Developing a Theoretical Framework to Inform the Design of a Teacher Professional Development Program to Enable Foundation to Year 2 Teachers of Mathematics to Build on Indigenous and Low-SES Students' Cultural Capital

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This paper reports on the early stages of the conceptualisation and implementation of the Accelerated Inclusive Mathematics—Early Understandings (AIM EU) project, a project whose major goals are to advance theory and practice in the improvement of Foundation to Year 2 (F–2) teachers' capacity to teach mathematics and through this to enhance F–2 Indigenous and low-SES students' levels of engagement and learning of mathematics. A design-research methodology was used to achieve the advancement of theory and practice. The major outcome of the research is a revised theoretical framework to inform the design and implementation of culturally relevant mathematics pedagogy for F–2 Indigenous and low-SES students.

Keywords: teacher professional development • multicultural capital • knowledge for teaching • Indigenous students • low-SES students

Introduction

Many Indigenous and low-SES students in Australia are underachieving in mathematics when compared to the majority of students (Krakouer, 2015; Thornton, De Bortoli, & Buckley, 2013). This is reflected in the results in numeracy from the National Assessment Program—Literacy and Numeracy (NAPLAN) and the Programme for International Student Assessment (PISA). During the past 15 years, many students from Indigenous and low-SES backgrounds have been consistently performing at two–three years of schooling behind students from the highest socioeconomic quartile (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2015; Teach For Australia, 2016).

This consistent underachievement in mathematics by most Indigenous and low-SES students was the catalyst for the establishment of the YuMi Deadly Maths (YDM) program in 2009. Although the program was originally developed for Indigenous students, it has since been broadened to include all students. A primary focus of the YDM program has been to improve Foundation to Year 9 teachers' capacity to teach mathematics and through this to enhance students' levels of mathematics engagement and learning.

The pedagogy developed for YDM is built on three pillars:

1. *Mathematics learning*—students socially constructing knowledge through interaction with materials, activities, teachers, and other students to where they can see mathematics as an integrated structure of models, materials, and symbols leading to big ideas.
2. *Mathematics teaching*—teachers tailoring mathematics ideas to their students' interests, cultures, and backgrounds via the Reality–Abstraction–Mathematics–Reflection (RAMR) teaching cycle (YuMi Deadly Centre, 2014b) that (a) begins with the reality and interests of the students; (b) abstracts this reality to visualisation, language, and symbols through body, hand, and mind activities; (c) develops formal mathematics language and symbol relationships through practice and connections; and (d) reflects this new learning back to the world of the student through validation, application and extension.
3. *Mathematics in-service teacher education*—whole-school professional learning based on a leadership model and community involvement where teachers come together from clusters of schools to experience YDM and return to their school to trial the ideas using action research approaches.

Most of the schools that have thoroughly integrated the YDM philosophy and materials into their mathematics curriculum and pedagogical practices have been able to significantly enhance their Years 4–7 students' attitudes towards and learning of mathematics. Attitude improvement has been revealed in surveys and in interviews with teachers (Spina et al., 2017), and learning improvement has been revealed in recent (2015) Years 5 and 7 NAPLAN results (Spina et al., 2017). However, Year 3 NAPLAN numeracy results have not seen the same improvement, remaining relatively static except for cases where schools particularly focused on Foundation to Year 3 teachers during the course of the two-year YDM in-service teacher education program.

Based on this set of findings, researchers from the YuMi Deadly Centre at the Queensland University of Technology, in collaboration with one of the YDM program's schools, initiated the Accelerated Inclusive Mathematics—Early Understandings (AIM EU) project in 2015. The students in each of the classrooms in this school come from diverse cultural and linguistic backgrounds (e.g., Indigenous, Indian, Chinese), family structures, and SES environments, and have varying cultural attitudes towards school attendance. Thus, a major aim of this project was to develop a theoretical framework to inform the design of teacher professional development programs that provide teachers with the knowledge and dispositions to assist Foundation to Year 2 (F–2) students from different cultural, linguistic, and SES backgrounds to cross the cultural interface (Nakata, 2007) in mathematics classes from the subcultures of their peers and family into the subcultures of mathematics and school mathematics (cf. Aikenhead, 1996; Claussen & Osborne, 2012) and through this to enhance their attitudes towards and learning of mathematics.

The project is using a design-research methodology (Kelly, 2004). This methodology has two interrelated outcomes: (a) constructing novel and effective educational practices; and (b) developing illuminating explanatory theory (Kelly, 2004). The enactment of the design-research methodology began with the development of an initial theoretical framework. This framework was used to inform the design of the modules of a prototype teacher professional development (PD) program that focuses on how F–2 teachers can (a) identify critical teaching points, (b) use diagnostic tools to identify barriers to early understanding, and (c) accelerate learning so that all Indigenous and low-SES students will attain satisfactory or higher levels of mathematical knowledge by Year 3. During the ensuing PD program, participating teachers are introduced to the modules and the theoretical framework that underlay their development. Following the PD program, teachers engage in cycles of action research. Each cycle provides feedback that is used not only to refine the resources and explain the outcomes, but also to make advances to the theoretical framework. Both quantitative (e.g., surveys, pre- and post-tests) and qualitative methods (e.g., reflective journals, interviews, and observations) are being used to collect data.

In the following sections, we begin with a description of the genesis of the initial theoretical framework. We then present the framework itself. Next, we present our reflections on the early implementation stages of the AIM EU project. Following this, we present a revised theoretical framework that is currently being used to inform future research and development in the project.

Genesis of the Initial Theoretical Framework

During an early meeting with the teachers from the AIM EU project school, the teachers were asked to hypothesise why they thought the Year 3 students' NAPLAN numeracy results had remained relatively static. Most of the teachers responded with cultural deficit explanations (Owens, 2015; Valencia & Solórzano, 1997); that is, their explanations primarily focused on students' home environments and/or cultural backgrounds as the root causes of the students' underperformance in numeracy.

Unfortunately, cultural deficit explanations usually lead to adverse effects on Indigenous and low-SES students' learning (Goldenberg, 2014; Parhar & Sensoy, 2011; Trumbull & Pacheco, 2005; Valencia & Solórzano, 1997). For example, teachers with cultural deficit explanations tend to (a) take less responsibility for their students' learning (Trumbull & Pacheco, 2005); (b) have lower expectations and negative bias towards low-SES students (Barton, 2004; Brogan, 2009); and (c) disregard low-SES students' cultural knowledge and informal mathematical experiences (Connolly, 2012; L. Matthews, 2003).

As a reaction to what Valencia and Solórzano (1997) refer to as the "cultural deficit myth", many educators (e.g., Carter, 2005; Gay, 2010; Giroux, 1990; Goldenberg, 2014; Ladson-Billings, 1995; Nieto, 2004) have since the 1990s been calling for the introduction of culturally responsive or culturally relevant pedagogy (CRP) to address the educational needs of Indigenous and low-SES students. Unlike pedagogies based on cultural deficit models, CRP uses the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them (Gay, 2010). That is, rather than focusing on students' "weaknesses", this pedagogy "teaches to and through the strengths" of the Indigenous and low-SES students (Gay, 2010; Howard, 2003; Lewthwaite, Owen, Doiron, Renaud, & McMillan, 2014).

Five essential components are incorporated within the notion of CRP. First, it requires teachers to acknowledge how deficit-based notions of Indigenous and low-SES students continue to permeate traditional school thinking, practices, and placement, and critique their own thoughts and practices to ensure they do not reinforce prejudicial behaviour (Howard, 2003). Second, it requires teachers to recognise the explicit connection between culture and learning, and see all students' cultural capital as an asset and not a detriment to their school success (Buxton, 2017; Howard, 2003; Mills, 2008). As Bourdieu's (1990) concept of cultural capital is not clearly defined and is open to varied interpretations (Sullivan, 2002), in the AIM EU project we made a conscious decision to use an operationalised definition derived from Connolly (2012) and Mills (2008), namely that cultural capital is the discourses, cultural norms and habits, funds of knowledge, and repertoires that are infused or embodied in people. By broadening the types of cultural capital that are valued in the classroom, we believe that teachers can act as agents of transformation rather than reproduction (cf. Mills, 2008). That is, they can transform the life experiences of and open up opportunities for all young people, especially those disadvantaged by poverty and marginalised by difference. Third, CRP requires teachers to set out to add other cultural capital to their students' repertoires of knowledge (Claussen & Osborne, 2012; Delpit, 1992; Mills, 2008) by providing them with access to "the best of what contemporary society has to offer" (Comber & Hill, 2000, p. 80), namely the cultural capital valued by dominant groups (Mills, 2008; Nakata, 2007). According to Claussen and Osborne (2012), any formal education that fails to remediate for a lack of the dominant cultural capital in underprivileged students simply serves to perpetuate the status quo. Fourth, it requires teachers to be mindful of how traditional teaching practices reflect middle-class, western cultural values, and thus seek to incorporate a wider range of dynamic and fluid teaching practices (Buxton, 2017; Howard, 2003). Fifth, it requires mutual accommodation (Nieto, 2004) to be engendered between teachers and the students and their families (Buxton, 2017; L. Matthews, 2003; Owens, 2015; Weinstein, Tomlinson-Clarke, & Curran, 2004). Thus, teachers are required not only to build on students' language and culture but also to equip students and their families with the capabilities to function within the culture of the school in key areas needed for academic progress and appropriate behaviour (e.g., attendance, homework, punctuality).

