



Re-highlighting the potential of critical numeracy

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Abstract

Since the development of the term numeracy in the mid-fifties in the United Kingdom, the concept of what numeracy is and how it is defined has undergone many changes. The Australian education community continues to explore the concept of numeracy, consider the place and definition of numeracy in the curriculum and consider its relationship with mathematics. Currently, the Australian curriculum incorporates mathematics as one of seven learning areas and numeracy as one of seven general capabilities. Numeracy is defined as the capacity, confidence and disposition to use mathematics. Other general capabilities include critical and creative thinking, ethical behaviour, personal and social competence and intercultural understanding. This paper explores numeracy from an Australian Curriculum perspective and extends this view to consider the potential of “critical numeracy”. Using the lens of Freire’s critical pedagogy, this paper discusses a perspective of critical pedagogy for mathematics and numeracy that challenges teachers to address student lifeworlds, their community and social issues.

Keywords Numeracy · Critical mathematics education · Education for sustainability and eco justice

Since the development of the term numeracy in the mid-fifties in the United Kingdom, the concept of what numeracy is and how it is defined has undergone many changes. The Australian education community continues to explore the concept of numeracy, consider the place and definition of numeracy in the

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curriculum and consider its relationship with mathematics. Currently, the Australian curriculum incorporates mathematics as one of seven learning areas and numeracy as one of seven general capabilities. Numeracy is defined as the capacity, confidence and disposition to use mathematics. Other general capabilities include critical and creative thinking, ethical understanding, personal and social capability and intercultural understanding. Using the lens of Freire’s critical pedagogy, in this paper, we discuss a perspective of critical pedagogy for mathematics and numeracy that challenges teachers to address student lifeworlds, their community and social issues. Although the ideas of numeracy and critical approaches to teaching mathematics are not new, the current and ongoing global issues such as sustainability, climate change, access to fresh water and poverty remind us of the importance of empowering students to be informed contributors to society.

Introduction

In Australia, the media message about mathematics for the past 5 years has highlighted declining standards, with students from low socio-economic status (SES) backgrounds consistently being flagged as underperforming (Thomson et al. 2013). These media outputs include releases from the chief scientist and bodies such as the Australian Mathematical Sciences Institute (AMSI). What these media conversations and outputs do not highlight are differences in terms of context. For example, as Zevenbergen (1998) has argued, access to mathematical language norms and discourse is not socially equitable, and this can result in an imbalance in achievement between students from socially disadvantaged backgrounds and their middle-class counterparts. However, perceived academic “failure” in these standardised tests could potentially be having a negative effect on students, impacting on their self-confidence, motivation and persistence (Dweck 2009), and this in turn could be reinforcing negative self-concepts around their abilities to do mathematics. Frankenstein (1983, p.1) has argued that mathematics education should draw on Freire’s view that critical education must involve “problem-posing in which all involved are challenged to reconsider and recreate their prior knowledge”. To do this, two things need to be foregrounded by teachers: (i) connecting curriculum and pedagogy to students’ lifeworlds and (ii) seeing students as critical thinkers.

The world that today’s students are operating in is complex. With each new advancement in digital technology comes a new set of ethical considerations. White and Cranitch (2010, p.54) have reminded us that these new digital and media demands call for education to prioritise equipping students with the skillset needed to “effectively acquire and critically respond to literacy and numeracy specific content in all disciplines”. With this in mind, we take a view of critical numeracy similar to that elaborated by Frankenstein (2009). We too see critical numeracy as an opportunity to do more than understand and apply mathematics, but as an opportunity to understand real-world issues. Mathematics can inform and provide provocations to make social justice issues clearer and create opportunities for an action for greater social justice (Frankenstein 2009). This socially critical perspective of numeracy aligns with the work of

Zevenbergen (1995) who highlighted the opportunities within numeracy to empower students to make socially critical decisions and to see how mathematics can inform and equip them with the knowledge to develop arguments and challenge/ question different perspectives. We support the view taken by Blue and Pinto (2017), who, in reference to the importance of financial literacy in today's world, make a case for a greater focus on social justice in mathematics teaching and hence numeracy

