Project-Based Learning & Measuring the Effect of Implementation

A Review of the Literature

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Project-based learning has the ability to be implemented in all content areas and grade levels of the education process. It can even incorporate multiple content areas at the same time. However, math is the content area of focus for this literature review. This area is particularly important due to a recent plummet in math scores across America (Donna St. George, 2023). According to the latest statistics, American students make up the smallest group of the top-performing students. This leads many to believe that this may have something to do with how mathematics is taught in the U.S. compared to other higher-performing countries (Richards, 2020). On the most recent PISA assessment, which is a global test administered to students all over the world, American students were "among the lowest ever measured by PISA in mathematics" for the U.S. according to the Organisation for Economic Co-operation and Development (D' Souza, 2023). This review of literature will address the characteristics of effective Project Based Learning (PBL), the addition of e-portfolios for students to take ownership of their learning, the steps that PBL must include to be effective, and how to measure the effects of PBL in the math classroom. This topic is important because future generations need brilliant mathematicians for various specialized and crucial careers. “Several largely overlooked reports, including from the Department of Defense, raise alarms about how Americans’ disdain for math is a threat to national security” (Undark Magazine, 2023).

Teaching Methods in America

How math is taught in the United States is much different than that of other high-performing countries. The PISA assessment recently started including questions regarding how students acquire math (MindShift, 2016). The responses to these questions identified three distinct learning styles, rote learning by memorization, self-monitoring, and relational strategies.

The U.S. was in the top three for learners who relied on the memorization approach for learning math (Boaler & Zoido, 2016). This strategy proved to be unsuccessful because the memorizers turned out to be the lowest performing and the countries with the highest number of memorizers performed the worst on the PISA assessment (Boaler & Zoido, 2016). In the U.S. memorization and rote learning are often implemented in the classroom because of the time constraints and pressure put on the educators to get through a specific list of requirements (Boaler & Zoido, 2016). Therefore, teachers are not allowed the time to deeply explore the math topics that the learners need to fully conceptualize the material. Another reason that many teachers turn to memorization methods is that that is how they were taught. Either way memorization teaching methods do not allow for the learner to be interested or engaged in math which leads to little learning (Larmer, 2021).

Characteristics of Effective Teaching Methods

Upon much research, three conductive characteristics of effective teaching methods. Those three conducive characteristics are that the teaching method should be engaging, motivating, and require critical thinking (Scholastic, 2019). These crucial Key factors of effective teaching methods will lead to successful student learning if properly executed and followed through.

Engagement is critical for student success and even their future outside of school. Student engagement has been defined as “the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught, which extends to the level of motivation they have to learn and progress in their education” (The Glossary of Education Reform, 2016). It has been found that students who are highly engaged in their learning are less likely to get into trouble in their adolescent years (Promethean, 2022).

Another characteristic is motivation, which engagement usually produces. However, it is important to not confuse the two as they are distinct (Olsen & Peterson, 2015). Motivation can be defined as "the process whereby goal‐directed activities are initiated and sustained" (Cook & Artino, 2016). Research has found that students are often driven by extrinsic motivation being that their main focus for learning is just to get good grades. True learning does not take through extrinsic motivation but rather intrinsic motivation (Kyndt, Sweller, & Clark, 2011). A study previously conducted showed that students with autonomous motivation took on a deeper approach to learning and students who were not autonomously motivated took on a more surface-level approach (Kyndt, Sweller, & Clark, 2011). This proves that if students are motivated they will be more equipped and ready to gain a deeper knowledge of the content they are presented with. The same study also showed that the more autonomously motivated students are, the more they will look further into the problem at hand, whereas low-motivation learners will perceive that they do not have enough information to solve the problem (Kyndt, Sweller, & Clark, 2011). This thought process ties into the next characteristic of effective teaching methods, critical thinking.

Effective teaching methods require learners to produce and practice critical thinking skills. Critical thinking can be defined as "a fundamental skill that allows individuals to analyze, evaluate, and interpret information objectively and rationally" (Baker, 2023). The method should pose open-ended questions to promote the stimulation of critical thinking skills. These critical thinking skills will teach the student to better analyze information, build connections, and come up with innovations that will solve complex problems (Yousafzai, 2023). This skill should be carefully planned and incorporated into the teaching method. Many students may not yet be familiar with critical thinking and feel more comfortable with simple questioning. This is why

critical thinking must be explained and demonstrated to students to model for them what it is, what it looks like, and what is expected (Schadt, 2021). This skill can and should be practiced in effective teaching methods by posing several daily opportunities for students to foster their critical thinking skills through complex questioning (Schadt, 2021). Individuals with strong critical thinking skills have been shown to be more well-informed, have better decision-making skills, have better self-reflection skills, and have the ability to identify incorrect information more so than those without strong critical thinking skills. They are also shown to be able to come up with innovative solutions to complex challenges (Baker, 2023). With affluent critical thinking skills, students will be less dependent on the teacher and instead seek to find solutions and information on their own (Childcare Education Institute, 2023). One of the best ways to foster critical thinking skills is through the use of collaboration. By providing opportunities to collaborate you are allowing the students to hone in their deductive reasoning, critical thinking, and communication skills. Allowing these educational deep discussions will provide students with more learning than working individually. Critical thinking was also ranked the second top skill by the World Economic Forum. Complex problem-solving scored first, which can be built by attaining critical thinking (University of the People, 2020).

