Child-centred Inquiry Learning: How Mathematics Understanding Emerges

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Summary

This paper examines how mathematical understandings might emerge through student-centred inquiry. Data is drawn from a research project on student-centred curriculum integration that situated mathematics within authentic problem-solving contexts and involved students in collaboratively constructed curriculum. The project involved case studies in three New Zealand primary school classrooms. Mixed methods were used to collect data while participatory action research was the methodology employed. Three scenarios were described and analysed. The findings indicated that mathematics centred on real-life learning was highly engaging and that the measurement and geometric thinking explored went beyond New Zealand curriculum requirements.

Introduction

Mathematics and statistics are inextricably linked with everyday life - they are key elements of being an informed participant within a diverse range of culture and social groupings and hence are central to existing and contributing effectively in society. Mathematical, statistical, and probabilistic thinking are frequently drawn on and applied in everyday practical situations. Often the application of mathematical knowledge is considered as something that is situated at the end of a learning process, as an application of learnt skills, but it should also be an aspect of the initial engagement. Rather than commencing with certain abstractions or definitions to be applied later, some mathematics educators contend that the learning must start with rich contexts that require mathematical organisation or, in other words, contexts that can be mathematised (Freudenthal, 1968; van den Heuvel-Panhuizen, 2010).

When learners engage in the investigation of a problem, interpretation influences the nature of that engagement. The perspectives that underpin those interpretations are conditioned by socio-cultural experiences (Gallagher, 1992) and in turn influence the understandings that emerge (Calder, 2011). Wenger (1998) argued that learning is enhanced when the students develop a “thirst for learning of the kind that engages one’s identity on a meaningful trajectory and affords some ownership of meaning” (p. 270). In order to establish such ownership, teachers often attempt to design problem-solving contexts that relate to real-life situations (Lowrie, 2004). There is evidence that bringing student’s naturalistic out-of-school experiences into more traditional settings has positive effects on problem solving (Clancy & Lowrie, 2002). Lesh and Harel (2003), for example, maintained that the kind of problem-solving that should be emphasised in classroom contexts are simulations of real-life experiences where mathematical thinking is useful in the everyday lives of the student or their family and friends. Student-centred Curriculum Integration (CI) is a democratic teaching approach where relevant and meaningful contexts are central to curriculum design.
Students pursue questions, issues or inquiries that are of genuine interest to them and curriculum is collaboratively co-constructed (Beane, 1997). This power-sharing pedagogy heightens student ownership and raises relevance for students as they are fully involved throughout the learning process from the initial planning stage through to assessment. Subject area knowledge is employed in order to pursue pertinent issues of inquiry; for example, in mathematics children may explore strategies for calculating money or receive explicit teaching on place value and decimals to determine the costs of going on their class camp. In literacy, students might learn how to craft letters or emails to parents or members of the community to determine costs of potential camp activities or seek support with transport (Brough, 2008). Subject material is repositioned contextually but with a teacher overview so that curriculum imperatives have the opportunity to emerge. One objective is that learning is strengthened as children are motivated to acquire the skills and knowledge necessary to solve their particular inquiry question. A substantive body of research supports the efficacy of student-centred CI with heightened achievement reported, student positivity and enhanced engagement (Beane, 1997; Brough, 2012). Studies have identified that students’ motivation and persistence with tasks have increased (Nolan & McKinnon, 2003; Vars, 1997). The New Zealand Curriculum (Ministry of Education, 2007) advocates the use of relevant learning contexts and an inquiry approach which has very similar learning processes to student-centred CI. Recently, classroom environments have emerged that foster authentic inquiry to stimulate high-level thinking. Several new schools have been built and structured specifically to enhance student-centred inquiry learning through the use of resource hubs, ease of access to the internet, and flexible learning spaces or commons. Student-centred CI encompasses similar pedagogical principles including student-negotiated curriculum and the investigation of authentic problems.

