Strengthening Special Education Students Skills Through Project-based Learning in Mathematics

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Abstract: The purpose of this manuscript is to inform and explain the effectiveness of Project-Based Learning (PBL) in mathematics. It particularly focuses on the importance of PBL for students with learning disabilities. The manuscript will explore the advantages of both cognitive and social skill building that PBL offers. Project-based learning should be utilized regularly in the classroom with special education students to help develop critical skills. This approach to mathematics is beneficial to students who may struggle to see the big picture or the relevance of mathematical concepts. Project-based learning is a way to engage the learner, drive student inquiry, and present real-world applications. Research implies that mathematical reasoning is in fact taking place through project-based learning tasks.

Introduction

Project-based learning (PBL) should be utilized regularly in the classroom with special education students to help develop both cognitive and social skills. This approach to mathematics is beneficial to students who may struggle to see the big picture or the relevance of mathematical concepts. Picture a seventh-grade classroom where students are gathered around tables in small groups: students are up and out of their seats and you hear the sound of thinking take place! You can see the students' minds working like gears on a clock and hear mathematical words being spoken usefully and naturally. Imagine the movement of the whole classroom and the sight of all students getting involved in active learning!

> *A teacher proposes a new end of the year project to her class: this an inclusive classroom that has both general education students as well as special education students. A few students in the group begin to discuss the given project. Alex says to Jake, "This courtyard renovation project is going to be fun! I love working outside!" Jake replies, "I'm just glad we don't have to do math work!" Both students listened intently to the teacher giving a few directions and going over safety procedures, then left the rest up to the students' imagination.*
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> *Alex is a very hyperactive student who thrives when he is able to move about and talk to his peers, and Jake is an anxious student that needs more time to complete tasks and likes to work at his own speed by doing things his own way. The boys converse with the rest of the group to plan which roles they would like to have and how to get started. Alex says to the group, "I know we will need a lot of mulch and stones to fill those spotty areas over by the trees." "Yay, and maybe we can build a few birdhouses too!" says Jake. "How much do we have to spend on this project?" asked another group member. "Looks like we will be needing to keep track of how much we are spending, and how much everything is going to cost." said Jake. "Like a budget! I'd be good at that. I love doing spreadsheets and am pretty good with money! I saved up all of my earnings from mowing the lawn this year just to buy a brand-new bike." said another student.*

Now picture those students who struggle with comprehension of mathematical concepts and students who struggle to explain their reasoning in written form. Most students with special needs rely on step-by-step instruction to solve math problems. The problem is, when students go to recall these steps, they often store it in short-term memory for the time being and then forget it, unless it is not regularly used. With PBL, those students who have trouble recalling procedural concepts are given the ability to verbally explain their reasoning and physically show you their thought processes to prove, link, and apply mathematical concepts. PBL helps tap into the depths of knowledge and utilize the application of these concepts that can be stored in long-term memory and used in future problem solving. PBL lives in the world of applied learning, real-world problems, and public presentations of understanding. It also alleviates the pressure and stress of an incorrect answer. When students are actively learning, they are more apt to fix their mistakes and confidently move on, whereas other students tend to accept the "failure" and feel as if they are just not good at it. In this case, it helps students to start to internalize steps to solving problems.

Advantages of Cognitive and Social Skill Building

Social skill building is very important to incorporate into the curriculum for students with special needs. Many students struggle with social skills, and PBL allows opportunities for social interactions to happen naturally which is important specifically in mathematics. Group projects allow the student to approach new ideas and concepts in a creative, open context with minimal pressure. They allow students to open up and jump into an idea naturally where the pressure of making a mistake is lifted. Students will likely embrace mistakes and use them as a part of the learning process. Students of various learning abilities are able to work together and converse with peers at their own pace and comfort level.