Definition and Essential Elements for Successful Implementation of PBL

Project-based learning can be defined as problem-oriented and student-centered learning that is organized around projects (Thomas, 2000, as cited in Markula & Maija Aksela, 2022). Students work through these projects by working and collaborating while learning new content and skills (Markula & Maija Aksela, 2022). There are seven essential project design elements to ensure that PBL is accurately implemented. These steps are what sets PBL apart from traditional school projects. These seven elements are to create a driving question or problem, get students to

indulge in sustained inquiry, be sure that the project is authentic in every detail, give students a voice and choice in their work, provide opportunities for reflection, allow students to critique and revise peer work, and lastly provide an opportunity for students to publicly showcase their projects (Buck Institute for Education, n.d.).

Driving Questions. Driving questions are the driving factor behind a good PBL design. Although they can often be difficult to formulate, they are crucial to keeping the project on track (Lynch, 2019). The driving question or problem should be written to pique student interest, provide a motivator to find a solution, and be authentic (Bielik et al., 2018). It should also be a question that students can productively solve by thoroughly researching and one that is not a simple yes or no answer. The question should produce a sense of excitement for the students while they are building their learning and gaining new skills (Bielik et al., 2018). Even though the question should not be a simple one, it should also not be too difficult or students will feel that it is not attainable and give up. The driving problem or question should provide opportunities for students to come up with their questions (Bielik et al., 2018). If a proper driving question is formulated then the students will be able to build their critical thinking skills in their journey to solve the problem.

Sustained Inquiry. Project-based learning is different from traditional projects in that they require students to inquire along the whole learning journey rather than forming a product at the end of a unit or concept (Lee, n.d.). The driving question should lead to students coming up with more questions to thoroughly provide a solution. The types of questions students should be asking themselves are “What do I already know about this?” and “What do I need to know about this?” (Vermont Agency of Education, 2020). Rather than sitting and listening to lectures from a teacher, students are instructed through self-directed learning and only complete traditional

classwork such as textbooks, practice problems, etc. when they need to know how to continue their their research of the driving question's solution (Lee, n.d.). This sustained inquiry should lead to learners being able to use their creativity to develop an innovative solution to the real-world, authentic driving question (Vermont Agency of Education, 2020).

Authenticity. According to John Larmer, John Mergendoller, and Suzie Boss in their book, *Setting the Standard for Project Based Learning: A Proven Approach to Rigorous Classroom Instruction*, there are four means to make PBL authentic. Those means are having authentic context, authentic tasks and tools, authentic impact, and student's personal authenticity showcased in their project (AVID, 2021). Authentic context implies providing students with some sort of real-world problem that is meaningful to them. This problem could involve them personally, their community, their school, their state, or even the planet (AVID, 2021). Authentic tasks and tools refer to the ability of students to have access to and utilize the proper tools to complete the tasks in the same manner a professional would. For instance, if the student's problem was pollution, students could create digital flyers and awareness brochures using the same tools that adult professionals would utilize to get their message across (AVID, 2021). Authentic impact means that students would create some type of solution that would have a real-life impact on the problem that they are solving such as cleaning up their school playground by creating flyers that promote students picking up trash (AVID, 2021). Personal authenticity means the student will be more engaged and have a personal interest in solving the problem at hand being that it directly impacts them. This allows the student to have clear reasoning behind why they are working so hard on the problem (AVID, 2021).

Voice and Choice. Student voice and choice go hand in hand but they are very distinct. Student voice refers to their opinions and thoughts being heard. Student choice could refer to

allowing them to have a choice in the manner in which they present their findings or having a choice in the topic they cover (Larmer, 2024). While those are just a couple of examples of voice and choice there are numerous other ways a teacher could implement voice and choice into their classroom. Depending on the age and level of the students, this could look very different. For instance, one way that you could offer choice to young elementary-aged students could be giving them the choice of where they want to sit to do their work or who they want to be in a group with (Miller, 2016). Being that PBL is student-centered and led, it offers plenty of opportunities for students to showcase their creativity and what they have to offer. By providing opportunities for students to have a voice and choice, they will be practicing the skills they need for the real world. Students who use their voice and can make smart decisions will be able to be great leaders.