These principles include the use of relevant learning themes. Students should be involved in the determination of the learning process, while Beane (1997) contended that themes should be organised around problems and issues. Students should pose questions arising from these situations. The second principle is negotiated curriculum, with teachers and students collaborative constructing the learning process (Fraser, 2000). This includes the teacher as facilitator, establishing a positive, risk-taking environment (Cook, 1996), and the students being involved with planning. This planning process includes: children anticipating and suggesting investigations, activities, skills and expertise that they may require to solve the issue at hand. The issue and investigation become the curriculum. Beane (1997) discusses life itself being the curriculum. The teacher use of in-depth questioning to scaffold learning appropriately (Fraser, 2000) and the students determining assessment, the assessment criteria, for instance (Beane, 1997) are also key principles of student-centred curriculum integration.

Educators are also suggesting that student-centred inquiry, based on problems the students pose, utilises authentic learning contexts and leads to a strong sense of student ownership, enhanced student engagement and understanding, and motivation to learn (Beane, 1997; Brough, 2008; Dowden, 2010). Affective dimensions of the process, including motivation and task persistence, are more likely to be enhanced in authentic situations. Some researchers contend that recreating learning processes in the classroom situation that are similar to those
arising from out-of-school mathematical processes will enhance mathematical thinking in real life situations (e.g., Bonotto, 2002). De Corte, Verschaffel and Greer (2000) maintained that in order for students to make meaningful connections between problem solving and real-life contexts, they need to be immersed in innovative learning environments that are radically different to traditional classroom practices. They proposed that tasks should be well structured, diverse and authentic. Authentic tasks reflect the nature of real problems because they are complex, ill structured, contain multiple perspectives and offer multiple pathways or solutions (Young, 1993).

In addition, the nature of inquiries involves many skills that are not measurable through standardised tests such as the ability to negotiate, create knowledge, think creatively and critically, and work together for the common good. These kinds of competencies align with the New Zealand Curriculum (2007). Contemporary integrative theorist James Beane (1997), advanced these notions further theorising a curriculum design which used student generated learning contexts, and involved students and teachers collaboratively constructing curriculum. Meanwhile, others have found that using digital pedagogical media enhances students engagement with authentic mathematical inquiry and facilitates the research, analysis and presentation elements of the inquiry process (Salsovic, 2009; Calder, 2011).

This paper reports on an aspect of a participatory action research (PAR) project which explored the implementation of the principles and practices of student-centred curriculum integration in primary school settings (Brough, 2012). The research question for the broader study was: What happens in classrooms where teachers are attempting to incorporate the democratic principles and practices inherent in student-centred curriculum integration? This paper examines the nature of the mathematics learning that the students engaged with through utilising the student-centred inquiry approach, including the teacher and students’ co-construction of the learning process. The paper contends that authentic engagement led to powerful learning opportunities.

**Methodology**

Mixed methods were used to collect data, these included: semi-structured interviews, focus group meetings, informal discussions (electronic and face to face), naturalistic observations, work samples, and photographs. Three teacher participants were involved, the age range of the children in their classes spanned from 5 to 11 years of age. A case study approach was used to document this nine-month inquiry. The three teachers were involved in a series of three self-reflective cycles involving planning a change; acting, and observing what occurs; reflecting, and then planning further actions. The third phase focussed on how students could be more involved in curriculum planning. While the teachers developed individual inquiry questions, each cycle included collaborative reflection and dialogue between all the participants.

The case study approach sanctioned a range of indepth contextual methods of data collection suitable for examining the complexity of a classroom situation. However, inherent to the case study design is the compromise required regarding the generalisation of results. There is also
potential for researcher bias and subjectivity, while a tendency to lack rigour has also been considered a limitation of the case study approach. While acknowledging the potential of these aspects to influence findings, the breadth and nature of the data collection was considered sufficient to ensure validity, while gaining further insights into classroom practice where student-centred curriculum integration was used.

Participatory Action Research (PAR) was the methodology used to interpret the data. It was chosen because its emancipatory research process was in keeping with the democratic pedagogy of student-centred CI. Hence, it enabled insights as participants explored a range of self-determined democratic inquiries. The principles and practices that the participants explored included how to create more democratic learning environments, the use of relevant learning contexts, and collaboratively constructed curriculum. The researcher was a participant and facilitator within the focus group meetings, which including the participant teachers self-reporting. The ensuing discussion was part of the data, as were the teacher reflections in their shared blog. While a broad range of disciplines were required to pursue the meaningful questions arising during the project, the focus of this paper is the mathematics that occurred. While three scenarios will be the discussed, the first is examined in more detail.