In the current iteration of the Australian Curriculum (Australian Curriculum Assessment and Reporting Authority/ACARA 2018), numeracy continues (as it has since 2010) to be a priority and this is evidenced in three ways. Firstly, numeracy is included as one of seven general capabilities; secondly, it is explicitly evidenced in the learning area of mathematics; and thirdly, it appears in the numeracy continuum which has been developed to show age-appropriate stages of numeracy development. In establishing a view of numeracy, the 2014 and later 2018 curriculum documents build on the 2010 draft by acknowledging the importance of developing student confidence and dispositions to use mathematics in their daily life. The term numeracy also features strongly in other learning areas of the Australian national curriculum such as English and science, where using data in an informed way is understood to be very important (Goos et al. 2012). In the drafting stage of the Australian national curriculum, the view of numeracy that emerged (ACARA 2010, p.19) suggested that ideally students became “numerate as they develop the capacities, confidence and dispositions to use mathematics at school, at home, at work and in community life. In the context of schooling, numeracy is about students engaging with whatever mathematics they need within and across all learning areas”. The current curriculum document also outlines the need for students to “recognise[ing] and understand[ing] the role of mathematics in the world”, while also suggesting there is potential for teachers to select and provide opportunities for students to understand and recognise the “interconnected nature of mathematical knowledge, other learning areas and the wider world, and encourage them to use their mathematical skills broadly”.

In this paper, we discuss the potential of critical numeracy as a means to refocus the narrative about mathematics. The term *critical numeracy* has been used by many (see Geiger et al. 2015a, b), and its value in education has been highlighted by Watson (2009). Mathematics is a social and cultural practice, and critical numeracy provides a vehicle for responding to the inequity in access and participation in mathematics. Teaching is about more than the transfer of knowledge and skills, as noted by Seaton (2002, p. 9):

There is growing consensus that education must extend its traditional goal of student mastery of subject-centred scholastic knowledge, to include the development of individuals who can prosper in complex and changing social, cultural and economic worlds.

In this paper, we posit that taking a critical numeracy perspective creates opportunities for a narrative around mathematics that is inclusive of all, that recognises the value of knowledge that students have, and empowers them to think critically about mathematics and the world in which they live. Much of the recent literature on numeracy highlights the need to integrate a critical numeracy perspective, a view which supports the Australian education agenda of educating informed citizens. We also consider the

potential of the concept of “critical numeracy” as understood through the lens of Freire’s (1970) social pedagogy perspective. The idea of critical pedagogy explored in this paper is one that challenges teachers to address student lifeworlds by drawing on community and social issues by means of problem-posing. Towards the end of this paper, we include examples from a teacher education middle school program, designed and taught by us, that illustrate a socially critical perspective.

Perspectives of numeracy

According to Cockcroft (1982), the concept and term “numeracy” was developed in the mid-fifties in the Crowther Report (Crowther 1959). The original definition of numeracy was a narrow content-driven term defined as “a word to represent the mirror image of literacy” (cited in Cockcroft 1982, p. 11). This has broadened in more recent times to a more holistic view that refers to using and choosing mathematics in daily life (Geiger et al. 2015a, b, p.611) and argues for the development of the “the capacity to make effective use of mathematics in contexts related to the personal life, workplace, and in exercising civil responsibilities”. Despite the transformations that this term has undergone in the past 60 years, the primary drivers of change within the education sector for the “understanding” of what numeracy is or encompasses are typically educational policy and curriculum (both national and international) (Kemp and Hogan 2000). In the Australian context, where a National Curriculum was initiated in 2010, mathematics (a learning area) and numeracy (a general capability) were identified as key priorities for all age levels of curriculum.

Since the early 1990s, there has been much discussion in the Australian mathematics literature about numeracy. A chronological perspective of how the literature defines numeracy would start with a discussion of Maureen Forrest’s work on numeracy which built on literacy developments at the time. Her framework (Forrest 1997) included the four roles of a numerate person, a framework adapted from Freebody and Luke’s (1990) four roles of a literate person. Her model presented four key phases of numeracy: the technician, the user, the participant and the analyst. It was intended to support teachers to “critically examine their practice and consider whether one of the roles is being foregrounded to the exclusion of others” and to highlight the importance of incorporating a critical lens that encourages inquiry into whose interest is being served by the status quo (Forrest 1997, p. 7). In this early work, Forrest made reference to the need for students to have strong mathematical backgrounds and also for mathematics (and English) teaching to be taught across the curriculum. Following this, Scott (2000) presented an alternative view of numeracy. Scott’s view was centred on three core elements: confidence, content and context. At first glance, this model might suggest a rather simplistic view of numeracy that aligns with a view of numeracy as having the confidence to use mathematical content in different contexts. However, Scott (2000) also discussed the presence of the vocal majority and the background focus of “street-wise” or “situated” mathematics. This opens up discussion about the need to acknowledge the “funds of knowledge” (Gonzalez and Moll 2002) that students bring with them to the classroom and also reminds us of the inequality of access to education. The social experiences and backgrounds of students cannot be ignored when seeking to understand practices that lead to students’ success at school (Bourdieu