Reflection. Students should always be provided with an opportunity to reflect on their journey. Another distinct difference between PBL and traditional projects is that PBL requires educators to allow students reflection time (Field, 2024). Reflection is an important element in PBL because it allows the student to make connections and meanings of their work. This set reflection time will permit the student to fully take in their journey and digest what they have learned (Field, 2024). However, they do not just need time to reflect at the end of their experience but rather throughout the whole process. This can be done by having students reflect on the content, the process, the purpose, and their self (Field, 2024). By reflecting on their content students will be clear about what they are doing and should be focusing on from the get-go. Without this reflection, many students will inevitably be lost and confused from the beginning which will just create a debacle for them in the long run. By having students reflect on the process they will be able to become more flexible and effective (Field, 2024). Reflecting on the purpose of their project, students will be able to recognize why their project matters. This

will inherently make them more motivated and engaged in their work while ensuring they are working with intention (Field, 2024). By reflecting on their self, students will be able to put all the pieces together. They will make sense of what they have learned, why they learned it, what they can do, and how much they have accomplished. This will create a sense of pride and excitement. It also creates opportunities for students to reflect on areas in which they can personally grow (Field, 2024).

Critique & Revise. Critiquing and providing feedback to peers is a powerful element of PBL. However, it can be a bumpy one to navigate. If a student has not been properly exposed to welcoming feedback they will become defensive quickly. This is why students need to be exposed and scaffolded in the critiquing and revising process (Larmer, 2016). Sentence stems can be used to teach students how to provide and respond to feedback so that conversations and other communication remain respectful. It is important to stress to students that they are all in the same learning community and want to help each other, not harm each other. Another way to foster this process is to provide practice to students so they learn how to properly give feedback without being harsh. Rubrics can also be used to provide clear directions of what they are looking for and what specific feedback to give (Larmer, 2016). Without a rubric, some students will be at a loss of thoughts for feedback and some will be overly critical of others work. It is recommended that teachers work in small groups to model how to effectively give feedback and the language that should be used (Larmer, 2016).

Public Presentation. Effective implementation of PBL requires that facilitators provide students with the opportunity to showcase and present their work to a public audience. This public audience should be beyond the classroom and should be some sort of stockholder in the project at hand. For instance, community leaders, school boards, and other leaders of the

community. The use of public presentations provides numerous benefits for preparing students for the future. In today's world, students need to be well-equipped with 21st-century skills and that includes giving presentations (Niehoff, 2017). In PBL another important aspect of the public presentation element is that the audience needs to be able to provide some type of feedback to the student regarding their work (AVID, 2021). When presenting their presentations students need to be able to explain how they made their choices, the process of inquiry, what they learned, and any other relevant information regarding their project (AVID, 2021). The presentation should be made available for public view long before the project is over. This will allow students to attain feedback and revise their final presentation before the end of the journey (AVID, 2021). Public presentations provide many benefits including but not limited to engagement, motivation, confidence, collaboration, and strengthened agency (Lee Anna Stirling, 2022).

Measuring PBL Effectiveness

The effectiveness of Project-based learning in the math classroom can be measured through various ways. One way that many researchers measure the effects is through overall student success. A study that was published in 2021 showed that project-based learning showed a positive correlation in student success across the board being that the project was cross-curricular even though math was the focus. The study was measured by analyzing the scores of the end-of-year second-grade students to the same set of students with their third-grade scores. The study was implemented over three months (Lazic et al., 2021). Upon further research, evidence proved that there is a need for more studies on measuring the effectiveness of project-based learning in the math classroom, especially elementary math. Many studies focus on a specific element of PBL but not the overall achievement and growth of student's math skills.

Teacher and Student Attitude Towards PBL

Teachers may have hesitations going into the implementation of PBL because of the amount of extra work they need to commit to, the timelines they are given, and many more daily struggles teachers often face. However, a study of thirteen teachers with various years of experience with PBL all showed excitement in their perception of implementing PBL in their classrooms (Levy & Dor, n.d.). These teachers were documented as showing excitement in various meetings and interviews (Levy & Dor, n.d.). Likewise, students also showed positive perceptions toward PBL. In a study conducted in a small charter school, students were quoted as stating "We're not just learning to learn" (Turcotte et al., 2022). The findings of the study showed many more positive indicators from this set of students that proved students felt favorable of PBL. For instance, "they felt that their creativity and ideas were appreciated, they were empowered to take responsibility for developing potential solutions, and they had the opportunity to develop meaningful relationships with stakeholders" (Turcotte et al., 2022).

Summary

Project-based learning has been proven to show many beneficial outcomes for students and teachers alike. Student achievement has been shown to increase when PBL is properly implemented and followed through (Lazic et al., 2021). There are many students on the effectiveness of PBL regarding engagement and creativity. However, there is a need for more research on the effectiveness of student growth and achievement in the math elementary classroom. As a researcher on this topic, I plan to explore the effectiveness of PBL in the math elementary classroom and the effects it has on specifically student growth and achievement. I will do this through the use of mixed-method action research. I want to be able to give a true result of the results of PBL implementation and I know that by using mixed-method research, I

will be able to get the full picture of what PBL can achieve. I will be using a combination of observations, surveys, and scores on NWEA MAP from the beginning of the year to the end. This study will aim to support the implementation of project-based learning in the elementary mathematics classroom.

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