Within mathematics and science education communities, there has been a call for the increased adoption of curricula and pedagogical practices consistent with the five essential components of CRP identified above to support the learning of Indigenous and low-SES students (see Abrams, Taylor, & Guo, 2013; Aguirre et al., 2012; Boaler & Staples, 2008; Huang & Lin, 2013; McKinley, 2007; Nam, Roehrig, Kern, & Reynolds, 2013). For example, many mathematics and science educators have suggested that curriculum should be infused with rich connections to students' cultural and linguistic backgrounds within family and community contexts (see Belgarde, Mitchell, & Arquero, 2002; Brayboy & Castagno, 2008; MacDonald & Lowrie, 2011; Roehrig, Campbell, Dalbotten, & Varma, 2012). To do this, it has been suggested that teachers should source information about traditional and local knowledge related to current mathematics and science topics from local community members and elders (Grootenboer & Sullivan, 2013; Nam et al., 2013). In addition, the adoption of a wider range of dynamic and fluid teaching practices that promote active student engagement in their learning has been suggested (Frigo et al., 2003; L. Matthews, 2003; YuMi Deadly Centre, 2014b).

Much emphasis also has been placed on the need for teachers to help low-SES and Indigenous students to gain access to the higher level mathematics and science knowledge necessary to open up opportunities and transform their life experiences (Chalmers & Nason, 2017; Gutiérrez, 2008; Roehrig et al., 2012; YuMi Deadly Centre, 2014a). Indeed, some seminal thinkers in the field (e.g., Abrams et al., 2013; Claussen & Osborne, 2012; Kidman, Yen, & Abrams, 2013) argue that most schools are failing to provide Indigenous and low-SES students equitable epistemic access to higher level mathematics and science knowledge. Because of this, many of these students are being excluded from critical pedagogical conversations geared to moving them towards more advanced levels of learning (Kidman et al., 2013, p. 48). In recent years, some mathematics and science educators have set out to address this perceived limitation in many current mathematics and science education programs for Indigenous and low-SES students. For example, it has been suggested that more emphasis needs to be placed on the teaching/learning of "overarching" big ideas and on inducting students into the cultural practices of mathematics and science (i.e., the "habits of mind" of practitioners and how they create, evaluate, and advance knowledge) rather than on a miscellany of facts, both in mathematics education (e.g., Chalmers, Carter, Cooper, & Nason, 2017; Cooper, Carter, & Lowe, 2016; Dougherty & Zilliox, 2003; Venenciano & Dougherty, 2014; YuMi Deadly Centre, 2014a, 2014b) and in science education (e.g., Claussen & Osbourne, 2012; Roehrig et al., 2012). According to Claussen and Osborne (2012), providing such knowledge to Indigenous and low-SES students would not only go some way to redressing the "symbolic violence" they experience through much of their mathematics and science education, but also help them to see both the intrinsic value of their mathematics and science classes for their own thinking and the extrinsic value for future employment.

Because CRP teaching perspectives seemed to provide a most efficacious means for directly addressing the existing "cultural deficit" mindsets of the F–2 teachers in our project school, an initial theoretical framework based on CRP principles was developed. During the development of the initial theoretical framework, we were cognisant of the need for the framework to inform the design of teacher PD programs that would facilitate the development in our F–2 teachers of the knowledge and dispositions to design and implement mathematics education programs for Indigenous and low-SES students that address Gutiérrez's (2007) four dimensions for successful intervention programs:

1. access to resources that enable the students to engage with quality mathematics;
2. achievement in terms of increased levels of engagement in mathematics and in terms of improved test scores;
3. identity (maintenance of cultural, linguistic, and familial connections); and
4. power (students understanding how mathematics can be used to effect changes in school or society).

During the development of the initial theoretical framework, we also were cognisant of the fact that there are great variations within Indigenous and low-SES student groups (Gutiérrez, 2008). Thus, there was a perceived need for the theoretical framework to scaffold the design of teacher PD programs that not only focus on the needs of Indigenous and low-SES students at the bottom end of the proficiency scale in the F–2 years, but also focus on accelerating and enhancing the mathematical learning of other F–2 Indigenous and low-SES students. This perceived need was based on findings from research on the influence of teaching practices on student achievement that indicate that emphasising interventions at the bottom end of the proficiency scale usually leads to students at the middle and top end of the scale hardly improving at all (Griffin, Care, Hutchinson, Arratia-Martinez, & McCabe, 2013).

Initial Theoretical Framework

The initial theoretical framework consists of six core components.

Component 1: Underlying Philosophy

The underlying philosophy of the AIM EU project is based on the following set of six beliefs and assumptions about students, teachers, schools, and communities derived principally from Goldenberg (2014), Gutiérrez (2008), Mills (2008), Parhar and Sensoy (2011), Sarra (2009, 2010), and YuMi Deadly Centre (2014b):

1. All Indigenous and low-SES students are entitled to mathematics teaching and learning that empowers them to understand their world mathematically and to solve problems in their reality.
2. All Indigenous and low-SES students can be empowered in their lives by mathematics if they understand it as a conceptual structure and a problem-solving tool.
3. All Indigenous and low-SES students can excel in mathematics while remaining strong and proud in their culture and heritage if taught actively, contextually, with respect and high expectations, and in a culturally safe manner.
4. A strong empowering mathematics program can profoundly and positively affect students' future employment and life chances, and have a positive influence on school and community.

5. All teachers can be empowered to teach mathematics with the above outcomes if they have the support of their school and system and the knowledge and resources to deliver effective pedagogy.
6. All Indigenous and low-SES communities can benefit from the above mathematics teaching and learning practices if school and community are connected through high expectations in an education program of which mathematics is a part.

Students are the focus of Beliefs and Assumptions 1–4. These four beliefs and assumptions collectively address Gutiérrez's (2007) four dimensions for successful intervention programs: access, achievement, identity, and power. Belief and Assumption 1 addresses the dimensions of access and power, Belief and Assumption 2 addresses the dimensions of achievement and power, Belief and Assumption 3 addresses the dimensions of achievement and identity, while Belief and Assumption 4 addresses the dimension of power. Beliefs and Assumptions 5 and 6 focus on teachers, schools and communities. These two beliefs and assumptions are based on the idea that teachers can change from deficit-based notions about Indigenous and low-SES students' learning if provided with appropriate and effective PD that helps them to develop the knowledge and dispositions to establish partnerships between school and community, to revise teaching approaches and curriculum, and to value Indigenous and low-SES students' cultural heritage (Owens, 2015; Parker, Bartell, & Novak, 2017; Warren, Quine, & DeVries, 2012).

Component 2: Recognition and Utilisation of Students' Cultural Capital

Within this component, we identify three sources of student cultural capital that may be used by teachers as starting points to facilitate the deep learning of mathematics by Indigenous and low-SES students: (a) mathematical identities, (b) cultures, and (c) communities.

Mathematical identities. Included under the umbrella of student mathematical identities are prior mathematical experiences (both formal and informal), beliefs about mathematics, dispositions towards mathematics, and prior mathematics knowledge and skills (both formal and informal). If teachers are cognisant of these factors, then they are more likely to be able to make the learning of mathematics more accessible and relevant for Indigenous and low-SES students (Buxton, 2017; Connolly, 2012; Grootenboer & Sullivan, 2013; Krakouer, 2015; Lewthwaite et al., 2014; Nam et al., 2013; YuMi Deadly Centre, 2014b).

Cultures. Teachers also need to learn from and about different aspects of their students' culture, such as their epistemologies and ontologies (ways of knowing and being), languages, backgrounds, and interests (Achinstein & Aguirre, 2008; Buckskin, 2012; Buxton, 2017; Dockery, 2009; Martin, 2009; Parhar & Sensoy, 2011; Sarra, 2010). For example, many Indigenous and low-SES students arrive at school with culturally based ontologies and epistemologies that are not congruent with those holding currency within the school (Abrams et al., 2013; Nam et al., 2013). According to Abrams et al. (2013), teachers need to find legitimate ways of integrating these students' different ways of knowing and being into their schooling to counteract the practice of teaching being detached from sociocultural contexts. Language affects students' conversion of representations and thinking styles when engaged in mathematics (Huang & Lin, 2013). Thus, teachers need to be aware of and recognise the usefulness of de-mathematised languages (e.g., Indigenous, folk, everyday) in making mathematics accessible to many Indigenous and low-SES students (Buxton, 2017; Luitel, 2013). Understanding students' backgrounds and interests can help teachers to provide students with meaningful contexts in which to situate the learning of mathematics (Boaler & Staples, 2008; Buxton, 2017; Grootenboer & Sullivan, 2013).