In all three schools, teachers were also required to implement mathematics using the numeracy framework (Ministry of Education, 2008). Children were grouped based on data attained during a diagnostic interview which assessed children’s strategic and mathematical knowledge. The mathematics that evolved naturally as part of student-centred CI took place beyond these times through inquiries triggered by students’ questions, classroom conversations or incidents from within the classroom or the community.

**Results and discussion**

The three scenarios examined emerged from authentic student questions or issues that arose from ongoing classroom practice. They were chosen because they were situations where the mathematics and associated discussion had emerged. They illustrated the nature of the mathematical processes and thinking. They also reflected a range of mathematical thinking. Although each had elements of a range of inter-related curriculum concepts, the prime focus of the first was geometry and measurement, the second, measurement, and the third, number. The teachers had heightened awareness of the potential opportunities that allow the students to pursue their own inquiries.

The first scenario to be discussed arose as part of an open democratic discussion which sought students’ opinions on how they might contribute to decision-making and how their learning might be enhanced in class. It involved a class of 10-year-olds. After several iterations of discussion and review, a suggestion emerged that learning would be far more effective in a bigger classroom and that the children’s small prefabricated classroom should be extended. This student initiated suggestion, although moderated through discussion and co-constructed with the teacher, was their response, and their proposal for exploration. It guided the ensuing, ongoing class learning programme. The children were motivated to explore different ways of extending the classroom.
As they began the designing process, some of the discussion focussed on comparing their room to the room next door. The children’s suggestions also included extending the classroom in either direction, and building a second story. They also suggested simple ideas for improving their current classroom e.g., a microwave so they could learn to cook, which would have involved them in measuring. They suggested they would need to learn how to measure accurately to draw plans. Inevitably, the notion of volume and how to measure it was engaged with. Over the subsequent week the proposition was explored using both geometric and measurement thinking.

Teacher (Toni): We started by talking about the space and how to use space in a classroom. We talked about how different shapes might work. They came up with exploring circles, rectangles, squares and other shapes, including irregular ones. I asked them to work in groups to consider different shaped classrooms. How would you make sure you could fit everything in? What gives you the most room for the size? What shapes worked best for doors and the furniture we have? They explored different shapes and drew sketch plans. One group even had a donut shape with the doors opening to the outside. When they wanted to open it into the middle they realised it wasn’t going to work very well after all. They saw that there was no flow and the space would be too confined without a hallway off it.

It is evident, from the nature of her questioning, that the teacher takes a facilitative role and evokes critical reflection. She is following their lead in terms of the topic of the investigation, but engaging with the students in ways that promote further thinking on the topic. Her question below illustrates this:

**How would you make sure you could fit everything in?**

From these initial conceptual drawings the students soon determined the need to envisage their plans in 3-dimensional space.

Toni: They drew floor plans and explored as 2D. They then set the plans out with multi-link cubes before exploding them up into their height. They built them up with the multilink cubes. They scaled them up with a centimetre cube block representing a cubic metre.

This led them back to the actual structure of their room and the problem of it being too small. They decided to measure the room. Again, this is evidence of the student decision making and their direct influence on the learning process. One group’s discussion initiated an approach to measuring the room.

Sam: We need to know how big the room really is now.

Fran: How are we going to measure it?

Sam: Let’s get a ruler and measure the length of the walls.

Tineke: And to the ceiling

One student was concerned with making sense of the information.

Sam: But what does that mean? How does that show us the space?

Tineke: Well we could find the area of the floor and see how much space we have to put stuff.
Sam posed insightful questions as they attempt to make sense of the relationship between 2-dimensional and 3-dimensional representations. This initiated, and then orchestrated, the group’s ongoing learning trajectory, which then informed the direction the class took. Again, this illustrated the student-negotiated curriculum that was evolving. The nine and ten-year-old students were unfamiliar with the concept of measuring in square metres. The teacher challenged the class to work in small groups and make one square metre out of paper. This was used to estimate and measure different areas of the school this helped the children gain an understanding of size and discover how length can be multiplied to determine area.

