Privileging a Contextual Approach to Teaching Mathematics: A Secondary Teacher's Perspective

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This paper focuses on using sociocultural theory to support a context-based approach to teaching mathematics. A goal of the research was to explore the opportunities-to-learn of using a context-based approach to enrich student engagement with mathematics. This paper focuses on the practice of one female secondary school teacher as expressed through an interview transcript. Data were analysed using a participation framework. Findings suggest that aspects of a context-based approach to teaching mathematics can be used by teachers to promote student engagement with mathematics in the secondary classroom.

The contexts in which mathematics tasks are framed play an important role in the development of student mathematical competencies (Organisation for Economic Co-Operation and Development [OECD], 2009). The Programme for International Student Assessment (PISA) recognises this importance and, as part of its assessment of 15 year olds mathematical competency, utilises real world type problems which require quantitative reasoning, spatial reasoning or problem solving (OECD, 2003). A context suitable for such a mathematics task according to PISA strives to be relevant to students, to shift between the mathematical and the everyday, and to be relevant to the production of a task solution (OECD, 2009). Through the use of such contexts, students may develop important mathematical competencies related to representation, reasoning, argumentation, and communication.

The emphasis on task context when teaching classroom mathematics has been used in varying degrees to locate the learning of mathematics within the social practices of the classroom (Cobb, Stephan, McClain, & Gravemeijer, 2001), to locate the knowing of mathematics within the resources of a mathematical community (Duguid, 2005), to situate the classroom as a community of practice (Hung & Chen, 2007), and to diagnose the difficulties students have when doing influential, large-scale mathematics assessment (Wijaya, van den Heuvel-Panhuizen, Doorman, & Robitzsch, 2014).

The social practices of the classroom may be said to encompass the resources and norms its members share when doing mathematics (Cobb et al., 2001). The resources of a mathematical community may be said to include the conventions and relationships that are pertinent to a community, for example economists, when knowing mathematics (Duguid, 2005; Hung & Chen, 2007). As such, knowing and doing mathematics needs to provide opportunities for students to apply mathematics to everyday life and to provide possibilities for mathematisation, that is, opportunities for students to organise information mathematically and to use their pre-existing knowledge and experiences to use that information to complete a mathematics task (Wijaya et al., 2014).

In other words, an understanding of context and its importance to knowing and doing mathematics needs to encompass the social contexts in which students do mathematics, the norms which privilege certain ways of thinking and knowing within those contexts, and the pedagogy that enables students to participate in those contexts. As such it is important that future research explores what opportunities-to-learn students are offered when engaging in context-based mathematics tasks. This paper provides insights into what these

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opportunities-to-learn may look like by exploring the thoughts of a female secondary teacher as she 'talks about' her class doing context-based tasks in her secondary mathematics classrooms.

Theoretical Framing

A context-based approach to teaching and learning is congruent with the writings of theorists such as Vygotsky who described the emergence of human development from social-cultural contexts. According to Vygotsky (1987), learning results from people participating in contexts where semiotically-mediated social interaction is facilitated through the use of psychological tools such as those associated with the signs and symbols (including language) of mathematics. Learning results from participation in shared practice and is mediated by the sociocultural, that is, by those tools constructed by others (e.g., algorithms, mnemonics, formulae, norms etc.) in which they share their ways of knowing and doing. It is through participating in historically and culturally situated contexts that a student's relationships to others, to activity, and to the world may be transformed over time to show congruence with the ways of knowing and doing of mature communities of practice - mathematicians, scientists, historians, etc. (Lave & Wenger, 1991). From this point of view, learning may be considered to be an independent process, but it proceeds through contexts that have social, cultural and historical dimensions. However, participating autonomously in classroom mathematical activity requires that teachers link students' individual mathematical thinking (representations) to the cultural, historical dimensions of mathematical practice through the provision of learning opportunities that are meaningful to students (Cobb et al., 2001).

One way of investigating what opportunities-to-learn students are offered when engaging in context-based tasks is to examine 'talk about' a classroom community (Lave & Wenger, 1991). One source of "talking about" a classroom community that fulfils this requirement is a teacher interview. This paper provides insights into the opportunities-to-learn provided to students in a secondary classroom that uses context-based tasks by exploring the utterances of a female secondary teacher as she 'talks about' her class doing mathematics.