Communities. Within each community, there are substantial repertoires of experiences, knowledge, events, and values that can be capitalised on in the classroom (Connolly, 2012; Moll, Amanti, Neff, & González, 1992; Moll & González, 2004; Yosso, 2005). For example, in their research with "minority" students in Arizona, Moll and his colleagues found that the communities of minority students had much specialised knowledge and skills associated with farming, construction, auto mechanics, animal husbandry, cooking, and various kinds of trade and business. The teachers participating in Moll's research studies were able to use the communities' specialised knowledge and skills as the basis for the development of many authentic mathematics and science activities.

Component 3: Systematic Addition of Cultural Capital

Within the AIM EU project, mathematics education is conceptualised as a source of embodied cultural capital that will enable students (regardless of the nature of any prior capital they may, or may not, already have acquired) to understand and engage in mathematics discourse relevant to their future cultural, academic, and professional lives (cf. Aikenhead, 1996; Claussen & Osborne, 2012). Thus in Component 3 (which is in effect a corollary to Belief and Assumption 1 in AIM EU's underlying philosophy), we have identified two types of mathematical knowledge that we believe should be systematically provided to F–2 Indigenous and low-SES students in order to prepare them better to handle formal abstractions and more complex mathematics in later years of schooling and life: (a) big ideas *of* mathematics, and (b) big ideas *about* mathematics.

Big ideas of mathematics. Big ideas refer to key ideas that link numerous mathematics discipline understandings into coherent wholes (Charles, 2005). Mathematics big ideas (e.g., concepts such equivalence and part-whole relationships, principles such as the inverse principle, strategies such as problem-solving strategies, and models such as set and number line models) provide students with overarching schema which can (a) help them make sense of what they have experienced in and out of the classroom; (b) lead them to more flexible and generalisable knowledge use; (c) prepare them to make sense of and master new mathematical concepts, processes, and strategies; (d) facilitate transfer of knowledge; and (e) improve problem solving (Chalmers et al., 2017; Cooper et al., 2016; Niemi, Vallone, & Vendlinski, 2006).

Big ideas about mathematics. In order to prepare them better for more advanced mathematics that they may need in later school years and also in their adult work and lives, young students should be provided with opportunities to develop productive mathematical "habits of mind" (Schoenfeld, 2016, p. 9). Habits of mind are sets of dispositions or ways of thinking that describe how practitioners in mathematics seek to understand the world; these habits of mind become an interpretive lens through which the practitioners view and seek solutions to complex problems (Gurung & Hayne, 2009). Students should also be provided with opportunities to experience how mathematics functions and in particular engage in the problem-solving and creative aspects of mathematics (YuMi Deadly Centre, 2014b). For example, students should be taught the role of mathematical symbols in providing both a language and a structure for mediating problem solving and creativity. Students should experience both the power of the symbols and the meaning associated with the symbols telling stories (C. Matthews, 2009). Understanding productive mathematics habits of mind and that mathematics is a problem-solving and creative endeavour both play crucial roles in helping students to legitimately participate in the discipline of mathematics (Chalmers et al., 2017; Cuoco, Goldenberg, & Mark, 2010).

Component 4: Focus on the Structure of Mathematics

This component is a corollary to Belief and Assumption 2 in AIM EU's underlying philosophy, namely that all Indigenous and low-SES students can be empowered in their lives by mathematics if they understand it as a conceptual structure and a problem-solving tool. Therefore, a major focus of the AIM EU project is on F–2 students learning about concepts that are fundamental or basic to the structure of mathematics (cf. Davydov, 1975a, 1975b, 1990). Understanding of these concepts lays the foundations for developing a disposition for sense-making and reasoning in the doing of mathematics (Venenciano & Dougherty, 2014).

To achieve this understanding, an approach grounded firmly in the real-world experiences of the young students is proposed for the teaching of these concepts. Thus teaching is situated in carefully structured sequences of learning activities that progress from the general to the specific and from pre-numeric to numeric. Based on prior research done in the YDM program and the application of Davydov's mathematics curriculum in Russia and the USA (e.g., Davydov, 1975a, 1975b, 1990; Dougherty & Zilliox, 2003; Schmittau & Morris, 2004; Venenciano & Dougherty, 2014), we contend that this progression from general to specific and from pre-numeric to numeric should enable students to acquire deep and powerful understandings of mathematical structures and principles. AIM EU's structured sequences of learning activities have the following properties:

1. *Isomorphism.* They use effective models and representations with strong isomorphism to desired internal mental models, few distracters, and many options for extension.
2. *Sequence.* They provide sequences of models/representations where there is increased flexibility, decreased overt structure, increased coverage, and continuous connectedness to reality.
3. *Nestedness.* Ideas behind consecutive steps are nested wherever possible.
4. *Integration.* More complex and advanced mathematical ideas are facilitated by integrating models.
5. *Comparison.* Abstraction is facilitated by comparison of models/representations to show commonalities that represent the kernel of desired internal mental model. (Cooper & Warren, 2011; Davydov, 1990; Warren & Cooper, 2009; YuMi Deadly Centre, 2014b).

Component 5: Whole-School and School–Community Approach

In order to have optimal impact on Indigenous and low-SES students' learning of mathematics, a comprehensive approach involving whole-school processes and school–community partnerships has been proposed for the AIM EU project.

Whole-school processes. Approaches to improve mathematics learning need to be allied with whole-school processes (Fotheringham, 2012; Sarra, 2011; YuMi Deadly Centre, 2014b). In the initial theoretical framework, we identify five whole-school processes whose aim is to improve the mathematical learning of Indigenous and low-SES students:

1. *Development and implementation of a whole-school plan* for improving student learning across *all* subject areas (Fotheringham, 2012; McTaggart & Curró, 2009; Sarra, 2009; YuMi Deadly Centre, 2014b).
2. *Whole-school policies for addressing challenging behaviour*. Schools need a common behavioural management program used consistently in each classroom. Without this, unacceptable behaviour can prevent the best mathematics instruction activities achieving their goals (Sarra, 2009; YuMi Deadly Centre, 2014b).
3. *Whole-school policies for supporting attendance.* These should not only focus on rewards for attendance; they also require ongoing commitment by teachers and aides to monitor students, and changes in school and classroom processes to attract students to the classroom (McTaggart & Curró, 2009; Sarra, 2009; YuMi Deadly Centre, 2014b).
4. *Ensure all classrooms are culturally and socially safe and empowering.* It is important to ensure teaching and learning pedagogy is meaningful to the social and cultural

contexts of the local learner, particularly for Aboriginal and Torres Strait Islander students (Fotheringham, 2012; McTaggart & Curró, 2009; Sarra, 2011; YuMi Deadly Centre, 2014b).

5. *Set up processes for building pride in self and school/community.* These need to be related to the strengths of the school and community, and to a system of school-wide rewards and incentives (Fotheringham, 2012; Sarra, 2009; YuMi Deadly Centre, 2014b).

School–community partnerships. Indigenous and low-SES students get better results in their education when schools and communities engage in two-way connected partnerships to create a shared vision for students and agreed ways for achieving it (Fotheringham, 2012; Frigo et al., 2003; Frigo & Simpson, 2001; Trumbull & Pacheco, 2005; YuMi Deadly Centre, 2014b). In the initial theoretical framework, we identify five strategies that the research literature indicates can be used to achieve this shared vision:

1. recognising families as first educators and welcoming them into the school (Fotheringham, 2012; Sarra, 2009; YuMi Deadly Centre, 2014b);
2. using various forums designed to ensure voices from the community are heard in the school (Fotheringham, 2012; Trumbull & Pacheco, 2005);
3. connecting leadership within the school and leadership within the community, often through principals using key community members as mentors (Fotheringham, 2012; Sarra, 2009; YuMi Deadly Centre, 2014b);
4. establishing partnerships and relationships that describe the school vision and ways of achieving it (Fotheringham, 2012); and
5. expanding notions about how members of the community can volunteer (Trumbull & Pacheco, 2005).

Component 6: Teacher as Learner

Any education reform seeking to promote academic success centred in students' cultural and community identities and their potential to engage in the critical pursuit of social justice are "undergirded by teachers' conceptions of themselves as relationship oriented, political, and caring; of knowledge and curriculum as dynamic and fallible; and of classroom, school, and community relations as collaborative, culturally centred, and supportive" (L. Matthews, 2003, p. 62). Thus, preparation for the successful introduction of CRP dictates a renewal of most teachers' knowledge about themselves, mathematics, and the teaching of mathematics (Aguirre et al., 2012; L. Matthews, 2003; Owens, 2015; Parhar & Sensoy, 2011; YuMi Deadly Centre, 2014b). For such renewal to occur, teachers need to adopt the role of learners who reflect on, critique, and advance their repertoires of knowledge (L. Matthews, 2003; YuMi Deadly Centre, 2014b).

A review of the literature indicates that for this to occur, teacher PD programs need to focus on (a) content, that is, what teachers learn; and (b) process, that is, how teachers learn (Guskey, 2003; Meyer, Vines, & Shankland, 2012). This focus on content and process is reflected in Component 6 of the initial theoretical framework.