Sam: What about making a cube like the multilink but bigger.

Toni: The students started with some measuring in groups. They found some lengths for the room, 10m long and 8m wide.

Toni talked about 2D and they identified things that were 2D. Someone suggested the carpet. What about the height of the carpet? The students considered making the 2D things into 3D.

Finn: We could turn the flat 2D stuff into things that you could sit on or put stuff on.

Sophie: Yeah sort of measure it up to 3D.

The teacher prompted them.

Toni: How can we use this information? How do we make it into 3D?

The students responded.

Ani: We could make paper cubes, like the multi cubes, scaling up.

Hine: We could roll up the paper to make the sides.

The students made the cubes.

Figure 1: Students measuring with model of cubic metre.
The students measured up the size of the room with the paper cubic metres. They rolled the cubes across the floor and marked off how long the classroom is. They started to measure up the wall as well to get the volume. Their classroom had a pitched roof, which presented an additional measuring challenge. The students ran into a problem when they hit the sloped angled roof. This provided a new challenge.

Eli: How are we going to measure that?

Once more, a key student question was elicited from consideration of, and reflection on, a challenge that arose from exploring their authentic problem. It informed and then set the direction for the next stage of the students’ ongoing mathematical exploration and thinking. They tried things and made lots of suggestions:

Ben: We could bend down the sides.
Matt: Yeah, flatten the sides a bit.
Ash: Maybe we could make some other shapes.

They spent nearly two weeks discussing and exploring ways to solve the problem of measuring the volume inside the angled roof.

Ben: People are measuring angles all the time. How are we going to get to it?
Chris: We could measure all around the outside.

The students tried modelling it with bits of paper to show the profiles. Eventually, the teacher Toni gave them some scaffolding to change their approach a bit.

Toni: What about cutting the squares down the middle.

She asked them to consider halving the apex triangle shape and investigating to see if they noticed anything that would help them to solve the problem. They worked on the challenge in groups. Several groups cut up the triangle and worked out that if the two halves of the triangle could be made into a rectangular shape which helped the children use existing knowledge to calculate the total area of the triangle. The children who generated this solution worked with other groups who were still engaged with the challenge.

They explored the relationship between the 2D square paper and the floor and the 3D equivalent and the volume. They explored and effectively used two-dimensional representations of 3D objects and made connections between the various measurement representations.

The class then considered what they had learned about cuboids to calculate the total volume of the room, using the length, width and height to determine their solution. The teacher supplied additional explicit teaching to the children who required support to calculate the challenge. This focused teaching was initiated by the questions that the students posed. These evolved from their motivation to solve an authentic, personally contextualised problem. This
A problem solving task revealed that their room was 20 cubic metres smaller than the class next door. Following this, the students created flow charts of the building process they anticipated would be required to bring their proposal to fruition. Recognising they would need help and advice the class arranged to consult with a builder and sought the expertise of a member of the local City Council who immediately offered to visit. In the interim the students began designing their classroom extension plans included adding on to either side of the building, or both, and second story options. They considered their own learning needs but anticipated the needs of future students, suggesting wheelchair ramps and proposing environmentally sustainable options.

The teacher mediated and facilitated that inquiry process so as to help ensure that the investigation and deriving a solution were manageable. Hence, while the students drove the process and the learning, the curriculum and context was co-constructed with the teacher. This required the teacher to have in-depth relational understanding of her students, as well as appropriate pedagogical content knowledge (PCK) to recognise the mathematical learning opportunities and to optimise them.

A visit from the council staff member presented further mathematical challenges as building costs per metre were shared for single and two-story options. Additional costs would need to be considered for the building permit, architectural plans and any appliances required. The children inquired about wheelchair ramp regulations and sizes of windows to maximise sun and minimise heating costs. Again, the questions emerged from student reflection, and they were related to other curriculum areas - social and environmental studies. The students were shaping the direction and the content of the learning. The environmental councillor explained about heating cubic metres. A protected historic tree situated on one side of the classroom led to a discussion on the length of roots and drip lines for trees. The children moved outside to estimate and step out the tree’s distance from the class. Following this visit, the children calculated the costs of different options and consequently the two-story options were highlighted. They repositioned plans that had included extensions on the tree side of the class and reconsidered some of the more ambitious and costly designs.