Method

Classroom Context

The interview focuses on this teacher's experiences in Year 11 and 12 classes where students were required to model and communicate solutions to real world type tasks situated within a problem-centred curriculum (for an example of these tasks see Redmond & Sheehy, 2009). In order to operationalise this curriculum this teacher had been using a sociocultural tool, Collective Argumentation (see Brown, 2017), to engage her students in the learning of mathematics. In brief, Collective Argumentation is a sociocultural approach to teaching and learning mathematics. Presented with a task framed in a problem-solving context, students are required to individually represent a solution to the task, join with a group to compare, explain and justify that solution and reach consensus within the group to a solution that can be presented to the class for discussion and validation.

Research Participant

The teacher who is the focus of this article, Jill, is a teacher with significant experience in the secondary mathematics classroom. Having taught in a number of different national and international educational jurisdictions, Jill was based in a middle-class Independent College situated in a major Australian city.

Interview Context

The 30-minute interview was conducted by a Research Assistant and took place in a mathematics classroom after school hours. Jill responded to a set of questions that were general in nature to assist reflection on issues related to teaching mathematics. The interview was situated within a larger study conducted over a three-year time frame that involved university educators working with school teachers of mathematics from schools located in South-East Queensland to bring about and reflect upon change in the way they teach mathematics.

Analytic Framework

Jill's interview was transcribed and subjected to a form of analysis derived from methods associated with sociocultural theory. This form of analysis centres on the broad categories of *location* - how the classroom is organised, *relationships* - the roles and responsibilities visible in the classroom, *content* - type of knowledge privileged in the classroom, *pedagogy* - what the teacher and students do in the classroom, and *assessment* - what is valued in the classroom (Vadeboncoeur, 2006). This paper focuses on the opportunities-to-learn in a secondary classroom that uses context-based tasks.

Analysis and Discussion

Location: Forward Thinking Versus Back Lashes

For Jill, the mathematics classroom emerges as a "forward thinking" space where students need to be prepared to apply "what they know" to "novel situations", a space where teachers need to provide students with 'opportunities' to be 'active participants' in a 21st Century society that has yet to be envisaged.

> I think we need to develop kids in 10 to 15 years for jobs that don't even exist, so we are really getting kids to be forward thinking. They have to be able to transfer what they know to novel situations because who knows what they are going to be doing in 20 years' time when they are finished school, uni, and then have a career. We need to be providing kids the opportunities to be active participants of a society we don't know, or can't even envisage because it's not here yet.

However, Jill worries that the present society in which the classroom is located will diametrically oppose this view of teaching mathematics, prepared to judge students as being "no good" at mathematics if they can't quickly perform mental calculations, even though they are "using" their mathematical knowledge in ways that "make sense of the world" in which they live.

> I worry that we get back lashes about kids not being able to do percentages and kids not being able to do this, that and the other, and it frustrates me because there's two very different opposing views there I see. We (teachers) beat them (students) around the head 50 times because they can't find 33.3% of 245. But if you (teachers) give them five minutes they probably can, but they can't do it in their head.

> It frustrates me… because it's such low level, this stuff that they (society) are saying, they (society) are actually missing the idea that these kids are actually really thinking in quite a sophisticated manner. They (students) are using all of this stuff that they (society) are saying that they can't do but they (the students) are using it in a way that actually makes sense of the world, real life problems. But because they can't do it instantaneously, that they (the students) are no good.

As suggested in the above analysis opportunities-to-learn in Jill's classrooms are expressed in the form of a tension between her classrooms and the society in which they are located. References to feeling 'frustrated' about what Jill interprets as society's privileging 'low level' expectations of what it means to know mathematics over students using mathematics to make sense of the real world echo the tension that exists between classrooms that privilege authentic contexts of learning, that is, those that mirror the kinds of practices evident in professional communities (e.g., economists), over contexts that mirror the skills of the everyday workplace. According to Hung and Chen (2007), such tension can be productive if it is dialectical in nature rather than diametrical, that is, where the transfer of high level processes, such as analysing, synthesising and modeling, to novel real-world situations occurs simultaneously with the development of skills such as mental computation. Jill's understanding of the need for this complementarity is evident in the relationships she sees in her classroom.