1993). For example, access to mathematical language norms and discourse is not socially equitable. Zevenbergen (1998), and later Boaler and Greeno (2000) have highlighted how the everyday home language (even when it is English) can vary significantly from the formal school language of mathematics. This point of difference can be a source of tension when it comes to family/home interactions with school mathematics.

A 2004 definition of numeracy, put forward by the OECD (2004, p. 15), indicated that numeracy refers to “an individual’s capacity to identify and understand the role mathematics plays in the world, to make well-founded judgments, and to use and engage with mathematics in ways that meet the needs of that individual’s life as a *constructive, concerned and reflective citizen*” (our emphasis). Goos’ (2007) model of numeracy was intended to reflect “the multi-faceted nature of numeracy in the twenty-first century” (Goos et al. 2010); building on previous understandings of numeracy and adding the elements of “tools” and “critical orientation”. This early work of Goos (and later colleagues) worked from the Australian Association of Mathematics Teachers (AAMT) definition of numeracy; “to be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work and for participation in community and civic life” (AAMT 1997 p.15). Goos’ 2007 framework places *context* at the heart of numeracy (Goos et al. 2010) and also acknowledges the role of mathematics, technology and student disposition. However, in this work, she also added a *critical orientation* and highlighted the importance of numeracy in making informed decisions. In this interpretation of numeracy, critical orientation is defined as “know[ing] and use[ing] efficient methods, but also evaluate[ing] the reasonableness of the results obtained and [being] aware of appropriate and inappropriate uses of mathematical thinking to analyse situations and draw conclusions” (Goos et al. 2010 p. 212). This consideration, for both tools and critical orientation, was also reflected in the work of Paige, Lloyd and Chartres (2008) who focused on four dimensions of numeracy which are clearly connected to thinking and working mathematically (Forrest 1997; Frankenstein 2001; Johnston 1994; Scott 2000). The concept of *dimensions* of numeracy, as discussed by Paige, Lloyd and Chartres (2008), reflects a transdisciplinary approach to curriculum planning. The dimensions are: (1) the functional dimension, where mathematics is used to engage with day-to-day tasks; (2) the sociocultural dimension, where consideration is given to where the mathematics is used, what kind of mathematics is used, and how it is used, and understanding that this is often dependent on cultural or social contexts, or dependent on the history of how mathematics has been used in the past; (3) the technological dimension, where attention is paid to the fact that technologies impact on the mathematics used, and how it is used; and finally: (4) the critical dimension, where mathematics is used as a lens to make sense of and engage with social, physical, political, biological and spiritual environments in which we operate. The critical dimension of numeracy also involves planning and critiquing personal plans and taking action. It is where mathematics becomes a powerful ally to engage with ethical debates, issues of sustainability and equity, and considerations of where and whose vested interests are served. The critical dimension of numeracy provides the impetus for the evolution of transdisciplinary approaches when looking through a mathematics lens.