The mathematical thinking and knowledge gained through the class extension investigation involved students learning how to apply multiplicative strategies for area and volume, and how to measure using linear scales of metric units for length, area, volume and capacity. Further, the children needed to calculate various building costs which involved students having to apply additive and multiplicative strategies. While budgetary constraints prevented the extension becoming a reality, a large covered veranda has since been added to the classroom. The children reported that they enjoyed the project and the learning that took place. This context extended beyond the mathematics discussed, and included cross-curricula links to literacy, technology and science.

It also led them to investigate ways to measure other 3-dimensional structures in the school. Other explorations were initiated from their new mathematical understanding. One of these arose from the question: How much water is there in the swimming pool? They decided to measure the sides to get the surface area. They then dropped a stick down into the bottom and
found and marked off the wet mark to get the depth. Using their new understandings they were able to calculate the volume of the pool. The children discussed how they would now have no problem calculating the cubic volume of their school pool and other 3 dimensional shapes. The next scenario is set in a class of 5-year-olds.

Younger children more often think about and engage with their immediate world, their here and now. The questions and opportunities for student-centred learning frequently arise out of issues or events of more immediate interest. Themes may be initiated from small incidents evoked from the daily programme or a community event that has attracted student interest. The second scenario involved a year one class (5-year-olds). One particular morning a drain digger arrived at one school to create a large sump hole to rectify a drainage problem on the field. The arrival of a digger in the school grounds immediately captured the 5-year-old children’s attention and stimulated their curiosity. Students began asking questions and wanted to observe what was about to happen in the playground. Sensing an excellent learning opportunity the teacher took the class out to the field. The children began raising questions and making comments:

How will they get the digger off the truck? How deep do you think the hole is? How will they make the hole bigger? How will they get the heavy pipe into the hole? If he digs anymore he will end up in space. Look the dirt is changing colour as he digs.

While the teacher recognised the potential of the learning situation due to the student engagement and the curiosity that it evoked, the question that the students posed indicated and influenced the students’ learning trajectory – the way the learning unfolded and was engaged with. The children took photographs of the digger making the hole and they asked if they could talk to the driver so he could provide answers to their questions. The driver told the students the hole was to be four metres deep, he discussed what was happening and why, he introduced the children to what porous meant and discussed the layers of the earth. While safety issues prevented students peering fully into the hole as they had requested, the children suggested a viable alternative was to ask the driver to photograph the hole.

The children moved to the courts to work out how deep four metres was. The students made an initial estimation then decided they could use metre rulers to work out the problem. The students began measuring the four metre depth but there were only three rulers which presented a challenge for the five-year-olds. Eventually they determined they could reposition the first ruler to the end and consequently they successfully measured the holes depth.

The students initiated the nature of the approach to investigate the problem, including the choice of equipment. They lay down end on end and used a variety of other non-conventional measures such as their hands and body length to determine different ways to estimate and
then measure. The following day they wrote stories under the printed digger photographs and read “The little yellow digger” series. They also poured water over various object to understand what things were porous and which were not. In the initial phases of the project the teacher had focussed on establishing a classroom climate that was democratic, and empowering, she had actively sought student contribution and encouraged curiosity. The teacher achieved this by asking open-ended questions, not solving problems for children and having a high expectation level. Consequently, the children felt comfortable asking questions, making learning suggestions and solving problems for themselves.

The facilitative role of the teacher is critical here. Their recognition of the potential learning in situations, their willingness to follow the students lead, and their ability to prompt, mediate, and support a student led approach was central to the success of the co-constructed learning approach that evolved.

The students gained an understanding of a metre and how to measure. They used non-standard measurements, but as they came to realise that differing footsizes or heights produced different outcomes, they sought the connection to standard measurements. For some this led to a simple but profound understanding:

Jake: Hey, did you know these rulers are all the same length!

They learned to order and compare lengths and used estimation. While making comparisons between lengths some of the comments were:

Jane: It is way bigger than I thought.