Relationships: Talking Versus Telling

For Jill, building relationships with students is about giving students opportunities to learn through "talking to them" for the purpose of finding learning contexts that the students have "access to" and are better able to "contribute" to their learning of mathematics in terms of "confidence", others "interpretations" of their mathematical potentials, and through group interactions where students are more on "par" with each other.

> By talking to them, and it's just like, there are some boys that are in the class that like skateboarding which I just hate and so for me to try and find a context, that takes a lot of effort, but because they (the students) do have that access to the background information (skateboarding) they are certainly able to contribute more, which builds their confidence which builds, you know, other kids, I suppose interpretation of what they can build (mathematically model), or bring to the group which, you know, changes the dynamics of the group, you know all that sort of stuff.

For Jill, the success of the group relationships in her classrooms is dependent on the context in which the mathematics is situated.

> Sometimes I think the context, the start, the question that you (the teacher) use will, may, I don't know, keep the kid at that weak point, which you (the teacher) think they are, or it could actually give them an opportunity to join with the rest of the group and be on par, I don't know. They (the students) work really well as a group and they don't just work out who's, … like I am just trying to imagine now my Year 12s. They know that different people have strengths on different areas and so depending on the context, they will very quickly work out who they can conference with in order to check what they are doing in different sections. So, there's people who are really, really good at the language and the communication and justification of the solution. There are people that are really, really good at the mathematics. There are people that are good at like those questions that require high initiative and really complex thinking.

Through "talking" with students, Jill's understanding of what it means to be a teacher has "changed" and she expresses a "wonder" that some may think that she is not doing her "job".

> So, I think my understanding of teacher has certainly changed and I think that I wonder if a lot of people would think that I am not doing my job. Do you know what I mean, I know I am, but

> because I am not sitting up the front, because I am not telling the kids what to do. I am evoking an argument because of the context I chose, and the kids are arguing 'cause they don't agree with each other and they are using mathematical language they are using the mathematical equations.

Relationships in Jill's classrooms require an expansion of what it means to be a teacher from being an expert who can transmit knowledge to include being an evoker of mathematical argumentation where students, because of the contexts in which the mathematics is situated, are 'arguing' over ideas, using 'mathematical language' and its associated tools, for example, 'equations'. Such an expansion of the understanding of teacher is necessary for engaging students in authentic opportunities-for-learning that privilege conceptual mathematical conversations and reflection on those conversations (Cobb et al., 2001). As such, this expansion in understanding of what it means to be a teacher has become the cornerstone of the content Jill chooses to promote opportunities for her students to learn.

Content: Open-Ended Versus Single Solution

The learning experiences that Jill uses to teach mathematics in her classrooms privilege tasks that are "open-ended", that provide students with multiple entry points to access the mathematics, and that utilise contexts that provide all students with opportunities-to-learn even those who she once considered "weak" in the subject domain. When asked, "How have the learning experiences that you provide your students changed?", Jill responded,

> Oh, way, way different, they are much, more open-ended, they are not single solution oriented at all. There is a lot more entry points (in the tasks). Lot's more hooks for kids to take in. Cause right at the beginning (of a unit of work) you kind of know who your weak kids are. But once again I am now wondering whether that isn't something that I am conditioned (to do). Like I used to think that the kids would only get to this point. Am I pin-pointing kids who I think are weak who may not be, who may have just been (slow) because the context that I use, wasn't right for them? If I changed context would they be better? So, I wonder if, by changing context sometimes those weak kids you know will not actually be (weak), but have better access to the maths because of the context, so I try to mix it up a bit. I try and get a context that I find is interesting, certainly to me, if not to me then I try and find interests of the kids then I try and scope it (the task).

When "scoping" tasks for her students, Jill takes into consideration what students think "didn't work" and what "would work better" and tailors the content of her mathematics lessons to suit the "strengths" and "weaknesses", the "likes" and "dislikes" of her different classes of students.

> The kids are actually, that I teach, are really good, they are very open about what they like and what they don't like and they will try something new and they will be very honest about, nope that didn't work, this would work better if. So, I am more, um, I suppose open to the nuances of the class and changing what I do depending on their strengths and weaknesses and likes and dislikes. So, what I do in one class isn't necessarily what I do in another just because of the kids that you teach in the group. That would probably be where it has changed the most, whereas before I just had one (lesson), you know you set your lesson up into three bits and knock yourself out.

