

Addressing Concerns Related to Low Student Understanding in Mathematics in Manitoba

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Abstract

Students in Manitoba have demonstrated a lower-than-average understanding of mathematics concepts. Two areas that contribute to this level of understanding are quality of instruction and math anxiety in students and teachers. Quality of instruction can be addressed through the intentional design of lessons around quality, deeper thinking tasks. Building academically safe classrooms can improve math anxiety in students. Math anxiety in teachers can be addressed by providing professional development for teachers and appropriate coursework for pre-service teachers, thus also improving the quality of instruction. Focus on these two areas of concern could have positive benefits for increasing students' understanding of mathematics in Manitoba.

Students in Manitoba have demonstrated a lower-than-average understanding in mathematics concepts when compared to their peers in other provinces, as reported on the PCAP assessment in 2016 (Ballantyne, 2019) and provincial math assessment scores in the 2017/2018 school year (Government of Manitoba, n.d.a, n.d.b, n.d.c.). It is not possible for students to gain a deep understanding of concepts through low-quality instruction (Krall, 2018). Furthermore, math anxiety in students leads to lower performance during math class, and in teachers leads to lower quality instruction (Ganley et al., 2019). Quality of instruction and math anxiety will have to be addressed in Manitoba in order to understand and mitigate low understanding of mathematics concepts.

Problems Related to Low Student Understanding in Mathematics

Two areas that contribute to lower understanding in mathematics in general are quality of instruction and math anxiety. Students are often asked to memorize rote facts and procedures, and are not exposed to deeper level thinking. Alternatively, they are asked to focus on surface level questions, stalling student learning.

The second factor is that many students, and teachers, experience math anxiety. Math anxiety in students inhibits their ability to learn concepts, and math anxiety in teachers negatively affects instruction (Ganley et al., 2019). Quality of instruction and math anxiety in Manitoba classrooms negatively impact student experiences in mathematics classrooms, fostering fixed mindsets and negative mathematical identities (Boaler, 2019). This leads to low student understanding of concepts.

Quality of Instruction

It is nearly impossible for students to gain a deep understanding of concepts when they are presented with only low-quality rote tasks and questions. Furthermore, when students are not presented with the opportunities to see math as a creative discipline, their thinking around math concepts suffers (Krall, 2018). Teachers' understanding of the depth of questions they ask is highly skewed. In a recent study, it was found that teachers highly under-reported surface level (Depth of Knowledge 1) questions, and over-reported deeper level (Depth of Knowledge 4) questions in math classes (Barikmo, 2021). Instruction that focusses on Depth of Knowledge 1 tasks does not help students to learn concepts deeply, which helps them to compress newfound knowledge, making it easier to retrieve when needed for future problems (Boaler, 2019). When

teachers' level of questioning is deeper, their quality of instruction will also be deeper, focusing on more than procedures alone.

Quality of instruction is negatively affected by rote and procedural questioning and tasks. Students learn that math is about following instructions and rules, which places more emphasis on being fast and smart than on learning a deep understanding of concepts (Boaler & Williams, 2015). However, students learn best through non-traditional methods that encourage student discourse and collaboration in order to make sense of concepts and procedures, discovering the understanding behind them instead of memorizing (Ballantyne, 2019). Successful students learn to use multiple pathways in their brain, making sense of the math presented to them, looking for patterns, relationships, and connections. On the contrary, struggling students do not learn to use number sense, and instead focus on fixed procedures they may not yet understand (Boaler, 2019). Focusing on rote procedures and basic facts in isolation limits students in their learning of mathematics concepts. This leads students to believe they are not good at math, forming a negative mathematical identity, and preventing them further from making sense of concepts.

Math Anxiety

Math anxiety can occur when students do not see themselves as successful in math, which further leads to low performance and understanding. When students do not feel successful, they begin to develop a fixed mindset that they are not capable in math or are not a math person (Boaler, 2019). Furthermore, teachers with math anxiety tend to shy away from math in their teaching or teach concepts on a surface level that focuses on performing procedures over conceptual understanding (Ganley et al., 2019).