Content. In the initial theoretical framework, we propose that teacher PD programs should focus on enhancing teachers':

1. *Mathematical identities and cultural capital.* Teachers bring many prior mathematical experiences, beliefs and dispositions about mathematics, and mathematics knowledge and skills to the classroom that can greatly influence Indigenous and low-SES students' learning (Achinstein & Aguirre, 2008; Howard, 2003; L. Matthews, 2003; YuMi Deadly Centre, 2014b). For example, the enactment of CRP may

contradict teachers' beliefs and assumptions about the nature of mathematics, how it is taught, and the teacher's role and identity as these relate to teaching Indigenous and low-SES students (Leonard, Brooks, Barnes-Johnson, & Berry, 2010). The implementation of a CRP-based program thus often requires teachers to set aside their own ways of knowing mathematics and instead focus on students' ways of knowing (Parkeret al., 2017).

2. *Identity as a teacher.* In order to adopt a CRP approach that values multicultural knowledge (e.g., the use and application of mathematics in other cultures), teachers need to adopt the identity of a knowledgeable person who engages in mutual learning and a two-way flow and co-construction of knowledge with his/her Indigenous and low-SES students, teacher aides/liaison persons, and knowledgeable members of the local community (Bishop, Berryman, Cavanagh, & Teddy, 2008; Sarra, 2009; YuMi Deadly Centre, 2014b).
3. *Knowledge base about cultural diversity*. Explicit knowledge about cultural diversity is imperative to meeting the educational needs of Indigenous and low-SES students (Enyedy & Mukhopadhyay, 2007; Gay, 2002). According to Gay (2002), Indigenous and low-SES groups' cultural values, traditions, communication, learning styles, contributions, and relational patterns have direct implications for teaching and learning. If teachers do not comprehend this, they tend to reproduce their own mathematics learning experiences, drawing on traditional, teacher-centred pedagogies and decontextualised curricula (Aguirre et al., 2012). Thus, the implementation of a CRP-based program requires a PD program that concentrates on teachers' pedagogical content knowledge, including how to identify and pursue mathematically rich conversations and connect them to the students' own lives, local experiences, and interests (Enyedy & Mukhopadhyay, 2007).
4. *Knowledge base about the design of culturally relevant curricula.* In addition to acquiring a knowledge base about cultural diversity, teachers need to learn how to convert it into culturally responsive curriculum designs and instructional strategies that situate the learning of mathematics in local and cultural contexts and make it more relevant and meaningful for the Indigenous and low-SES students (Gay, 2002).
5. *Knowledge base about the creation of classroom climates that are conducive to learning by Indigenous and low-SES students.* Pedagogical actions are as important as multicultural curriculum designs in implementing culturally responsive teaching (Gay, 2002, p. 109). Thus, teachers need to learn how to use cultural scaffolding in teaching the Indigenous and low-SES students—that is, learning how to build on the students' cultures and experiences to expand their intellectual horizons and academic achievement. This begins by demonstrating culturally sensitive caring and building culturally responsive learning communities (Gay, 2002; Parhar & Sensoy, 2011; YuMi Deadly Centre, 2014b).
6. *Knowledge base about communication with culturally diverse students*. Determining what Indigenous and low-SES students know and can do, as well as what they are capable of knowing and doing, is often a function of how well teachers can communicate with them (Gay, 2002; McTaggart & Curró, 2009; YuMi Deadly Centre, 2014b). Understanding the communication styles of different cultural groups within a classroom is necessary to (a) avoid violating the cultural values of ethnically diverse students in instructional communications; (b) better decipher their intellectual abilities, needs, and competencies; and (c) teach them style or code-shifting skills so that they can communicate in different ways with different people in different settings for different purposes (Gay, 2002, p. 111).

7. *Knowledge base about delivery of instruction to culturally diverse students.* The teaching of mathematics to Indigenous and low-SES students needs to be multiculturalised in order to match instructional techniques to the learning styles of diverse students (Bishop et al., 2008; Gay, 2002; YuMi Deadly Centre, 2014b). Therefore, teachers need to develop rich repertoires of multicultural instructional examples to use in teaching culturally diverse students.

Process. A review of the literature indicates that teachers often experience difficulties, together with feelings of discomfort and anxiety, when asked to engage in the role of learners reflecting on, critiquing, and advancing their repertoires in the seven aspects of teacher knowledge, beliefs, and dispositions described above (Aguirre et al., 2012; Mathews, 2003; Parhar & Sensoy, 2011; Parker et al., 2017; YuMi Deadly Centre, 2014b). For example, Aguirre et al. (2012) found that teachers need increased opportunities to learn about students' cultural funds of knowledge and to explicitly identify children's out-of-school experiences as resources to support mathematics learning. Parker et al. (2017) found that their teachers did not develop some of the more "advanced" understandings related to power and privilege in society.

To address this issue, within the AIM EU theoretical framework we proposed three types of scaffolding that the literature indicates can be used to effectively facilitate learning of these seven aspects of teacher knowledge, beliefs, and dispositions: (a) curriculum development templates such as RAMR and YDM Planning–Teaching cycles (YuMi Deadly Centre, 2014b); (b) exemplars (e.g., resource books, lesson plans, diagnostic tests) operationalising various aspects of the initial theoretical framework (Renshaw, Baroutsis, van Kraayenoord, Goos, & Dole, 2013; YuMi Deadly Centre, 2014b); and (c) establishment and maintenance of professional knowledge-building communities of practice (Brett, Nason, & Woodruff, 2002; Cambourne, Ferry, & Kiggins, 2003; Nason, Chalmers, & Yeh, 2012; Owens, 2015; Snow, Griffin, & Burns, 2005).

Summary

The relationship between the components is based on the primacy of the underlying philosophy component. This is encapsulated in Figure 1. As this figure indicates, the set of beliefs and assumptions about students, teachers, schools, and communities underpins and integrates the other components into a coherent framework. Initially, there is a focus on cultural capital, which leads to the structure of mathematics and the need to have whole-of-school approaches, and to a focus on teacher as learner in a knowledge-building community (that is, moving clockwise around the circle).

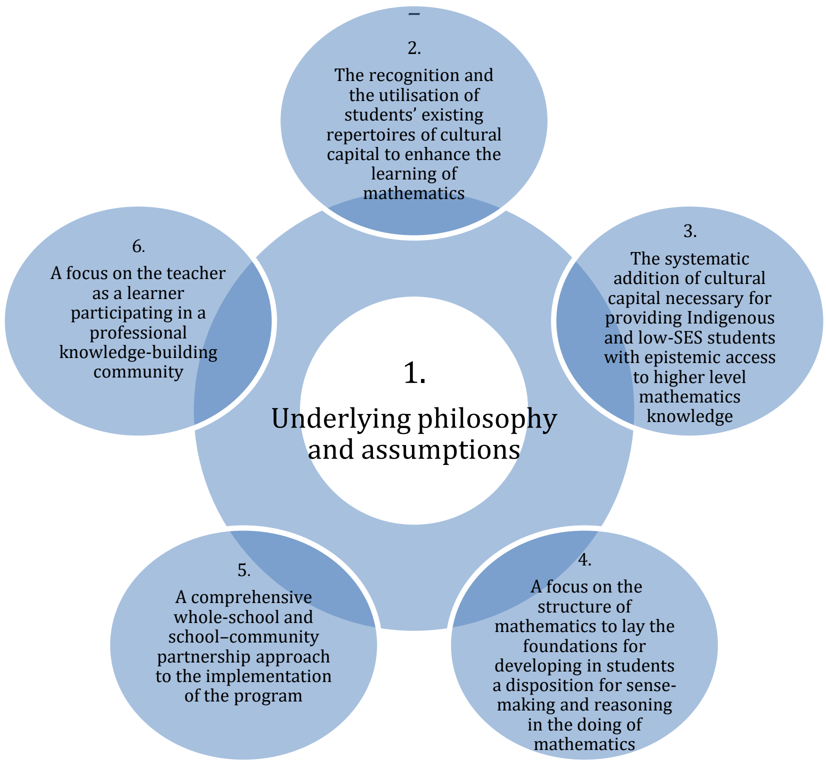

Figure 1. AIM EU theoretical framework.

Initial Reflections

The focus of these reflections was on progress that the F–2 teachers had made towards the development of knowledge, beliefs, and predispositions necessary for the successful design and implementation of CRP-based mathematics education programs such as that envisaged in AIM EU's initial theoretical framework. This is reflected in the framework presented in Table 1 for the analysis and synthesis of data underlying these reflections. As this table indicates, the reflections primarily focus on Component 6 (teacher as learner); however, these reflections also relate to Components 2, 3, and 4.

Table 1
Framework for Analysis and Synthesis of Data

Focus	Related Component(s)
Mathematics identities and cultural capital	Component 6
Identity as a teacher of instruction to culturally diverse students	Component 6
Knowledge base about the design of culturally relevant curricula	Components 2, 3, 4, 6
Knowledge base about communication with culturally diverse students	Components 2, 6
Knowledge base about delivery	Components 2, 6

The findings reported in the reflections were based on an analysis and synthesis of data from the following sources:

1. interviews with the in-service teacher educator (Anderson);
2. teacher in-service workshop evaluation surveys;
3. an online questionnaire;
4. reflective journals from the F–2 teachers; and
5. feedback from the in-school project facilitator/master teacher.