Mia: That is the same as three and a half of us.

Counting, simple fractional number concepts, and number operation strategies were also utilised within the measurement context.

The final scenario to be discussed emerged as a result of a regular classroom quiz which on this occasion featured questions on New Zealand. The 10-year-old students discovered they were unable to answer most of the questions and they quickly identified a problem that existed within their class, which was that they knew little about their own country. When asked by their teacher what they thought they could do about the problem, the children suggested they could get to know more about places in New Zealand by planning a holiday to a particular destination. This was a student-initiated approach. The students suggested a way to research and consider different parts of New Zealand within a study that contained mathematical, language and social aspects. As with the previous situations, this illustrated circumstances where the approach taken by the teacher facilitated a student-led approach to the mathematical learning. They suggested presenting their learning to each other to enable them to learn about more than one place. The learning criteria was negotiated and co-constructed by the students and the teacher. It included: A $2000.00 budget, researching visitor attractions and costs, a one hour travel limit to visit an attraction, a visit to a geographical or historical feature of significance, a timetable of events, car hire costs, grocery expenditure, petrol and accommodation costs. “The Great Family Road Trip” was to be
presented in a travel expo format promoting the town as an appealing travel destination. Hence, the assessment criteria were also co-constructed.

The process for deciding who would research which towns was discussed with consensus gained between the students as to which approach to take. Children were randomly allocated towns through a blindfolded spin then pin in the map system they invented. The task saw students contacting local attractions, hire car companies, tourist information centres and the internet for information. As a result of this research project, the children received free coupons and discount vouchers to many New Zealand attractions. After viewing one of the promotional power points, the city council concerned asked to include it at their visitors’ centre. The mathematics that was required included: using a range of additive and multiplicative strategies, number knowledge to calculate multiplication and division problems, calculating grocery costs, distances in kilometres, travel time, and petrol expenditure while maintaining the $2000.00 budget. Numerous families used the information to plan their up and coming school holidays, going on trips that used their own child’s destination and the destinations of others. The coupons to the various local attractions were utilised and highly valued.

The three scenarios described arose out of student questions and negotiated inquiry. The students were involved in the planning and inquiry processes, while the teacher took a more facilitative role. Nevertheless, this included the development of skills and processes as they arose, or at times when they were anticipated. The manner in which this influenced the learning and the engagement of the students is discussed below.

Conclusions

This paper examined mathematics as it emerged through student-initiated inquiries. The study identified several aspects of mathematics that were utilised within the context of the integrated student-negotiated learning activity, and elements of the learning process that were different from more traditional pedagogical processes. Firstly, the nature of the conceptual knowledge that the students engaged with.

During their inquiry the students in the first scenario had explored and effectively used two-dimensional representations of 3D objects, enhanced their understanding of area and volume, and made connections between the various measurement representations. The mathematical thinking and knowledge gained through the class extension investigation involved students learning how to apply multiplicative strategies for area and volume, and how to measure using metric units for length, area and volume. Further, the children needed to calculate various building costs that involved students having to apply additive and multiplicative strategies.

The 5-year-old students in the second scenario used estimation, measurement (both non-standard and standard) and number processes that emerged from the desire to address their questions evoked by their curiosity with an incidental school event. The third scenario involved a student-initiated realistic context that included some conditional decision-making. It created mathematical learning opportunities in number and measurement including additive
and multiplicative strategies, and measurement involving both distance and time. These mathematical concepts and processes were encountered within the context of researching or analysing an authentic real-life problem. Hence, there was a direct purpose for the utilisation of the conceptual knowledge or process, and reason for the students to identify and understand what was required.

As well, the data included examples of co-constructed mathematics curriculum, with the content and pedagogical approach taken, initiated by students’ questions and suggestions. Meanwhile, the involvement of the teachers to enable resolution to the student-led inquiries, highlighted the facilitative, open approach required by the teacher, and the need for both relational knowledge of the students and mathematics PCK to best optimise the potential learning situations for mathematics. They needed to know the students’ individual and collective interests and circumstances so as to successfully mediate and co-construct the appropriate form of the authentic context for the class, and support examination of individual or group questions. They also required knowledge of the students’ mathematical understandings to best negotiate, and enable, the differentiation of the learning for the class and individual students. The teachers’ PCK also influenced the nature and amount of scaffolding that the investigation entailed. Correspondingly, student self-evaluation and reflection influenced student decision-making in terms of the questions raised and the support they desired.