This approach to scoping the content of mathematics lessons is congruent with the PISA stages of mathematisation necessary for facilitating student comprehension, transformation, processing, and encoding of mathematical tasks (Wijaya, van den Heuvel-Panhuizen, Doorman, & Robitzsch, 2014). In other words, employing content in the mathematics classroom situated within contexts which are familiar to and of interest to students assists students to identify and select information and to choose mathematical knowledge and procedures relevant to completing a particular mathematical task. It is not

surprising, therefore, that Jill's pedagogy as expressed in her interview privileges student participation and engagement with mathematics.

Pedagogy: Drawing Forward Versus Limiting

Teaching emerges from Jill's interview as having to do with "drawing forward" students by privileging learning outcomes that are "better" for students, "different" to what the students have had in the past and that differentiate the classroom in terms of learning "styles", "questions" posed, and "thinking routines".

> I try and get some outcomes that are better for kids, or different for kids, or maybe even not so much look at the high end, but look at the gamut of activities and see what I can direct different styles, different questions, different thinking routines to get the kids to draw forward.

Using a context-based approach to teaching as facilitated by Collective Argumentation (CA) has provided Jill with the tools to provide her students with learning-opportunities that provide them "time to think", to "go" with that thinking, and to take "different paths to achieving the higher expectation" of what it means to participate in the mathematics of the classroom.

> The big thing that I noticed with CA, my expectations of where I thought, you know you have a big list of four things that you want to do in a lesson, where the kids got to, you know I always thought they will be able to do this, this and this and then I will have to help them with the following things, whereas, by not sort of, by allowing them that time to think at the beginning (represent individually), it sort of really made me think that I was limiting what I was doing by how I was teaching the class. I mean that has definitely changed, I have much higher expectations and I actually think a lot more about how the kids are responding and um lay out different paths for them to take and then go with what they think.

As implied in the above interview extracts, using an approach to teaching such as CA that facilitates context-based teaching is characterised by a strong connection to the sociocultural context of the classroom, that is the roles assigned to teacher and students, the social relationships that emerge when those roles interact and by the demands of the practice of teaching and learning (Hung & Chen, 2007) in this case mathematics. For Jill, these characteristics permeate assessment in her classrooms.

Assessment: Continuous Versus Rigid

For Jill, assessment seems to be concerned not only with the "rigidity" of a "high stakes" regime, but also with "reflections" and mathematical "performances" mediated through a "context" based approach to the "transfer" of understanding.

> I use continuous assessment all the time. And when I say, we do reflections and performances and when I say assessment practices, we have high stakes assessment, which is rigid across the year level that can't be changed and it's the same for everyone and that's fine. There's not a lot we can do about that because we have external assessment, but the other assessment that we do is continuous. Once a fortnight we'll do, it could be just a question, it could be a complex question requiring the kids to actually put all of the stuff they have done in the last few weeks together and apply it in a context to see if, for me, to see if they have got the ability to transfer. Do they know it well enough, have we explored it well enough, so they can actually now hook in (their understanding) and transfer to a different context?

Reflections for Jill go beyond "telling what you did" to linking understanding to the "usefulness" of mathematical knowledge in other "subjects" and to "exploring misconceptions" as a means of providing "feedback" to students.

> Sometimes it's a reflection and of the things (assessment) that I have used it is probably best, but it takes the longest to get the kids to do it well. Are the reflections where, you know in the first three or four months they'll just tell you what they did and, you'll be like, well I was there too, I know what happened. It's more a question of how you have understood what you have done, what it (your understanding) links to, where could we be going with it, where else is it useful in any other subjects, because the kids just see maths in maths and they never draw a graph ever in science or anything like that, which is crazy. But so, my assessment practice has changed. Then based on what I get from those reflections, those misconceptions can come up and then we will go and explore them. So, it's a bit of a feedback loop.

Using assessment in a continuous fashion as described above is in tune with viewing teaching and learning as sociocultural practice, where learning is viewed as continuous participation in the practice of a community (e.g., mathematicians) rather than as being an abrupt movement from novice to knower evidenced through the successful completion of an external exam (Lave & Wenger, 1991), a view of assessment consistent with a context-based approach to teaching and learning mathematics.