The data went through three major phases of analysis: *reduction*, *display*, and *conclusion drawing and verification* (cf. Miles & Huberman, 1994). Reduction of data was achieved by the translation of data into tables and graphs. A concept map was then constructed to display and synthesise the data from all of the sources. This facilitated the process of conclusion drawing by Nason and Stütz. In order to achieve "investigator triangulation" (Yin, 2003, p. 98), the conclusions were evaluated by having the other two authors (Anderson and Cooper) look for evidence to confirm or refute the conclusions.

Findings on Teacher Progress

Teachers' mathematical identities and cultural capital. At the beginning of the AIM EU program, the teachers had absolutist-like conceptions of mathematics (Ernest, n.d.). That is, mathematics was viewed as a culture-free discipline that involves the application of learnt procedures, and in which every task has a unique, fixed, and objectively right answer. According to Ernest (n.d.), an absolutist-like view often is manifested in school by giving students mainly unrelated routine mathematical tasks, coupled with disapproval and criticism of any failure to achieve this answer. Data derived from interviews with the in-service teacher educator and from the teachers' requests for topics to be addressed in future workshops indicated that most teachers were in the process of beginning to abandon their absolutist conceptions of mathematics. This was reflected in their increased willingness to explore different ways of doing mathematics and an increased willingness to explore how their students' cultural capital could be exploited to enhance learning.

The data also indicated two important advances in the teachers' repertoires of mathematical cultural capital: (a) increased knowledge of and interest in the exploration of big ideas of and about mathematics, and (b) increased interest in the exploration of mathematical structures. The in-service teacher educator found that the teachers had become increasingly amazed about what they did not know. According to her, for many of the teachers this was an epiphanic experience, one that has been the catalyst for the teachers to seriously reflect on, critique, and advance their repertoires of mathematical content knowledge.

Identity as a teacher. Closely allied with their absolutist-like conceptions of mathematics, at the beginning of the AIM EU program the F–2 teachers tended to manifest traditional transmission models of teaching (Renshaw, 1992) in which they identified as dispensers of knowledge. A teacher's job from this perspective is to supply students with a designated body of knowledge set out in the curriculum in a predetermined order. Academic achievement is seen as students' ability to demonstrate, replicate, or retransmit this designated body of knowledge back to the teacher. Concurrently with their gradual abandonment of absolutist-like conceptions of mathematics, we noted a very gradual shift in teacher identity from that of a dispenser of knowledge to that of a person who is willing to engage in a two-way flow and co-construction of knowledge with his/her Indigenous and low-SES students. For example, data (as listed above) indicated that many teachers were now expecting their students to try to make more use of their own ideas, "allowing children to experience mathematics and where they take it". Teachers also mentioned "having to think about meaningful ways for the students to apply their new learning". Further, teachers reported that students were focusing more on trying to make connections between what they were learning now and what they had learnt in the past; for example, "they [students] are making more connections and have language to describe/explain their thinking", or, as another teacher mentioned, students were "excited – connect to concepts". In the questionnaire, 10 of 12 teachers also indicated that they had increased their levels of expectation for their students.

Knowledge base about the design of culturally relevant curricula. All 12 teachers indicated that they were increasingly trying more to relate the teaching of mathematics to their students' real-life experiences. This was not only reflected in their questionnaire responses but also in the in-service teacher workshop evaluation surveys in which they were asked: "What ideas would you like to further explore as you seek to reflect on your current practices when teaching mathematics?" Included in their responses to this question were: "more 'relationship' to relate real life maths → RAMR" and "more ways to use everyday resources". For nine teachers one way to do this was to access students' cultural/individual backgrounds when planning mathematical learning activities. They reported that in order to do this, they were increasingly sourcing information about their students' cultural funds of knowledge (Aguirre et al., 2012) from the school's Indigenous liaison officer.

Knowledge base about communication with culturally diverse students. The analysis of data indicated this was one of the areas in which the teachers had made most advances in their repertoires of knowledge about teaching Indigenous and low-SES students. Nine of the teachers indicated that one of the ways in which they perceived that their teaching had most improved was in their considered use of language when making explanations and questioning students. This outcome was not unexpected, because the teachers were most keen for the in-service teacher educator during the course of the in-service workshops to broach teaching and language issues such as (a) how to allow students to explain in their own language, (b) the role of storytelling in learning mathematics, (c) the links between language and thinking, (d) the relationship between language and mathematics, and (e) the language and terminology of mathematics.

Knowledge base about delivery of instruction to culturally diverse students. The analysis of data indicated that advances by the teachers in this knowledge base had been made in two ways. First, advances had been made in their repertoires of knowledge about mathematical content and structures. Data from the in-service workshop evaluation surveys and the notes from interviews with the in-service teacher educator indicated that most of the teachers were increasingly focusing on the structures of mathematics. For example, in the in-service workshop evaluation surveys the teachers indicated much interest in the exploration of "knowledge of the early elements of each maths strand". The facilitator felt that the teachers had become aware of advancements in their knowledge about mathematical content and structures, particularly when it came to the sequencing of mathematical content.

Second, advances were noted in the teachers' repertoires of general mathematics pedagogical knowledge. In the questionnaire, 10 of 12 teachers reported advancement in their repertoires of pedagogical skills, which were being manifested in the following ways: (a) teachers were now placing greater emphasis on the use of concrete materials; (b) they were now identifying what students needed to know before they moved on; and (c) they were more mindful in their administration and interpretation of diagnostic tests. The changes in these three aspects of their general mathematics pedagogical skills were mirrored by changes they reported in how they were using the resource books. Rather than using them merely as a source of lesson plans, the teachers were now more closely exploring how the concrete models in the books could be used to facilitate student learning of mathematics (i.e., be used to generate knowledge rather than illustrate knowledge). The teachers also were now using the resource books to help ascertain whether students were ready to move on to new mathematical topics. Similarly, with diagnostic tests they were now using the resource books to help understand what diagnostic test items mean, what they are really identifying, and how to meaningfully interpret the results from diagnostic tests.

Discussion

The analysis of the data indicated that during the early stages of its implementation, the AIM EU project had been successful in facilitating most F–2 teachers' development of knowledge, beliefs and predispositions necessary for the successful design and implementation of CRP-based mathematics education programs. For example, most of the teachers had made considerable advances to their repertoires of knowledge about mathematics structures and about mathematics big ideas. They also had made considerable advances in their knowledge bases about the considered use of language when making explanations and questioning students.

However, most of the F–2 teachers were found to be still experiencing difficulty in "letting go" (L. Matthews, 2003) of traditional perspectives of teaching. Thus, rather than adopting the identity of a teacher who is willing to engage in a two-way flow and co-construction of knowledge with his/her Indigenous and low-SES students, on many occasions the teachers were still adopting the identity of experts who were there to "educate" the students, parents, and community. This was particularly in the cases of teachers who had made the least efforts to gain insights into the Indigenous and low-SES students' local and cultural contexts (e.g., values, relational patterns, traditions).

We also found that, although the teachers appeared to have made advances in their knowledge base with respect to cultural awareness and dispositions for cultural responsiveness that would support them in knowing and supporting their students in the manner of a culturally responsive teacher, most of the time the F–2 teachers were not as yet making what Aguirre et al. (2012) describes as meaningful connections to their students' mathematical cultural capital. Most of the learning tasks that they were designing were not providing opportunities for students to leverage their community experiences as resources for engaging and making sense of the mathematical learning activities. Instead, most of the teachers were making either superficial or explicit but underdeveloped attempts to connect the learning activities to students' cultural capital.

Revised Theoretical Framework

The reflections provided the catalyst for a revision of AIM EU's initial theoretical framework. The revised version of the theoretical framework is presented in Figure 2. As is illustrated in Figure 2, the revised theoretical framework consists of three layers:

1. underlying philosophy (Component 1);
2. network of Components 2–6; and
3. projected outcomes.

Subsumed within the underlying philosophy in Layer 1 is the set of beliefs and assumptions about students, teachers, schools, and communities listed in Component 1 of the initial theoretical framework. These beliefs and assumptions provide the epistemological and ontological overview for the framework. The projected outcomes (i.e., the enhanced engagement and learning of mathematics by Indigenous and low-SES students) are found in Layer 3 at the bottom of Figure 2.

Component 6 of the initial framework (teacher as learner) has been placed in the core of the network of five components found in the middle layer of the revised framework presented in Figure 2. As was noted in the reflections, some of the F–2 teachers seemed to be having difficulties in "letting go" (L. Matthews, 2003) of their traditional transmitters of knowledge identities as teachers and many of their deficit-based notions about Indigenous and low-SES students' learning. To address this dilemma, we felt that the teacher PD program needed to have the teachers focus and reflect more closely on their roles as learners and have them critique their own thoughts and practices to ensure they do not reinforce prejudicial behaviour. This intent is reflected in the placement of Component 6 at the centre of the revised theoretical framework.