Recent research has affirmed what many educators have known for ages: social-emotional learning, or SEL, is a critical component of effective education. Melville (2020) indicated that students see academic progress that is long-lasting when they experience activities in the classroom that include collaboration, empathy, and problem-solving.

When special needs students work with peers of all ability levels and learning styles as is an essential aspect of PBL, they can work cooperatively, present different ideas and new ways of thinking. In 2019, Ohio adopted Social and Emotional Learning Standards for grades k-12. The goal of these standards is to achieve is to prepare students for postsecondary life through social-emotional learning. Social-emotional skills have been shown to positively impact long-term success by increasing academic achievement and economic mobility.

The openness of PBL builds confidence in students with learning disabilities which in turn builds cognitive strength. Mathematics requires the use of cognitive skills such as working memory, visual-spatial processing, and visualization. PBL opens opportunities for students to utilize all of the cognitive skills mentioned. "Project-based learning requires that students solve difficult problems, which may ultimately help them become effective problem solvers and lead to a broader and more complex understanding of the subject matter" (Wurdinger et. al., 2016. p. 19).

Building problem solvers is, in fact, sharpening cognitive skills. Students begin to gain an understanding of the world around them which makes the mathematical connections into working memory. Students with special needs thrive when they are able to make sense of the content or make real connections to their learning. Research has shown that PBL does just that with a movement away from teacher focused and directed instruction toward a more student focused, independent, knowledge-building instructional design (Scardamalia & Bereiter, 1991).

Effectiveness of PBL in Mathematics for Special Education Students

PBL presents itself as a real-world math problem and makes it applicable to students' daily lives or situations. Larina (2016) suggests that "Real world math problems are designed to make students apply concepts and procedures that they have learned from the school course" (p. 4). She also reveals that using everyday language should be considered as well as symbols and events that students come across in their everyday lives. Using math terms in everyday language provides an opportunity for mathematical reasoning to take place. "Reasoning is the process of manipulating and analyzing objects, representations, diagrams, symbols, or statements to draw conclusions based on evidence or assumptions" (Battista, 2010, p. 1).

Mathematical literacy also allows students to reason, problem solve, and analyze mathematical information all of which exist in real-world mathematical applications. Our mathematics classroom should reveal to students the opportunities to apply math within the world around them. Laycock (1970) stated that the teaching of math should include a connection to real life in the presentation of ideas, concepts and systems; students should be challenge to explore and be creative.

At times, students with learning disabilities may show reluctance to investigate and ask questions on how to go about solving problems or finding answers. Students usually wait for teacher prompting or direction to get them through, whereas PBL pushes students to work together with their peers and solve problems by asking questions. This not only brings upon social interactions with peers, but also allows students to make mistakes by trial and error and learn from them. From here the sense of accomplishment from perseverance builds up their confidence as well. Perseverance and confidence are much needed skills in the real-world; when these students are working at a job, they must show confidence and be able to solve any problems that may arise. These skills are important not only in the workplace but within the community as well. Development of these useful life skills ensures that students with special needs can live as independently as possible.

Effectiveness in Mathematics

Most school mathematical practices suggest that students are to be told what to do and how to do it. Idris (2006) suggests that in "most classrooms, math is taught to students as if it is a complete and unchangeable body of knowledge, with all rules and procedures. Mathematics is actually a changing and growing body of knowledge" (p. 109). When there is creativity in the teaching and learning of math, it

brings out a sense of meaning for the physical world for our students. Students learn to reason, connect ideas, and think logically. Real-word mathematical tasks and project-based learning encompasses all of those things. But research has shown that less emphasis is placed on creative ways of expressing ideas and instead focuses on simply displaying mathematical solutions.

The mathematics curricula in many schools do not address the day-to-day needs of students whether these students are college bound, career bound, or neither. Everyday math skills are needed for every functioning citizen in society. To some degree, mathematics proficiency is needed for most jobs. Some occupations may revolve around mathematical practices and live within the mathematics community, while others rely on the use of functional mathematics.