The students engaged enthusiastically with solutions for the problem or with exploring the situation. It was also found that they were highly motivated, and engaged with conceptual and mathematical understandings that extended well beyond curriculum year level guidelines, particularly in measurement and geometry. For example, the year 5 and 6 class measuring in 3-dimensional spaces and calculating the volumes of triangular prisms in the classroom extension situation. Links were made to other curriculum areas e.g., language and science, while the key competencies were also achieved including: thinking and problem solving, managing self, and participating and contributing (Ministry of Education, 2007). Some of the students addressed authentic ethical and social dilemmas e.g., consideration of the wheelchair ramp and the historical tree in the classroom extension scenario.

Student-centred CI teaching often takes place “just in time” as students require skills to solve particular problems. This enabled the students to identify the purpose for the acquisition of skills while it also enabled the understanding to be situated within meaningful contexts. Some researchers contend this leads to enhanced understanding (e.g., Beane, 1997). There were certainly instances in the study when the transferability of newly acquired conceptual knowledge was demonstrated e.g., finding the volume of trapezoid prisms from the classroom to the swimming pool context. Teachers require excellent content knowledge to recognise the potential of children’s inquiries and to extend children into new subject material positioned within a meaningful learning context. While teachers of student-centred CI are required to assume a more facilitative and empowering approach to teaching, extending children’s mathematical thinking into areas they may not have considered is frequently required and explicit teaching is still vitally important. This explicit teaching was sometimes in the form of
needs-based workshops – these needs were frequently self-identified and initiated by student inquiry.

In the primary school setting, younger children are often more concerned with the here and now and consequently issues of immediate interest can be used as potential learning themes such as the classroom extension (Brough & Calder, 2012). In the second scenario, the mathematics learning was invaluable in terms of applying problem-solving skills to a meaningful context, and developing estimation and measurement skills including using conventional and non-conventional measures. This is in contrast to a more traditional mathematics lesson, which would have predetermined what was to be measured and how, and likely served no legitimate purpose in the children’s eyes. Again, the students determined the nature of the inquiry, and the learning process, through the questions that were evoked through engagement with the authentic student-initiated inquiry.

In the first scenario, extending the classroom, introducing the children into considering volume extended children’s mathematical knowledge and also helped children to understand how higher studs and roof apex can give the illusion of space. They understood that additional volume does not always result in any additional floor area. Student-centred CI provided an environment where the children were encouraged to make suggestions and consequently these children identified a learning context that they perceived to be highly relevant to their needs and learning. A high level of motivation and engagement was witnessed throughout the project with children wanting to work through the lunch breaks and discussion of the learning taking place at home. Not only did the purpose become apparent, the contextualisation of the content appears to embed the students’ learning and the understanding better, while making links to other content and processes clearer. Hence the learning is of a more relational nature.

Teachers in the project pursued issues of substance that arose on a daily basis and the learning opportunities were frequently negotiated with the students. Teacher flexibility was essential in order for learning to be genuine, on the spot, and authentic. It required teachers to break away from more traditional structured mathematics programmes that commence with abstractions and instead use meaningful contexts that can be mathematised (van den Heuvel-Panhuizen, 2010). Teachers required democratic and empowering pedagogical understandings combined with excellent curriculum content knowledge, and a high expectation of students. They needed in-depth understandings of their students’ interests and personal circumstances, their individual and collective mathematical understandings, and appropriate mathematical PCK.

This study was small in scale, and therefore it is difficult to draw generalised conclusions. Nevertheless, it served to build upon emerging research on the benefits of contextualised learning in mathematics. It also demonstrated that content knowledge is not lost when using student-initiated learning contexts. Instead, it was repositioned within highly engaging learning contexts, while understanding was facilitated and enhanced. Students were motivated to acquire conceptual knowledge and mathematical processes and strategies.
References