Math anxiety can be found in children as young as five years old (Tomasetto et al., 2021). This anxiety can lead to students being unable to access the information they do know, such as basic math facts, and inhibits the learning of new information because they are not able to access the working memory in their brains (Boaler & Williams, 2015). If nothing changes, students continue through school with this anxiety and develop a fixed mindset that they are not good at math. These students do not see themselves as successful, which correlates with their achievement in math and leads to math anxiety and avoidance (Boaler & Foster, 2021). Addressing math anxiety in students could have profound implications for student understanding in math because students would have an unlimited mindset about math and their abilities in math.

Teachers who experience math anxiety spend less time planning and teaching math (Ganley et al., 2019). When they do teach math, they plan lessons that are more teacher centred and focused on procedural understanding of surface level skills instead of deep, conceptual understanding (Ganley et al., 2019). These experiences tell students that math is a procedural discipline, as opposed to a creative discipline requiring deep critical thinking (Krall, 2018). Therefore, math anxiety experienced by teachers contributes to surface level lessons and questioning in math classrooms, not providing students with the opportunity to learn math at a deep level.

Solutions to Address Low Student Understanding in Mathematics

Addressing the areas of low-quality instruction and math anxiety in our classrooms will provide students in Manitoba the opportunity to increase their understanding of mathematics concepts and build positive mathematical mindsets. Lessons, tasks, and activities should be designed in ways that promote discussion and deep understanding of concepts. At the same time, there is a need to address math anxiety and build academically safe classrooms wherein all students feel safe to contribute their thinking. Further, math anxiety of practising teachers and pre-service teachers must be addressed to build their confidence and skills in teaching math. Addressing the quality of instruction and math anxiety in Manitoba is critical to responding to low student understanding in math.

Quality of Instruction

Shifting instruction from rote, procedural lessons to lessons focused around conceptual understanding and connections emphasizes student thinking. To do this, teachers need to make visible the knowledge that students contribute to lessons and allow students to struggle productively with problems (Liljedahl, 2021). Highlighting student thinking creates an environment wherein teachers are not the only source of knowledge in the classroom, helping students to see themselves as contributors. Shifting to student-centred instruction encourages students to make sense of the concepts, which should be the focus of each math lesson (Small & Duff, 2018). Students retain their newfound knowledge and skills better when given the opportunity to learn through high-level tasks as opposed to low-level rote procedural tasks, because they are thinking more deeply about concepts (Krall, 2018). Therefore, students need to be asked to make sense of quality tasks and problems, and to struggle with their ideas in order to develop a deep understanding of the concepts learned. Shifting from *teaching procedures* to *teaching through problem solving* puts the onus on students to make sense of concepts.

In order to improve student understanding, teachers must facilitate learning opportunities by designing lessons around quality tasks that focus on learning concepts on a deep level as opposed to only at a surface level (Smith et al., 2020). Quality tasks create interest for students, requiring them to think deeply and pushing them to extend ideas beyond the superficial thinking involved in traditional lessons and activities. Once students are engaged in concepts, they can be expected to think deeply about the ideas they are learning (Small & Duff, 2018). Designing lessons around quality tasks engages students and encourages them to want to know the math needed to solve problems. Quality tasks spark curiosity and engagement among students. They have multiple access points for all students to enter and require deep understanding of mathematical content. Quality tasks can be used to by teachers to connect and extend understanding and encourage creativity in finding solutions (Krall, 2018). An example of quality tasks is asking students to find all of the possible perimeters of a rectangle with a given area. This requires students to find multiple solutions, as opposed to a surface level type task such as solving for the perimeter and area of a single rectangle given the length and width. Students engaging with quality tasks find themselves connecting their understanding of concepts and skills because they are thinking about how they can best solve a problem or complete a task. Teachers can focus students toward understanding due to the engagement of students and their need to understand concepts in order to be successful in solving problems.

Focusing questions, intentionally designed around student thinking, helps students to think critically about concepts. On the other hand, funneling questions guide students to a specific method for answering a problem, which is usually the teacher's way of thinking (Herbal-Eisenmann & Breyfogle, 2005). Teachers can improve their questioning techniques by listening to their students for their understanding of concepts rather than listening only for misconceptions or solutions (Krall, 2018). Being intentional about the types of questions asked during a lesson can create a learning experience for students whereby they are guided to think about the concepts being learned, and their understanding of those concepts. This will encourage students to move beyond using step-by-step procedures in isolation with little meaning understood.