Conclusion

This paper has explored a secondary teacher's interview script relating to implementing a context-based approach to providing students with learning-opportunities in the subject domain of mathematics. As reported by Jill this approach has the potential to focus the teacher on actively preparing students for a 21st Century society that is continuously changing. In order to do this, teachers need to be flexible in their view of mathematics teaching and learning. However, implementing such a view in the classroom can be demanding as many in society may not consider that the teacher is doing their job as they are not up the front of the classroom telling the students what to do.

For Jill, promoting talk in the mathematics classroom provides the teacher with opportunities to form productive teaching-learning relationships with students where she can model mathematics concepts, ask inquiry type questions and provide feedback in a manner that assists students to build confidence, to bring their ideas to the class, and to contribute to the mathematics of the classroom. Content in the mathematics classroom, according to Jill, is focused on exploring the assumptions upon which ideas are based and on providing students with multiple points of entry to doing the mathematics. Content knowledge is not based on the language of "right" or "wrong" but rather on the appropriateness of ideas, concepts, and procedures to their context of use.

According to Jill's interview, pedagogy is concerned with bringing about the "best" outcome for each student, catering for different learning styles, posing questions that interest students and with 'drawing' students into the mathematics of the classroom through privileging different thinking routines. Assessment is not about the "rigid" measurement of student performance, but about providing students with continuous opportunities to reflect on their mathematics, to apply their understanding to different contexts, to see mathematics as being useful, and to explore misconceptions that come about in the knowing and doing of mathematics.

As referred in the above analysis of Jill's interview, there is a tension between what the community (parents, students and government leaders), think mathematics is and how it should be taught and the way Jill described how she develops an understanding of the mathematics in her classroom. Her concern about students not being given sufficient time to develop their understanding of the mathematics is a real concern. From Jill's utterances, it would appear that society seems to value more those aspects of mathematics that are able to be recalled quickly to obtain a correct result. However, the questions found in highly

influential forms of assessment such as PISA require students to be able to think mathematically and to be able to make links between ideas and concepts. It is our argument, that the opportunities-to-learn that are afforded when teachers use a context-based approach to teaching mathematics, such as CA, privilege the development of student understanding that is facilitative of making links between ideas and concepts, between the everyday and the mathematical. Such an approach to providing learning-opportunities for students is in line with the work of researchers such as Cobb et al. (2001) and Hung and Chen (2007). However, before the use of such context-based approaches can spread to other secondary mathematics classroom, in Jill's words, "we need to let go a little bit of this rigorous view of mathematics that they (the students) have to know how to do everything".

References

Brown, R. (2017). Using collective argumentation to engage students in a primary mathematics classroom. *Mathematics Education Research Journal.* doi:10.1007/s13394-017-0198-2

Cobb, P., Stephan, M., McClain, K., & Gravemeijer, K. (2001). Participating in classroom mathematical practices. *The Journal of the Learning Sciences, 10*(1&2), 113-163.

Duguid, P. (2005). "The art of knowing": Social and tacit dimensions of knowledge and the limits of the community of practice. *The Information Society*, *21*(2), 109-118.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge, England: Cambridge University Press.

Organisation for Economic Co-Operation and Development. (2003). *The PISA 2003 assessment framework – Mathematics, reading, science, and problem-solving knowledge and skills.* Paris: Author.

Organisation for Economic Co-Operation and Development. (2009). *Learning mathematics for life. A view perspective from PISA*. Paris, France: Author.

Redmond, T., & Sheey, J. (2009). Reconceptualising agency in a senior mathematics classroom. In R. Hunter, B. Bicknell, & T. Burgess (Eds.), *Crossing divides: Proceedings of the 32nd Annual Conference of the Mathematics Education Research Group of Australasia* (Vol. 2). Palmerston North, NZ: MERGA.

Vadeboncoeur, J. A. (2006). Engaging young people: Learning in informal contexts. *Review of Research in Education, 30*, 239-278.

Vygotsky, L (1987). Thinking and Speech. In R. W. Rieber and A. S. Carton (Eds.), *The collected works of L.S. Vygotsky, Volume 1: Problems of general psychology*. New York, NY: Plenum Press.

Wijaya, A., van den Heuvel-Panhuizen, M., Doorman, M., & Robitzsch, A. (2014). Difficulties in solving context-based PISA mathematics tasks: An analysis of students' errors. *The Mathematics Enthusiast*, *11*(3), Article 8.