In the network of five components placed in the middle layer of the revised framework, sociocultural components 2 (recognition and utilisation of students' cultural capital) and 5 (whole-school and school–community approach) on the left form a vertical symmetry with cognitive components 3 (systematic addition of cultural capital) and 4 (focus on the structure of mathematics) on the right. This was done to address our finding that most of our F–2 teachers were tending to make superficial or underdeveloped connections between the mathematics subsumed within the learning activities and their students' cultural capital. In particular, we wanted to help our teachers "to identify and pursue mathematically rich conversations and connect them to their students' own lives, local experiences, and interests" (Enyedy & Mukhopadhyay, 2007, p. 170). We wanted the teachers to investigate more deeply the term "relevant" in CRP and actively explore three interpretations of "relevant" identified in Enyedy and Mukhopadhyay (2007, p. 170): (a) interpretations that focus on familiarity of the content or context of the lesson and borrow these contexts from students' daily lives; (b) interpretations that focus on the motivational value of a lesson's perceived value to students' lives outside of school; and (c) interpretations that focus on the familiarity of the process and participation structures by which students engage with the lesson, and the degree to which students' existing repertoires for participation are made legitimate in the academic context.

Within the middle layer of the revised framework, integration between the sociocultural and cognitive components is provided by (a) direct two-way links between Components 2 and 3 and between Components 4 and 5; and (b) indirect two-way links via Component 6 (teacher as learner) at the core of the system. It is envisaged that this systems framework will help overcome the conceptual isolation of components during future implementations of the AIM EU project. For example, when teachers are building on ideas from the students' existing mathematical cultural capital (Component 2) to facilitate the construction of big ideas of and/or about mathematics (Component 3), they will include in their plans opportunities for students to "fold back" (Martin, 2008) in order for them to revisit/rework and thus deepen past knowledge.

By making the conceptual links between these five components explicit, we feel that the revised framework overcomes a major limitation of the initial theoretical framework: the implicit nature of the conceptual links between these five components. It was felt that this had negatively affected the impact of the in-service workshops, the overview booklet, and the module booklets. The AIM overview booklet focuses strongly on the sociocultural milieu in which the teaching and learning is situated. By contrast, the nine modules within the in-service workshops focus on mathematics teaching and how AIM EU can be used to sequence instruction so that powerful early understandings in mathematics can be developed. The Reality section of the RAMR teaching cycle presented in the overview booklet requires teachers to begin from culture. However, we have found that unless teachers learn the importance of this stage and how to gain and use knowledge about students' cultural backgrounds, it can be neglected within in-school trials and training. Thus, it is highly probable for explicit links between mathematical structures, language, and big ideas and the sociocultural aspects of learning mathematics not to be made by the teachers.

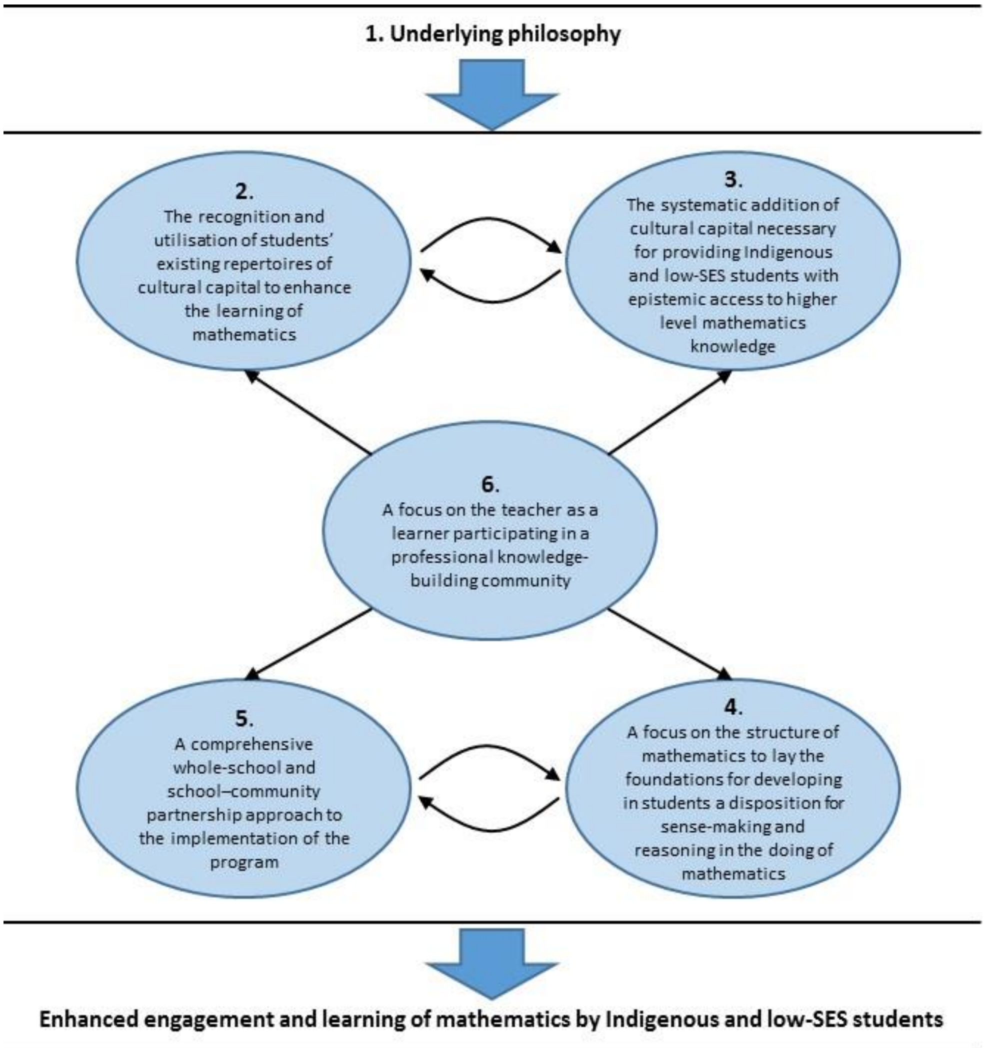

Figure 2. Revised AIM EU theoretical framework.

Conclusion

In this paper, we reported on the initial stages of the development of a theoretical framework to inform the design of teacher professional programs to enable F–2 teachers of mathematics to build on Indigenous and low-SES students' cultural capital. Our reflections from the initial stages of the AIM EU project led to substantial modifications being made to the initial theoretical framework. In the revised theoretical framework (Figure 2), the components of the framework have been integrated into a system network subsumed within a flowchart. The revised theoretical framework clearly indicates that teacher learning being conceived in terms of both culture and mathematics, and addressing teachers' prior beliefs and conceptions about working with community, are both central issues that need to be addressed in the in-service education of teachers of Indigenous and low-SES students. The revised framework also indicates how teachers' weaknesses in one component can be overcome by appropriate activity in other components within the framework. For example, Component 4 (focus on structure) in Figure 2 could scaffold teachers by concurrently taking into account the big ideas of and about mathematics (Component 3) and possible contexts provided by the students' cultures and communities (Components 2 and 5).

In conclusion, we would again stress that AIM EU is in the early stages of its implementation, and thus should be perceived as being a "work in progress". Substantial modifications have already occurred and probably in the future also will occur at both the macro- and micro-levels of the AIM EU project and its theoretical framework.

References

Abrams, E., Taylor, P. C., & Guo, C-L. (2013). Contextualizing culturally relevant science and mathematics teaching for Indigenous learners. *International Journal of Science and Mathematics Education, 11*(1), 1–21.

Achinstein, B., & Aguirre, J. (2008). Cultural match or culturally suspect: How new teachers of color negotiate sociocultural challenges in the classroom. *Teachers College Record, 110*(8), 1505–1540.

Aguirre, J. M., Turner, E. E., Gau Bartell, T., Kalinec-Craig, C., Foote, M. Q., Roth McDuffie, A., & Drake, C. (2012). Making connections in practice: How prospective elementary teachers connect to children's mathematical thinking and community funds of knowledge in mathematics education. *Journal of Teacher Education, 64*(2), 178–192. https://doi.org/10.1177/0022487112466900

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27(*1), 1–52. doi:10.1080/03057269608560077

Australian Curriculum, Assessment and Reporting Authority. (2015). *2015 National Assessment Program – Literacy and Numeracy. Achievement in reading, persuasive writing, language conventions and numeracy: National report for 2015*. Retrieved from http://www.nap.edu.au/_resources/2015_NAPLAN_national_report.pdf

Barton, P. E. (2004). Why does the gap persist? *Educational Leadership, 6*(3), 8–13.

Belgarde, M., Mitchell, R., & Arquero, A. (2002). What do we have to do to create culturally responsive programs? The challenge of transforming American Indian teacher education. *Action in Teacher Education, 24*(2), 42–54.

Bishop, R., Berryman, M., Cavanagh, T., & Teddy, L. (2008). A culturally responsive pedagogy of relations: Effective teaching for Māori students. In A. St. George, S. Brown, & J. O'Neill (Eds.), *Facing the big questions in teaching: Purpose, power and learning* (pp. 165–172). Melbourne: Cengage Learning.

Boaler, J., & Staples, M. (2008). Creating mathematical futures through an equitable teaching approach: The case of Railside School. *Teachers College Record, 110*(3), 608–645.