PBL and real-world problems have significant similarities as both focus on allowing students to persevere with real-world situations by creating mathematical projects. Projects should be focused on real world topics to increase student engagement.

> We must create a more expansive definition of student success. Project-based learning doesn't exist in the vacuum of bubble answer sheets. Project-based learning lives in the world of applied learning, real world problems and public presentations of understanding. We must be willing to use multiple measures to understand students' growth and success (Berkeley, 2017, p. 1).

A study that was conducted by Boaler (1998) provided an opportunity for students to get creative as well as use mathematical reasoning to explain their project and how it is being applied in the real-world. According to Boaler (1998), PBL helped students become more flexible and able to develop knowledge that was useful and applicable in many areas. Lesh et al. (1979) makes a claim in his book that, "In group problem solving settings, a variety of complex processes related to proof, and the use of mathematical language and symbolism become specializations of communication skills which are familiar (in other contexts) and meaningful to average ability students" (p. 2). Not all of the students who participated in this study had an interest in architecture or construction, however, it revealed relevance for geometry in multiple careers. Students are then able to gain knowledge and possible interest in certain careers because of the exposure and opportunity of project-based learning. Working in a group on a project does just that: provides mathematical argumentation to take place as well as discourse, which implies that real-world math and project-based learning indeed encompasses these constructs.

What about those students with learning disabilities who may not further their education to the collegiate level and depend on the skills and knowledge they have acquired through their primary and secondary schooling? Patton et al.'s (1997) study used various mathematical related life skills from the National Longitudinal Transition Study with students with learning disabilities. The researchers wanted to know the types of math skills that would be encountered in adulthood, and which of those were of importance to teach within the curriculum. The study showed how a life skills approach to mathematics has an effect on students with disabilities preparing for adulthood and indicated that for these students, the curriculum should emphasize math skills with practical uses at home, at work and in the community.

Conclusion

Students with special needs rely on exploration and using a variety of learning styles. These are provided for in the use of PBL. Mathematics is a significant part of all of our lives, whether our knowledge of math is extensive or not. Most individuals are able to generalize the math they were taught and find it applicable in everyday life. Teachers can teach and promote mathematical thinking and reasoning within our schooling, careers, and everyday lives through PBL. Teachers are also able to find methods of teaching these concepts to all types of learners, especially those who are curious about how these concepts are applied and show importance to real life.

It is clear from the research that many schools use different approaches when it comes to instructing and assessing mathematical ideas. Most of the research implies mathematical reasoning is in fact taking place through project-based learning tasks as well as real-world math problems. PBL also furthers the thinking of mathematical concepts that will benefit students not only after high school graduation but leading up to it as well. It is important that teachers understand the impact of PBL and bringing in real-world mathematics to all students at all ability levels. Most teachers get caught up with only teaching procedural knowledge in math, rather than the applied math. In the early grades, research shows that it is more suitable to incorporate these types of teaching styles and problems, but a continued focus like this is not beneficial through all grade levels. It can be argued that most real-world math problems are more applicable to older students who have prior knowledge of real-world situations or experiences to help make connections. For students with specific learning disabilities, most applied math or functional math is taught in the transitional courses rather than in the general curriculum where this focus would help to develop the math skills and knowledge of these students. More classrooms need to incorporate PLB in their curriculum whether the classrooms are resource rooms, inclusive classrooms, or general education classrooms.

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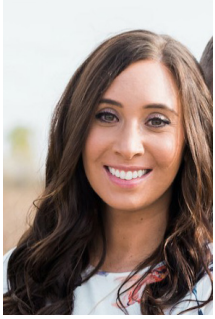

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Cara graduated with a bachelor's degree in special education from the University of Toledo in 2011and recently, earned her master's degree in curriculum and instruction from the University of Toledo. She is currently an Intervention Specialist at Fassett Junior High, where she has taught for the past 9 years.