Teaching Reasoning within Mathematics to Students with Severe to Profound Needs

Pon Tsou

Abstract: Teaching reasoning within mathematics to students, specifically students with severe to profound special needs; requires student adaptive pedagogy, the use of discourse, and a focus on increasing motivation. This manuscript will explore some methods to promote and encourage discourse within mathematics, with a focus on how to do so in a practical and meaningful way for students with severe to profound special needs. This must be done by considering the individual needs of each student to increase intrinsic motivation which will help promote both generalization and maintenance of the skills learned.

Introduction

Mathematics can be considered as a universal language among the human species, and a deeper understanding of the subject matter can lead to a deeper understanding of the world around us. For this to be true, we must look beyond the surface level algorithmic approach commonly used in mathematics and dig deeper to understand the reasoning behind the approaches, the methods, and the formulas. To achieve this deeper understanding of mathematics, we as educators must focus on teaching reasoning of the subject matter. An effective way to achieve this is by offering opportunities for discourse within the classroom, which in turn allows the students to explore their own thoughts of the task at hand.

The best way to make this possible for all students is to use a student adaptive pedagogy which must be implemented at all levels. This student adaptive pedagogy approach is valuable to all students; however, it is especially important for students who have severe to profound needs. Finally, reasoning and other types of deeper learning are only achievable if the students themselves are invested in their own education. One of the best ways to do so is by fostering intrinsic motivation within our students. By installing the inherent desire to learn, the knowledge they will absorb will increase in both quality and quantity. In short, teaching students reasoning within mathematics, specifically to those with severe to profound special needs, requires student adaptive pedagogy, the selective use of discourse, and a focus on fostering intrinsic motivation.

Vignette

Throughout this paper, I will refer to the following vignette to illustrate and elaborate on the importance of each topic that may occur in real life.

The setting for the vignette will be a life skills room of a middle school. The students within this room all have severe to profound needs in either one or multiple areas of life. These areas include academics, adaptive living skills, and other health impairments. The subject being taught is math, specifically identifying and making purchases using money in practical circumstances. The classroom itself is a large room consisting of one teacher, two paraprofessionals, and eight students.

As this paper progresses, this vignette will be used to illustrate how reasoning can promote maintenance and generalization, how discourse could be applied in real life situations, examples of student adaptive pedagogy, and how intrinsic motivation may be increased through Maslow's Hierarchy of Needs.

Importance of Reasoning

According to the former president of the National Council of Teachers of Mathematics (NCTM), Hank Kepner "when you are looking at doing something in mathematics, there is always a reason behind doing it" (Kepner, 2010, p. 20). Reasoning within mathematics is arguably the most important and most effective way to teach mathematics. Reasoning helps facilitate learning the "why", not simply the "how". While the "how" is important, mere memorization has a tendency to be forgotten quickly and limited in scope. When learning the "why", students are better able to maintain and generalize what they have learned.

National Council of Teachers of Mathematics (2001) state:

> People who reason and think analytically tend to note patterns, structure, or regularities in both real-world situations and symbolic objects; they ask if those patterns are accidental or if they occur for a reason; and they conjecture and prove. (p. 56)

This ability to think analytically and note patterns can be generalized to other areas of everyday life outside of academics. It allows the student to take the same concepts that they learn in school and apply it to other areas of their life. Additionally, this deeper learning allows them to maintain their knowledge for longer periods of time. By understanding the deeper meaning behind the algorithms, why they are the way they are and not just memorizing the algorithms, students are more likely to remember what they have learned beyond the classroom. Perhaps most importantly, by performing the action of reasoning, students are able to strengthen their critical thinking ability.

Specifically for students with severe to profound special needs, the ability to use critical thinking is typically more challenging, in some cases, impossible. It is because critical thinking requires abstract thinking. The ability to ponder and question aspects of the problem that are not explicitly mentioned, nor inherently obvious, requires the student to think outside the box. This outside the box thinking, or abstract thinking is crucial to reasoning and the ability to reason. This is why reasoning is especially difficult for students with severe/profound needs, but at the same time, particularly important for them. Reasoning not only requires a certain amount of critical thinking to work, but it actively promotes critical thinking as an outcome. While it may not be completely possible for some students to fully obtain the ability to use critical thinking, any gains in that area are positive. Critical thinking assists with all areas of autonomy including self-determination, self-efficacy, and self-advocating. The ability to think for oneself, a crucial result of critical thinking, allows for all of these pivotal aspects of autonomy to bloom.

In relation to generalization and maintenance, the skills learned are a fundamental aspect of teaching students with severe to profound special needs. Referring to the vignette, students that are able to retain the ability to identify and make

purchases using money will be able to obtain a greater amount of autonomy and independence. They will be able to perform that skill in varying settings and with different people. Ultimately the goal of a life skills room is to provide as much autonomy as possible and to teach skills that their typical peers are capable of. To achieve that, a certain amount of generalization and maintenance is required. One of the more efficient ways to promote generalization and maintenance is through reasoning by promoting a deeper thinking within the students.