Critical numeracy: a view from the work of Frankenstein

Paulo Freire has been described as “one of the most important critical educators of the twentieth century” (Giroux 2010, p. 715). He is credited as one of the founders of critical pedagogy, where this is defined as “associated with approaches to education that emphasize critical literacy, the capacity to decode, demystify, and deconstruct the taken for granted narratives, symbols, metaphors, and tropes that guide the production of truth within texts (Carlson 2003, p. 46). Frankenstein’s (1983) work reminds us of an aspect of critical pedagogy/education theory which can inform some of what we do in mathematics education, beginning with Freire’s view that knowledge is: (1) not static, in that it “is continually created and re-created as people reflect and act on the world” (Frankenstein 1983, p. 316); and (2) not neutral, in that it evolves and develops by interacting with the world. While there are aspects of mathematics content that can be considered static, to view the body of mathematics as static would suggest that mathematics is a fixed body of knowledge and hence that school mathematics is a curriculum of static entities to be learned (National Council of Teachers of Mathematics 1989). However, the reality is that “mathematics changes over time, for each thoughtful mathematician within a generation often formulates a definition according to his lights” (Orton and Wain 1994, p. 10). While this may seem like a trivial matter, the fact remains that the nature and role of mathematics, as perceived by society, has a major influence on school mathematics curriculum (Dossey 1992) and also on teaching and pedagogy. Those who perceive mathematics as a static entity may well argue that a transmission model of teaching is the most effective. However, along with Frankenstein and others we disagree with this view. Dossey (1992, p. 42), for example, has argued for a shift in thinking, suggesting that mathematics “must be accepted as a human activity, an activity not strictly governed by any one school of thought (logician, formalist or constructivist)”. Seeing mathematics as a human activity leads to the second point highlighted by Frankenstein (1983); that is, that mathematics is not neutral.

Some time ago, Frankenstein (1983, p.9) discussed how many people believe that mathematics is neutral, and consists of “neutral facts discovered, not created, by people through their interactions with the world”. But she reminded us that the conversation is more than a “them/us or neutral/non-neutral” debate. Drawing on Freire’s notion of the relationship between subjectivity and objectivity, she provided a number of examples to justify this assertion. This view is similar to that put forward over 20 years later by Kemp (2009). Both authors pre-empted the current era of “fake news” and the use of mathematics as a tool to mislead people; for example, the misleading use of statistics in marketing by loan companies (a chosen topic for investigation by a first-year pre-service teacher who investigated the different rates of interest charged by two short-term loan companies and showed how quickly a \$500 loan would accumulate to a large and potentially unmanageable amount of debt when a payment was missed). The use of mathematics in this way highlights how mathematics – with the exception perhaps of pure mathematics – is not neutral, and more importantly, numeracy is never neutral. Chartres (2008) not only noted the potential of mathematics to empower learners but also how mathematics is equally likely to disempower, marginalise or exclude. NAPLAN (National Assessment Program – Literacy and Numeracy) is an example of this in action on a large scale. Australian student progress and mathematical

competence is typically measured, by the general public and the media, by performance on the national standardised test in numeracy in Australia known as NAPLAN, or indeed in international standardised tests such as TIMSS (Trends in International Mathematics and Science Study) and PISA (the Programme for International Student Assessment). However, NAPLAN, like any other numeracy assessment item, is not neutral, and it does make assumptions about students' access to experiences and language. Frankenstein (2009, p.111) highlighted this in her example about how a task such as totalling a grocery bill can be far more complex than it appears. She reminded us of the hidden messages in problem-solving tasks:

I certainly would want students to solve such problems—comparing grocery bills in poor neighbourhoods with those in rich neighbourhoods, for example, or countless other mathematical investigations that could relate to issues of hunger and capitalism where tens of millions of tons of surplus food rot for the profit of a few (Mittal 2002) while approximately 40 million people die from hunger and hunger-related illness every year and available evidence indicates that up to 20,000,000 citizens [living in the USA] may be hungry at least some period of time each month (National Council of Churches 2007).

Frankenstein (1983, p.1) argued that mathematics education should draw on Freire's view that critical education must involve "problem-posing in which all involved are challenged to reconsider and recreate their prior knowledge". To do this, two things need to be foregrounded: (i) connecting to students' life-worlds and (ii) seeing students as critical thinkers. The idea of problem-posing in mathematics classrooms is well established (see, i.e. Lowrie (2002) who discussed the importance of problem-posing, children's capacity to problem pose and different ways problem-posing is understood and enacted in mathematics classrooms). However, in critical numeracy, we are not referring to the type of problem-posing that requires students to think creatively about the context, we are proposing a critical numeracy perspective that challenges and questions *why* things are the way they are, *what* can be done and by *whom*? This is congruent with Ernest's (2015) desire for the personally, culturally and socially relevant curriculum which, he suggests, would have "powerful incidental benefits for society, as well as for individual students" (Ernest 2015 p. 22). Gutstein (2012 p. 301) too has argued that community-based connections are key and should be combined with "critical knowledge". He argues the importance of working from/with a genuine problem, not an artificial problem related to the topic, because genuine authentic contexts can be both engaging and challenging from a learning perspective. An example he gives is basing the learning of probability and statistics on a local issue of Latino and African American catchment areas.

