flipped classrooms (in which students review an online lecture before the lecture session and come to the classroom to have an interactive session with the teacher), mobile devices with apps, and video games and simulations (part-time trainers, integrated simulators, virtual reality) are all being used to enhance the mathematical education and numeracy skills of undergraduate health science students (e.g. Bell & Latham, 2018; Birt, Moore, & Cowling, 2017; Clarkson, 2018; Coben & Weeks, 2014; Cotta, Shah, Almgren, Macias-Moriarity, & Mody, 2016; Foss et al., 2014; Foss, Mordt, Oftedal, & Løkken, 2013; Huang, Hew, & Lo, 2018; Kay & Kletskin, 2012; McMullan, 2018; Schwartz, 2014).

The use of online simulations and virtual learning spaces, for example, enable learners to develop procedural knowledge in safe, controlled environments that eliminate risk to patients, while also providing students with authentic contexts and realistic visualisation that is integral to contextual learning (Guze, 2015). From a learning perspective, research has shown that the use of online simulations, virtual learning spaces, online practice quizzes and online activities and resources promote active learning (Hunter Revell & McCurry, 2013; Stolic, 2014) and increase propensity for student engagement with the mathematical content of a course (Clarkson, 2018; Hunter Revell & McCurry, 2013; Stolic, 2014). Online resources designed as an intervention to target mathematical concepts and skills have also been found to lead to increases in overall pass rates in medication dosage calculation tests (Mackie & Bruce, 2016), improvements in students’ arithmetic skills (Karabag Aydin & Dinc, 2017) and calculation confidence (Ramjan et al., 2014). It has been suggested that that as online technologies empower students to learn at any time, in any environment, and at their own speed, these technologies thus increase success rates by permitting as many repetitions and as much engagement as required (Karabag Aydin & Dinc, 2017; Ramjan et al., 2014). While technology plays an important role in more fully engaging students with mathematics learning in a way that also leads to increased mathematics understanding, research also points out that the most successful pedagogical interventions utilise multi-modal, blended learning approaches where traditional face-to-face lectures and/or tutorials are combined with multiple online, self-directed learning resources (Choudhary & Malthus, 2017; Mackie & Bruce, 2016; Ramjan et al., 2014; Stolic, 2014).

Conclusion

The paramedical science discipline is not alone in needing to address the way mathematics education is approached in its degree programs; across Australia and across all disciplines there has been a general decline in the mathematical preparedness of all students entering universities, with many students embarking on a degree without the fundamental mathematical skills they will need to start their university education (Dalby et al., 2013; Joyce, Hine, & Anderton, 2017; Nicholas, Poladian, Mack, & Wilson, 2015; Varsavsky, 2010). One of the major difficulties with raising the mathematics skill base of a country or region is the under-preparedness in mathematics of incoming students to universities, which subsequently results in low levels of success with university-level mathematics (Rylands & Shearman, 2015; Varsavsky, 2010). Such low levels of success are certainly worrying for health-related degrees, such as paramedical science, where robust mathematical skills are essential to students' future careers and the safety of patients with whom they will potentially come into contact.

The literature exploring mathematics education in the health sciences identifies a number of approaches and strategies that consistently contribute to the improvement of student outcomes in mathematics-related skill development in the health sciences. While these approaches and strategies may already be currently used, either fully or in part, by some paramedicine educators, research into the application of these approaches and strategies in the paramedical context is lacking. Future research into mathematics education in paramedical science thus needs to explore such questions as: How can paramedical numeracy be improved through a whole-of curriculum approach? How can educators implement a consistent and collaborative approach to mathematics education across an entire paramedicine degree and which methods for teaching mathematics might be best suited for this? Which active learning strategies will best promote mathematics success in paramedicine education? How can paramedicine educators provide students with learning approaches that align mathematics to the ways they will use and experience mathematics in clinical practice? How can assessment be modified to reflect this more 'real-life' experience of mathematics (rather than traditional 'pen and paper' tests)? How can online technologies be used to increase and improve the situational or contextual learning of mathematics? And, how can online technologies be used to increase and improve student engagement with mathematics?

This last question – how to improve student engagement in mathematics – is indeed an important research area, as student engagement in mathematics is arguably integral to the development of strong numeracy competency. Yet, while research has focused on the importance of teaching for the contextual application of mathematics, as well as the important role technology plays in supporting contemporary learning experiences, there is a dearth of research specifically examining how improving student engagement in mathematics in health science courses, including paramedicine, can lead to improved student outcomes in numeracy specific to that discipline. Certainly, there exists a need to explore how the often-weak numeracy skills of paramedicine (and other health science) students may be addressed through strategies that increase their engagement in academic numeracy. There also exists a need for the development of innovative pedagogies that utilise active engagement strategies and interactive technologies in the teaching of mathematics to undergraduate paramedicine students in a way that increases mathematics engagement while also increasing health-related numeracy skills.

Finally, from the wider perspective of academic numeracy, there is also a question around theorising numeracy, as it is arguably still in an untheorized state (Coben, 2006; Craig & Guzmán, 2018). The theorisation of numeracy is important because numeracy has, by and large, not been accomplished despite its prioritisation since the early 2000s as an area of education that 'matters' (Bass, 2003). While there are various explanations as to why numeracy has not been accomplished (see: Craig & Guzmán, 2018), it is important we continue to question and explore why numeracy has developed – or failed to develop – despite its apparent importance and scholars' prolonged attention. In addition, as longstanding debates about how to best teach and organise numeracy skills are increasingly unsettled by the changing communication technologies through which we learn and carry out our day-to-day lives (Hamilton, Hillier, & Tett, 2006), we need to continue to explore how theory can positively inform practice and vice versa. As argued by Craig and Guzmán (2018), a dialogic relationship between developing programs and theorizing can exist productively, playing a role in advancing our thinking and in disrupting our common-sense conceptualizations that arguably lead to stagnation.

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