Effectiveness of Discourse

When students are engaged in discourse within mathematics, they are better able to engage in reasoning and other aspects of learning to further their education. A very important byproduct of discourse is that students tend to develop a certain amount of "ownership" over their own learning. Offering opportunities to take ownership over their own learning allows the student to figure out things their way, or in other words to "break down the barriers of ownership in the classroom" (Rumsey & Langrall, 2016, p. 417). In doing this, students have the opportunity to think for themselves, determine if they agree with another or not, and most importantly, rationally support their beliefs/ideas. The ultimate goal, to foster reasoning:

> Moreover, by having opportunities to confront such issues as being specific about the conditions of the numbers, critiquing the claims of others, and considering unfamiliar claims confidently, the students gained a conceptual understanding of the arithmetic properties, rather than only a procedural understanding. (Rumsey & Langrall, 2016, p. 419)

Essentially, students stopped merely memorizing formulas and problems, instead they went beyond to better understand the concepts, "to [understand] what they mean and why they are true" (Rumsey & Langrall, 2016, p. 419).

In addition to developing a sense of ownership over their own learning and reasoning, students can also develop a sense of confidence. According to Rumsey and Langrall (2016) "[W]e needed to provide opportunities for students to develop their own ideas and to have the confidence to validate or challenge the claims of others" (p. 417). To discuss those disagreements, a student must possess some level of confidence in their own opinions. If they lack that level of confidence, strategically providing opportunities to allow them to speak up will help build that confidence. Specifically allowing for multiple correct answers, or by asking open-ended questions allows the students to build confidence. Once they build that confidence, students that were originally hesitant will be more willing to step out of their comfort zone and take chances. This circles back to reasoning. By voicing their own opinions, by taking ownership over their own learning, by building confidence, the students are better able to think differently and think beyond what was explicitly taught to them.

Using the vignette as an example, students need to be able to tell not only when they make an error, but also when other people make errors as well - specifically, when receiving change back from a purchase. When performing this skill in real life, to live as autonomous a life as possible, the student must understand the value of money they are manipulating. If they give an amount larger than what is owed, they are then owed money. If what was returned is incorrect, the students must

understand that an error occurred and use discourse to correct it. This is useful in real life practical situations, and helps with self-determination, self-efficacy, and self-advocating in the form of increasing self-confidence.

Need for Student Adaptive Pedagogy

Student adaptive pedagogy is defined as:

> [H]ow teachers diagnoses and addresses his or her students' needs by (a) encouraging them to continue pursuing a productive problem-solving path or pointing out aspects of their current reasoning, (b) using questions or suggestions to orient student attention to useful resources with which to elaborate their thinking, and (c) re-voicing student's ideas to highlight key information or to reorganize their ideas for proper expression. (Xin et al., 2019, p. 43)

The term student adaptive pedagogy can essentially be switched out with "differentiation" or "individualized approach"; however, since the source I chose used "student adaptive pedagogy", that is the term I will use in this paper. Student adaptive pedagogy is important for effective instruction to all students; however, it is essential for students with severe to profound needs. In some cases, effective instruction is impossible without the use of student adaptive pedagogy. In other words, each student learns and demonstrates their knowledge differently. Additionally, each student has a different background which greatly affects their cognitive and emotional abilities. Finally, there are individuals who require accommodations and modifications to function at a similar level when compared to their peers. A great example of an individualized approach is Universal Design for Learning (UDL). UDL uses a three-tiered approach - focusing on delivering the lesson, assessing the students on said lesson, and motivating the students in general. The key component to UDL is that differentiation must be considered from the inception of the lesson, not added in after the fact. When differentiation is considered from the beginning, it is better distributed throughout the lesson plan and more effectively delivered to the students. Additionally, differentiation helps all students, not just the ones that require it. Different modalities, repeated exposure, and varying approaches help all students gain a deeper understanding of the subject matter. For students that require these approaches, they obtain a basic understanding of the topic, whereas for other students, they gain a mastery over the topic.

The fundamental need for student adaptive pedagogy can be illustrated with the vignette. In a room with eight severe to profound special needs students, there will likely be a myriad of accommodation and modification requirements. One student may have visual impairments, while another has auditory impairments. Many students will likely have fine motor skill difficulties, while others may be non-verbal. Other hurdles which are not physical may also occur. Social anxiety, learned helplessness, disruptive learned behavior, along with many other potential emotional and/or behavioral difficulties are common occurrences. These differences require a student adaptive pedagogy which takes into consideration the specific student, and their unique needs. The student with visual impairments may require a worksheet with larger fonts, pictures instead of words, and/or braille. The student with auditory impairments may require more visual references, subtitled videos, and/or special

headphones. Students with fine motor skill difficulties will require different types of assessments, instead of writing, they may need to use stamps or stickers. Students who are non-verbal won't be able to answer questions in the traditional fashion, they may need to approach the board, use speech generating devices (SGD), or use sign language. Students with emotional or behavioral difficulties are motivated differently. For example, a need for control is often common. Therefore, having them participate in a way which allows them to feel that sense of control is very helpful. Regardless of their capabilities, each student will learn in their own unique way.