We also had them study census tract data and consider how to enlarge the boundaries in North Lawndale so that students from there would have the same chance to be accepted as the Little Village students. This entailed calculating acceptance probabilities for both communities, with various ratios of African American and Latina/o students—and this was further complicated mathematically because each neighbourhood has different numbers of high-school aged

students. Students also examined data for other nearby schools, as well as local area maps, and overall, they mathematized the central problem of having one new school building for too many students from two different communities (Gutstein 2012 p.305).

Examples such as this highlight the way in which deep and meaningful mathematical connections can be made. It demonstrates how data can be brought to life and how teachers can require students to think mathematically and apply their knowledge. In doing this, in socially critical ways, we, as teachers, are empowering our students to be “ethical, active and informed citizens” (Goos et al. 2010, p. 214).

Critical numeracy in action

Connecting with student lifeworlds is not a new phenomenon and is well established in the literature, for example, through Gonzalez and Moll’s (2002) funds of knowledge discussed earlier. More specifically though an understanding that the lifeworld of today’s students is rapidly evolving is required. For example, many of the digital technologies of 2019 didn’t exist, or at least were not mainstreamed, 5 years ago. Today’s digital age is a fast-moving culture, and it has become even more important to capture the imagination of students, entice their curiosities and encourage them to think, question and challenge – to develop critical consciousness. Freire (2005) defines critical consciousness as being aware of one’s place in the world and one’s ability to intervene in different ways. The examples discussed in this section are an attempt at encouraging the pre-service teachers to reflect on their presence in and impact on the world, and how they can enact and inspire change, in this case with a focus on sustainability. In an attempt to model how this might be achieved, we do this in a number of ways with our own teacher education students in a university context. First-year pre-service teachers are challenged to generate questions and collect data about a local community or personal issue/concern for their final assignment. The issues identified typically include personal and social issues such as examining finances, cost and health of fresh food versus fast food, and ethical travel. The pre-service teachers are required to present their reflections on how this impacted on their lifestyle choices. Topics that the students have chosen to investigate include:

- What are my weekly carbon emissions and can I reduce them?
- Is it cheaper to fly or drive to Cairns and what’s the environmental impact of both?
- How difficult do banks make understanding the hidden charges of travel cards and who does this affect most?
- Should a pensioner really be getting a pay-as-you-go membership for the gym?
- Water usage and possible reduction strategies for a family of four versus a single female.
- Understanding budgeting as a first-year university student.
- Impact of speed on fuel consumption, the cost to me and the environment.

Whilst today’s pre-service teachers have been raised with an awareness of environmental issues such as the importance of recycling, not using single use containers and

an awareness of environmental degradation, many of their daily practices are the antithesis of good practice. This is what Jucker (2002, 2016) calls eco-illiteracy. An example of how we try to highlight eco-literacy with our pre-service teachers is by asking them to identify an aspect of their daily life (e.g. reducing showers time, cycling to university, not using single use coffee cups, etc.) and to make a Pledge of Green. This Pledge of Green is a commitment to reduce their own carbon footprint in some way or a commitment to provide a positive impact on something (Paige 2016). Pre-service teachers are then required to use a mathematical lens to quantify their personal impact and compare ecological footprints with their peers. Two student examples (outlines) of the 2018 topics are provided in Table 1.