Bourdieu, P. (1990). *Reproduction in education, society, and culture.* London: Sage in association with Theory, Culture & Society, Dept. of Administrative and Social Studies, Teesside Polytechnic.

Brayboy, B. M. J., & Castagno, A. E. (2008). How might native science inform "informal science learning"? *Cultural Studies of Science Education, 3*, 731–750.

Brett, C., Nason, R. A., & Woodruff, E. (2002). Communities of inquiry among pre-service teachers investigating mathematics. *THEMES in Education, 3*(1), 39–62.

Brogan, R. (2009). *Relations between school outcomes and school SES*. Retrieved from http://www.education.com/reference/article/socioeconomic-status/

Buckskin, P. (2012). Engaging Indigenous students: The important relationship between Aboriginal and Torres Strait Islander students and their teachers. In K. Price (Ed.), *Aboriginal and Torres Strait Islander Education*. Port Melbourne, VIC: Cambridge University Press.

Buxton, L. (2017). Ditching deficit thinking: Changing to a culture of high expectations. *Issues in Educational Research, 27*(2), 198–214.

Cambourne, B., Ferry, B., & Kiggins, J. (2003). The knowledge building community odyssey: Reflections on the journey. *Change: Transformations in Education, 6*(2), 57–66.

Carter, P. L. (2005). *Keepin' it real: School success beyond Black and White*. New York: Oxford University Press.

Chalmers, C., Carter, M., Cooper, T., & Nason, R. (2017). Implementing "big ideas" to advance the teaching and learning of science, technology, engineering and mathematics (STEM). *International Journal of Science and Mathematics Education, 15*(Suppl 1), 25–43. doi:10.1007/s10763-017-9799-1

Chalmers, C., & Nason, R. (2017). Systems thinking approach to robotics curriculum in schools. In M. S. Khine (Ed.), *Robotics in STEM education: Redesigning the learning experience* (pp. 33–57). Cham, Switzerland: Springer International Publishing.

Charles, R. I. (2005). Big ideas and understandings as the foundation for elementary and middle school mathematics. *Journal of Mathematics Education Leadership, 7*(3), 9–24.

Claussen, S., & Osborne, J. (2012). Bourdieu's notion of cultural capital and its implications for the science curriculum. *Science Education, 97*(1), 58–79. doi:10.1002/sce.21040

Comber, B., & Hill, S. (2000) Socio-economic disadvantage, literacy and social justice: Learning from longitudinal case study research. *Australian Educational Researcher, 27*(3), 79–97.

Connolly, S. (2012). *Students' cultural capital: A study of assessment for learning as a field of exchange* (Unpublished PhD thesis). Queensland University of Technology, Brisbane, QLD.

Cooper, T. J., Carter, M. G., & Lowe, J. A. (2016). Using the big ideas of mathematics to "close the gap". In C. Csíkos, A. Rausch, & J. Szitányi (Eds.), *Proceedings of the 40th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 171–178). Szeged, Hungary: PME.

Cooper, T. J., & Warren, E. (2011). Years 2 to 6 students' ability to generalise: Models, representations and theory for teaching and learning. In J. Cai & E. Knuth (Eds.), *Early algebraization: A global dialogue from multiple perspectives* (pp. 187–214), Advances in Mathematics Education. Berlin Heidelberg: Springer-Verlag. doi:10.1007/978-3-642-17735-4_12

Cuoco, A., Goldenberg, E. P., & Mark, J. (2010). Contemporary curriculum issues: Organizing a curriculum around mathematical habits of mind. *Mathematics Teacher, 103*(9), 682–688.

Davydov, V. V. (1975a). Logical and psychological problems of elementary mathematics as an academic subject. In L. P. Steffe (Ed.), *Children's capacity for learning mathematics. Soviet studies in the psychology of learning and teaching mathematics* (Vol. VII, pp. 55–107). Chicago: University of Chicago.

Davydov, V. V. (1975b). The psychological characteristics of the "prenumerical" period of mathematics instruction. In L. P. Steffe (Ed.), *Children's capacity for learning mathematics. Soviet studies in the psychology of learning and teaching mathematics* (Vol. VII, pp. 109–205). Chicago: University of Chicago.

Davydov, V. V. (1990). *Types of generalization in instruction: Logical and psychological problems in the structuring of school curricula. Soviet studies in mathematics education* (Vol. 2). Reston, VA: National Council of Teachers of Mathematics.

Delpit, L. (1992) Acquisition of literate discourse: Bowing before the master? *Theory into practice, 31*(4), 296–302.

Dockery, A. M. (2009). *Culture and wellbeing: The case of Indigenous Australians* (CLMR Discussion Paper Series 09/01). Perth: The Centre for Labour Market Research. Retrieved from http://ceebi.curtin.edu.au/local/docs/2009.01_CultureWellbeing.pdf

Dougherty, B., & Zilliox, J. (2003). Voyaging from theory and practice in teaching and learning: A view from Hawai'i. In N. Pateman, B. Dougherty, & J. Zilliox (Eds.), *Proceedings of the 27th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, pp. 31–46). College of Education, Honolulu: University of Hawaii.

Enyedy, N., & Mukhopadhyay, S. (2007). They don't show nothing I didn't know: Emergent tensions between culturally relevant pedagogy and mathematics pedagogy. *Journal of the Learning Sciences, 16*(2), 139–174. doi:10.1080/10508400701193671

Ernest, P. (n.d.). *What is the philosophy of mathematics education?* Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.197.5854&rep=rep1&type=pdf

Fotheringham, P. (2012). *What works. The Work Program. Success in remote schools: A research study of eleven improving remote schools.* Abbotsford, VIC: National Curriculum Services Pty Ltd. Retrieved from http://www.whatworks.edu.au/upload/1341805220784_file_SuccessinRemoteSchools2012.pdf

Frigo, T., Corrigan, M., Adams, I., Hughes, C., Stephens, M., & Woods, D. (2003). *Supporting English literacy and numeracy learning for Indigenous students in the early years* (ACER Monograph 57). Camberwell, VIC: Australian Council for Educational Research.

Frigo, T., & Simpson, L. (2001). *Research into the numeracy development of Aboriginal students: Implications for the NSW K–10 Mathematics Syllabus*. Sydney: Office of the Board of Studies New South Wales.

Gay, G. (2002). Preparing for culturally responsive teaching. *Journal of Teacher Education, 53*(1), 106–116.

Gay, G. (2010). *Culturally responsive teaching: Theory, research, and practice* (2nd ed.). New York, NY: Teachers College Press.

Giroux, H. (1990). Reading texts, literacy, and textual authority. *Journal of Education, 172*(1), 85–103.

Goldenberg, B. M. (2014). White teachers in urban classrooms: Embracing non-white students' cultural capital for better teaching and learning. *Urban Education, 49*(1), 111–144.

Griffin, P., Care, E., Hutchinson, D., Arratia-Martinez, A., & McCabe, C. (2013). *Assessment and learning partnerships: The influence of teaching practices on student achievement.* Melbourne: Assessment Research Centre, The University of Melbourne.

Grootenboer, P., & Sullivan, P. (2013). Remote indigenous students' understanding of measurement. *International Journal of Science and Mathematics Education, 11*(1), 169–189.

Gurung, N., & Hayne, A. (2009). *Exploring signature pedagogies: Approaches to teaching disciplinary habits of mind.* Sterling, VA: Stylus Publishing.

Guskey, T. R. (2003). What makes professional development effective? *Phi Delta Kappan, 84*(10), 748–750.

Gutiérrez, R. (2007). Context matters: Equity, success, and the future of mathematics education. In T. Lamberg & L. R. Wiest (Eds.), *Proceedings of the 29th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 1–18). Reno: University of Nevada.

Gutiérrez, R. (2008). A "gap-gazing" fetish in mathematics education? Problematizing research on the achievement gap. *Journal for Research in Mathematics Education, 39*(4), 357–364.

Howard, T. C. (2003). Culturally relevant pedagogy: Ingredients for critical teacher reflection. *Theory into Practice, 42*(3), 195–202. http://dx.doi.org/10.1207/s15430421tip4203_5

Huang, C-H., & Lin, F-L. (2013). Using activity theory to model Atayal students' classroom mathematical activity. *International Journal of Science and Mathematics Education, 11*(1), 213–236.

Kelly, A. E. (2004). Design research in education: Yes, but is it methodological? *Journal of the Learning Sciences, 13*(1), 115–128.

Kidman, J., Yen, C-F., & Abrams, E. (2013). Indigenous students' experiences of the hidden curriculum in science education: A cross-national study in New Zealand and Taiwan. *International Journal of Science and Mathematics Education, 11*(1), 43–64.

Krakouer, J. (2015). *Literature review relating to the current context and discourse on Indigenous cultural awareness in the teaching space: Critical pedagogies and improving Indigenous learning outcomes through cultural responsiveness*. Camberwell, VIC: Australian Council for Educational Research.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Education Research Journal, 32*, 465–491.

Leonard, J., Brooks, W., Barnes-Johnson, J., & Berry, R. Q. (2010). The nuances and complexities of teaching mathematics for cultural relevance and social justice. *Journal of Teacher Education, 61*(3), 261–270.