Impact of Intrinsic Motivation

Motivation is important for several reasons. Examples include motivation pushes students, keeps their interests, and increases engagement. These are all important; however, our duty as teachers is not to merely get them through a lesson, but to prepare our students for an independent future. This is where motivation is paramount:

> Motivation is not only important in its own right; it is also an important predictor of learning and achievement. Students who are more motivated to learn persist longer, produce higher quality effort, learn more deeply, and perform better in classes and on standardized tests. (Hulleman & Hulleman, 2018, para. 6)

By fostering motivation, we can create citizens that push further, try harder and achieve more. This is true because with proper motivation, a greater amount of effort is produced, which will likely lead to greater accomplishments. These accomplishments may then lead to pride in said accomplishments. This pride in turn leads to further motivation. This is shown in Erikson's Stages of Psychosocial Development, most prominently with the fourth stage - Industry VS. Inferiority. Within this stage, the child has an internal struggle of competence vs. incompetence, that will determine their pride within themselves. It is claimed that "the child now feels the need to win approval by demonstrating specific competencies that are valued by society and begin to develop a sense of pride in their accomplishments" (Mcleod, 2024, What Happens During This Stage section). Furthermore:

> If children are encouraged and reinforced for their initiative, they begin to feel industrious (competent) and feel confident in their ability to achieve goals. If this initiative is not encouraged, if parents or teacher[s] restricts it, then the child begins to feel inferior, doubting his own abilities, and therefore may not reach his or her potential. (Mcleod, 2024, Success and Failure in Stage Four section)

Essentially, this has the potential to create a self-perpetuating cycle of motivation-fueled achievements, which can be carried into adulthood.

Going back to the vignette, motivation would come in the form of appealing to the student's desire for lessons that will affect them in a practical manner. Affecting their real life outside of academia, the students will realistically both care more and work harder in their lessons. Additionally, students with severe to profound needs often have a desire to act like and perform tasks similar to their typical peers. These students often live a life where they are seen as the "other". Being able to perform

tasks that are similar to those around them allows them to feel a sense of belonging which they may not otherwise achieve. This sense of belonging is exemplified in Maslow's Hierarchy of Needs, where a sense of belongingness is essential to meet higher needs such as cognitive needs and self-actualization. This intrinsic motivation not only makes them more attentive and engaged in the classroom, but can also permeate through to other areas of their lives as well, increasing their likelihood of autonomy.

Conclusion

Reasoning within mathematics is not only an effective way to teach mathematics but could be considered the ideal way to teach mathematics. To do so, we as teachers need to keep in mind how to best use discourse, focusing on targeted student adaptive pedagogy, and increasing intrinsic motivation. Discourse fosters the ability to use reasoning and a sense of ownership over their own learning and increases confidence. Student adaptive pedagogy allows for individualized, differentiated lessons which take into account the needs of the students and gives them the best opportunity to acquire deeper conceptual learning. Intrinsic motivation allows the lessons to take greater effect and promote a sense of autonomy which may not be achieved otherwise. With these factors in mind, teachers can best convey their lessons to all students in a manner that would be beneficial to them. These approaches are especially important for students with severe to profound special needs. This provides them with the best opportunity for a full and fulfilling life outside of academia.

References

Hulleman, C.S., & Hulleman, T. (2018, January 10). An important piece of the Student Motivation Puzzle. *FutureEd.* https://www.future-ed.org/reversing-the-decline-in-student-motivation/

Kepner, H. (2010). Teaching Math with Reasoning. *District Administration, 46*(3), 20-22.

Mcleod, S. (2024, January 25). Erik Erikson's stages of Psychosocial Development. *Simply Psychology.* https://www.simplypsychology.org/erik-erikson.html

National Council of Teachers of Mathematics. (2001). *Principles and standards for school mathematics.* Reston, VA: NCTM

Rumsey, C., & Langrall, C. W. (2016). Promoting Mathematical Argumentation. *Teaching Children Mathematics, 22*, 463-466

Xin, Y. P., Chiu, M. M., Tzur, R., Ma, X., Park, J. Y., & Yang, X. (2019). Linking teacher–learner discourse with mathematical reasoning of students with learning disabilities: An exploratory study. *Learning Disability Quarterly, 43*(1), 43–56. https://doi.org/10.1177/0731948719858707

About the Author

Pon Tsou has a bachelor's in science and technology and is currently working on his master's in special education, with a focus in Moderate to Intense Needs. He has been working as a Substitute Teacher for the last three years and has procured a position as an Intervention Specialist.