This type of task challenges students to examine their established values and practices and encourage them to move beyond focusing on the symptoms to focusing on the causes (e.g. overconsumption, overpopulation and over-pollution). They are examples of interdisciplinary-rich tasks which allow pre-service teachers to examine an issue from multiple perspectives. The pledge aims to build the knowledge and skill levels of the pre-service teacher, both at a personal and a professional level. These two examples reflect Lingard's (2007) stress on the importance of thoughtful activity that is creative, emotional or practical and which is also intellectually demanding and connected. This can be realised through socially-just frameworks that include the notions of connecting to student lifeworlds, in meaningful ways, and to their ideas through funds of knowledge (Moll et al. 1992). These pledges are not big grand gestures of change and of course won't change the world. They do, however, challenge each individual to reflect on their own place in and contributions to society and ask them to think about how they can be more socially-just or aware. Also, rather than teachers inflicting ideas or tasks on the students, it is left entirely open for them to decide on issues they regard as being important and allows for genuine connections with their lifeworlds. This approach also enables them to build on their existing funds of knowledge, be that about sustainability, climate change or indeed aspects of mathematics or science. The only requirement we have as teachers is that they report on their data and ensure that they take a critical numeracy focus. Working in this way not only has the potential to impact on students' own personal perspectives of local sustainability issues but it also engages the pre-service teachers in meaningful, useful mathematics. The requirement that they "present their data" is based on Freire's view that critical numeracy is more than "reproducing the past and understanding the present, [it is] about offering a way of thinking beyond the present, soaring beyond the immediate confines of one's experiences" (Giroux 2010 p.716). The presentation is intended to challenge the student to think: "What now/What next? What can we learn from this?" This can empower students with the knowledge that every small, individual step towards action is collectively a big step.

The challenge for all teachers is to connect their teaching with real life meaningful events and issues. Our view has been that if the mathematics curriculum is to connect to students' life-worlds in ways that reflect critical/social issues (Eckersley 2002; Lloyd 2004; O'Keeffe et al. 2018), then teaching must go beyond the technical, and embrace a much broader understanding of mathematics curriculum. For example, as Frankenstein (2001) argued, mathematics is made more accessible through real life contexts, and through an

Table 1 Examples of pledges and student comments from 2018

Student	Pledge	Impact										
A	I pledge to reduce the amount of plastic packaging on the fresh produce (fruit and vegetables) that I purchase	I recorded how many fruit and vegetable items I purchased each shopping trip, then recorded how many times I avoided plastic packaging for them. Over the time of the pledge, I went shopping for fresh produce 22 times - 248 items of fruit and vegetables were purchased - I avoided plastic packaging 219 times - I purchased 29 items with plastic packaging Therefore, I had a success rate of 45% for my pledge. I don't think this is good enough and is something that I will continue										
B	I pledge to reduce my consumption of meat; saving litres of water used to produce a small amount of meat	How much water does it take to create a small amount of meat? I learned the average Australian eats 111 kg of meat in a year The breaks down to: <table><tr><th>Per year</th><th>Per day</th></tr><tr><td>33 kg of beef</td><td>Beef = 85 g</td></tr><tr><td>25 kg of pork</td><td>Pork = 4 g</td></tr><tr><td>43 kg of chicken</td><td>Chicken = 117 g</td></tr><tr><td>9 kg of lamb</td><td>Lamb = 24 g</td></tr></table>	Per year	Per day	33 kg of beef	Beef = 85 g	25 kg of pork	Pork = 4 g	43 kg of chicken	Chicken = 117 g	9 kg of lamb	Lamb = 24 g
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33 kg of beef	Beef = 85 g											
25 kg of pork	Pork = 4 g											
43 kg of chicken	Chicken = 117 g											
9 kg of lamb	Lamb = 24 g											

interdisciplinary mathematics and social studies curriculum. Similarly, from a mathematical perspective, Chartres (2008, p.1) also reminds us that mathematics can be used in ways that empowers students, connecting with big ideas such as citizenship and democratic participation, but it can also be used to disempower and reinforce marginalisation and/or exclusion. He suggested that critical mathematics education and ethnomathematics provide opportunities for more

“equitable mathematics education and mathematics education for democracy and citizenship”.

As discussed by Paige and Hardy (2018), enacting pedagogy in a socially critical way necessitates taking a non-deficit approach, including valuing the knowledge and experience that students bring (Comber and Kamler 2004), and adopting socially critical contextual learning practices (Lingard and Macgregor 2014). This suggests that in order for pedagogy to deal with complex real-world problems, a significant shift in school curriculum is required. Similarly, different ways of thinking about what numeracy is, and how different mathematics (and other learning areas as relevant) concepts, processes and values can be drawn upon in learning, are needed. In order to address real-life issues/problems such as those associated with the land (erosion, Indigenous land rights, land uses, human impact), and food (politics of starvation, genetically engineered food, food security and food corporations), teachers and the curriculum need a holistic systems’ style of thinking so that students can learn to deal with complex webs of relationships (Lloyd and Paige 2008). This is an approach that politicises mathematics (at least some aspects of it!) and draws from the three values of sustainability, democracy and social justice embedded in the previous Australian society and environment curriculum. These values also connect well with the current cross curriculum priorities, especially sustainability, and this approach gives students the opportunity to confront real issues and provides opportunities for socially relevant learning (Cheong 2005).