Lewthwaite, B. E., Owen, T., Doiron, A., Renaud, R., & McMillan, B. (2014). Culturally responsive teaching in Yukon First Nations settings: What does it look like and what is its influence? *Canadian Journal of Educational Administration and Policy*, *155*(1), 1–34.

Luitel, B. C. (2013). Mathematics as an im/pure knowledge system: Symbiosis, (w)holism and synergy in mathematics education. *International Journal of Science and Mathematics Education, 11*(1), 65–87.

MacDonald, A., & Lowrie, T. (2011). Developing measurement concepts within context: Children's representations of length. *Mathematics Education Research Journal, 23*(1), 27–42.

Martin, K. L. (2009). Aboriginal worldview, knowledge and relatedness: Reconceptualising Aboriginal schooling as a teaching-learning and research interface. *Journal of Australian Indigenous Issues, 12*(4), 66–78.

Martin, L. C. (2008). Folding back and the dynamical growth of mathematical understanding: Elaborating the Pirie-Kieren theory. *The Journal of Mathematical Behavior, 27*(1), 64–85.

Matthews, C. (2009). Stories and symbols: Maths as storytelling. *Professional Voice, 6*(3), 45–50. Retrieved from https://issuu.com/aeu-vic/docs/pv_6_3/1?e=1350839/5379655

Matthews, L. E. (2003). Babies overboard! The complexities of incorporating culturally relevant teaching into mathematics instruction. *Educational Studies in Mathematics, 53*(1), 61–82.

McKinley, E. (2007). Postcolonialism, Indigenous students, and science education. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research in science education* (pp. 199–226). Mahwah, NJ: Lawrence Erlbaum.

McTaggart, R., & Curró, G. (2009). *Book language as a foreign language: ESL strategies for Indigenous learners.* Towong, QLD: Queensland College of Teachers.

Meyer, C. K., Vines, N. A., & Shankland, R. K. (2012). Designing high-quality professional development: Scaffolding secondary content-area teachers' discipline literacy instruction. *American Reading Forum Annual Yearbook [Online]* (Vol. 32). Retrieved from www.americanreadingforum.org/yearbook/12_yearbook/documents/Meyer-C-K-Vines-N-A-Shankland-R-K-(2012).pdf

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Newbury Park, CA: Sage.

Mills, C. (2008). Reproduction and transformation of inequalities in schooling: The transformative potential of the theoretical constructs of Bourdieu. *British Journal of Sociology of Education, 29*(1), 79–89.

Moll, L. C., Amanti, C., Neff, D., & González, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice, 31* (2), 132–141.

Moll, L. C., & González, N. (2004). Engaging life: A funds-of-knowledge approach to multicultural education. In J. Banks & C. A. McGee Banks (Eds.), *Handbook of research on multicultural education* (pp. 699–715). San Francisco, CA: Jossey-Bass.

Nakata, M. (2007). The cultural interface. *The Australian Journal of Indigenous Education, 36*(Supplement), 7–14.

Nam, Y., Roehrig, G., Kern, A., & Reynolds, B. (2013). Perceptions and practices of culturally relevant science teaching in American Indian classrooms. *International Journal of Science and Mathematics Education, 11*(1), 143–167.

Nason, R. A., Chalmers, C. A., & Yeh, A. (2012). Facilitating growth in prospective teachers' knowledge: Teaching geometry in primary schools. *Journal of Mathematics Teacher Education, 15*(3), 227–249.

Niemi, D., Vallone, J., & Vendlinski, T. (2006). *The power of big ideas in mathematics education: Development and pilot testing of POWERSOURCE assessments* (CSE Report 697). Los Angeles, CA: National Center for Research on Evaluation, Standards, and Student Testing (CRESST), University of California.

Nieto, S. (2004). *Affirming diversity: The sociopolitical context of multicultural education* (4th ed.). New York, NY: Pearson.

Owens, K. (2015). Changing the teaching of mathematics for improved Indigenous education in a rural Australian city. *Journal of Mathematics Teacher Education, 18*(1), 53–78.

Parhar, N., & Sensoy, O. (2011). Culturally relevant pedagogy redux: Canadian teachers' conceptions of their work and its challenges. *Canadian Journal of Education, 34*(2), 189–218.

Parker, F., Bartell, T. G., & Novak, J. D. (2017). Developing culturally responsive mathematics teachers: secondary teachers' evolving conceptions of knowing students. *Journal of Mathematics Teacher Education, 20*(3), 385–407.

Renshaw, P. (1992, November). *The sociocultural theory of teaching and learning: Implications for the curriculum in the Australian context.* Paper presented at the Twenty-Second Annual Conference of the Australian Association for Research in Education, Deakin University, Geelong, Victoria. Retrieved from http://webpages.charter.net/schmolze1/vygotsky/renshaw.html

Renshaw, P., Baroutsis, A., van Kraayenoord, C., Goos, M., & Dole, S. (2013). *Teachers using classroom data well: Identifying key features of effective practices* (Final Report). Brisbane: The University of Queensland.

Roehrig, G. H., Campbell, K. M., Dalbotten, D., & Varma, K. (2012). CYCLES: A culturally-relevant approach to climate change education in native communities. *Journal of Curriculum and Instruction, 6*(1), 73–89.

Sarra, C. (2009, September). *Indigenous leadership in education institute*. Paper presented at the Stronger Smarter Summit, Brisbane.

Sarra, C. (2010). Stronger smarter approaches to Indigenous leadership in Australia. In I. Snyder & J. Nieuwenhuysen (Eds.), *Closing the gap in education?* Melbourne: Monash University Publishing. Retrieved from http://www.publishing.monash.edu.au/books/cge.html

Sarra, C. (2011). *Strong and Smart – Towards a pedagogy for emancipation: Education for first peoples*. Abingdon, UK: Routledge.

Schmittau, J., & Morris, A. (2004). The development of algebra in the elementary mathematics curriculum of V. V. Davydov. *The Mathematics Teacher, 8*(1), 60–87.

Schoenfeld, A. H. (2016). Solving the problem of powerful instruction. In C. Csíkos, A. Rausch, & J. Szitányi, (Eds.), *Proceedings of the 40th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, pp. 3–18). Szeged, Hungary: PME.

Snow, C. E., Griffin, P., & Burns, M. S. (Eds.). (2005). *Knowledge to support the teaching of reading: Preparing teachers for a changing world.* San Francisco, CA: Jossey-Bass.

Spina, N., Carter, M., Cooper, T., Cottier, C., Farrington, G., & Stütz, A. (2017). *YuMi Deadly Centre impact evaluation report, March 2017*. Retrieved from http://ydc.qut.edu.au/about/evidence-of-effectiveness.jsp

Sullivan, A. (2002). Bourdieu and education: How useful is Bourdieu's theory for researchers? *The Netherlands' Journal of Social Sciences, 38*(2), 144–166.

Teach For Australia. (2016). *Australia's PISA results show educational disadvantage gap remains*. Retrieved from http://www.teachforaustralia.org/2016/12/07/australias-pisa-results-show-educational-disadvantage-gap-remains/

Thornton, S., De Bortoli, L., & Buckley, S. (2013). *PISA 2012: How Australia measures up*. Camberwell, VIC: Australian Council for Educational Research.

Trumbull, E., & Pacheco, M. (2005). *The teacher's guide to diversity: Building a knowledge base. Volume 1: Human development, culture and cognition*. The Education Alliance at Brown University. Retrieved from http://indiana.edu/~pbisin/resources/TeacherGuideVol1.pdf

Valencia, R. R., & Solórzano, D. G. (1997). Contemporary deficit thinking. In R. R. Valencia (Ed.). *The evolution of deficit thinking: Educational thought and practice* (pp. 160–210). London: Routledge Falmer.

Venenciano, L. & Dougherty, B. (2014). Addressing priorities for elementary school mathematics. *For the Learning of Mathematics, 34*(1), 18–24.

Warren, E., & Cooper, T. J. (2009). Developing mathematics understanding and abstraction: The case of equivalence in the elementary years. *Mathematics Education Research Journal, 21*(2), 76–95.

Warren, E. A., Quine, J., & DeVries, E. (2012). Supporting teachers' professional learning at a distance: A model for change in at-risk contexts. *Australian Journal of Teacher Education, 37*(6). http://dx.doi.org/10.14221/ajte.2012v37n6.1

Weinstein, C. S., Tomlinson-Clarke, S., & Curran, M. (2004). Toward a conception of culturally responsive classroom management. *Journal of Teacher Education, 55*(1), 25–38. doi:10.1177/0022487103259812

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed., Vol. 5). Thousand Oaks: Sage Publications.

Yosso, T. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race, Ethnicity and Education, 8*(1), 69–91.

YuMi Deadly Centre. (2014a). *YuMi Deadly Maths: Big ideas for mathematics – Prep to Year 9*. Kelvin Grove: Queensland University of Technology.

YuMi Deadly Centre. (2014b). *YuMi Deadly Maths: Overview – philosophy, pedagogy, change and culture*. Kelvin Grove: Queensland University of Technology.

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