A lesson should be designed with an appropriate learning goal that is explicit to what students are expected to learn instead of what they are supposed to do. Teachers can reflect on their lesson(s) by considering each student's ability to access tasks, and how a task will encourage students not only to think, but also to reason with the concepts. Once teachers have a quality learning goal, they can begin to select an appropriate task (Smith et al., 2020). Good tasks for problem solving have students become stuck, think, and try sometimes multiple strategies before they find the necessary knowledge to solve the problem (Lilidajhl, 2021). It is through these tasks that students build on their previous knowledge to form new and deep

understandings of concepts learned, and to connect ideas across curricula.

Selecting quality tasks is a critical component of lesson design, but there needs to be a framework to foster the appropriate conditions for students to discuss the concepts they are learning. Smith and Stein (2011) designed the five practices model for facilitating a math lesson to move toward a student-centred model of instruction. The components of the five practices model are anticipating a lesson, monitoring student responses to the lesson, selecting and sequencing student solutions, and finally connecting student solutions when consolidating the lesson. This framework assists teachers in guiding students toward a defined learning goal while encouraging student collaboration and discourse. Students are afforded more independence in their learning, and the teacher can focus attention on those students and groups who need it most (Liljedahl, 2021). Students can grapple with problems, try, fail, and eventually discover new understandings and connections to solve the problem. Teachers can conclude a lesson by connecting student thinking to key mathematical ideas and generalizations in order to develop deep conceptual understandings (Smith & Stein, 2011). Structuring lessons by using the five practices model provides teachers with the necessary lesson structure while considering the importance of student-centred learning in math.

Math Anxiety

Changing lesson design and facilitation to a focus on deep thinking around mathematical concepts will also help with addressing math anxiety. Teaching through problem solving shows students that the teacher believes in them and their mathematical abilities (Small & Duff, 2018). For our students to feel valued and be successful, they need to see their teachers having confidence in them. Part of this confidence is not solving a problem for the student, but instead asking questions to focus their thinking on the key concepts being learned (Herbal-Eisenmann & Breyfogle, 2005). Presenting students with quality problems, and allowing them to solve the problems without funneling them toward a solution, will build their confidence to do well in math because they will come to know that the teacher believes in them.

Furthermore, fostering academically safe classrooms will show students that their thinking is valued, and in turn they are valued. It is imperative that teachers be aware of the messages they send students with their actions, because these actions can be powerful predictors of students' feeling of safety in math (Krall, 2018). Teachers can build academically safe classrooms by encouraging and celebrating students when they show authentic math behaviours in school. Highlighting specific mathematical behaviours publicly shows students that their thinking as mathematicians is valued. However, this praise needs to be authentic for it to be received well by students (Krall, 2018). When praise is authentic and about the math students were using, teachers can build students' positive mathematical identities. Over time, students will feel safe to contribute their thinking in math class because they will have an environment wherein it is safe to do so.

For teachers to show their students that they believe in them, the teachers also need to believe in their own abilities in math. Professional development could help to increase teachers' confidence in their ability to do and teach math, effectively lowering anxiety for teaching math (Ballantyne, 2019). Professional development for practising teachers can be done through in-person training or by using technology to increase teacher knowledge for instructional decision making and to augment general knowledge for teaching math (Heck et al., 2019). To reduce math anxiety in pre-service teachers, universities can expose them to teaching by problem solving, creating thinking classrooms, and using the five practices model (Young & Dyess, 2021). Furthermore, professional development sessions and courses around developing a growth mindset for practising and pre-service teachers can lead to decreased math anxiety (Young & Dyess, 2021). Teachers who receive sustained professional development feel more prepared to teach in the areas they received the training in (Heck et al., 2019). Providing teachers with this professional development and coursework could help to lower the math

anxiety of teachers and increase the quality of instruction. Increasing awareness around math anxiety in teachers will help to put in place interventions such as increased professional development and coursework around high-quality teaching practices.

Conclusion

Two areas contributing to students in Manitoba having a lower-than-average understanding in mathematics concepts are quality of instruction and math anxiety. Quality of instruction can be addressed by designing lessons around quality tasks that promote thinking on the part of the students. Designing lessons by using the five practices model helps teachers shift to more student-centred lessons. Math anxiety in students can be addressed by building academically safe classrooms wherein all students feel that their thinking is valued. Math anxiety in teachers can be addressed through professional development for practising teachers and coursework for pre-service teachers. Addressing these two areas could assist Manitoba schools to respond to low performance in math and to increase understanding of concepts.

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