Summary and conclusion

Freire’s notion of problem-posing was intended to connect the student to community issues while challenging them to think critically about the content and what it means in that particular context. As discussed by Tytler et al. (2011), there is significant literature that argues we have to change the way we live, because the planet can no longer sustain our Western way of life. They also remind us that there is a growing body of education literature that suggests it is the responsibility of education to be part of the solution to global issues (Jucker 2016; Sterling 2001). This calls for renewed focus on socially critical perspectives of numeracy. Overlapping with the Australian Curriculum cross curriculum priority of sustainability, socially critically perspectives in mathematics provide ample opportunities for numeracy to be the driver of critical thinking. For example, a local issue around access to water (currently very relevant to areas in South Australia) could provide the context around which to learn and apply mathematics content (see Paige et al. 2018). The mathematics being learned or applied creates an opportunity to empower the learner to challenge local issues. For example, learners could investigate why there is water wastage when some are in drought and how much water is wasted in the school. They might question different access to clean water, or act locally in school and at home to reduce water wastage by examining the length of showers, time spent watering gardens and the impact of using synthetic turf on soil temperatures. Framed around the core ideas of numeracy we have discussed in this paper, such tasks require students to investigate and attempt to

solve real-life, local issues. Looking to the numeracy frameworks outlined above, such approaches could be built on a:

- Numeracy analyst perspective (Forrest 1997), questioning, how can I respond to this issue?
- Contextual perspective (Scott 2000), understanding and connecting to student contexts
- Critical orientation perspective (Goos 2007), using mathematical information to make decisions and judgements, add support to arguments and/or to challenge an argument
- Critical dimension perspective (Paige, Lloyd and Chartres 2008), using mathematics as a lens to make sense of, and engage with the social, physical, political, biological and spiritual environments in which we operate

Refocusing numeracy to include a critical numeracy approach has the potential to empower teachers and students to respond to real-world issues in meaningful ways (as appropriate). The notion of critical pedagogy is built on the thinking that understanding how power works is important. It assumes that being self-critical as well as critically self-conscious about “what it means to equip students with analytical skills to be self-reflective about the knowledge and values they confront in classrooms” (Giroux 2010, p.717) is creating a safe place for students to think, act and be and thus supports them to not only be ethical and informed citizens but also to understand the importance of being ethical and informed. The importance of this is emphasised in today’s digital age which brings with it a new set of moral dilemmas and brings to the fore the importance of critical consciousness. We believe that critical numeracy can play a significant role in developing and supporting this critical consciousness. Additionally, the current education climate has a focus on STEM education. Critical numeracy can play a crucial role in moving STEM teaching and learning beyond just functional and practical experiences such as building and creating to extend these learning experiences to consider the implications and impact of continuing to produce and consume more products.

In this paper, we have suggested that a problem-based pedagogical approach has the potential to frame critical numeracy and discussed how this perspective, where currently utilised in the world of “numeracy testing”, has marginalised and narrowed the view of critical numeracy rather than supported it. As discussed by Goos et al. (2010 p. 214), “the ultimate goal of learning through society and environment is to enable students to participate as ethical, active and informed citizens”. To do this, mathematics teaching needs to reflect an understanding of the potential of mathematics to inform and challenge students to think critically. Goos et al. (2010) proposed that this can be achieved by embedding an analytical approach to data interpretation. We wish to add to this by arguing that this alone may not be enough. There needs to be a clear focus on analysing the context (from which the data is generated), and this focus should be based on local or critical issues connected to students’ life-worlds. Such connections can build student motivation to extend their mathematical thinking. Such motivation comes from connecting students to their life-worlds – through important local issues that matter to them, to their locality, their environment in authentic and meaningful ways.

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