Problem-based Learning for Students with Learning Disabilities in Science Classrooms

Haley Meek

Abstract: Problem-based learning (PBL) methods are the standard in modern science education and provide hands-on, interactive learning experiences. Additionally, modern education practices encourage the inclusion of students with learning disabilities in general education classrooms. It is therefore important for science educators to understand the benefits of PBL and strategies for making these activities accessible to all students including those with learning disabilities. PBL methods have positive effects on academic achievement, student engagement and attitudes, classroom environments, self-efficacy, and social skills for both students with learning disabilities and general education students in the science classroom. When the proper supports and scaffolding are provided, students with learning disabilities are able to fully benefit from PBL approaches in the science classroom.

Introduction

Like the field of science itself, science education is ever changing to keep up with new discoveries and explanations of natural phenomena. In modern science classrooms instructional methods have shifted from lecture-dominated approaches to a focus on hands-on and interactive learning experiences (Treagust & Peterson, 1998; Gallagher et al., 1999; Slavin, 1999; Greenwald, 2000). Problem-based learning (PBL) methods perfectly encapsulate this idea of hands-on, interactive learning approaches and are often a central part of science education. This educational approach has become more and more popular in all content areas and is now considered the standard in science education (Treagust & Peterson, 1998; Gallagher et al., 1999; Slavin, 1999; Greenwald, 2000).

In science classes, PBL drives inquiry and critical thinking in addition to supporting a classroom community of science learners, which is emphasized in the Next Generation Science Standards (2013) created for science education. Additionally, there is a growing focus in modern science education on developing scientific literacy which involves gaining and using scientific knowledge in order to identify important questions, explain observations, and make conclusions about scientific issues based on evidence (OECD, 2006). Collaborative PBL approaches are useful in developing scientific literacy in students because they encourage students to engage with real-world issues to understand the nature of science and how it interacts with the world they live in (OECD, 2006).

Similar to the changes that science education has gone through over the years, the education of students with learning disabilities has also gone through major changes. Whereas once the common educational approach for students with learning disabilities was to separate them from general education classrooms, the Individuals with Disabilities Education Act (2004) encourages the education of students with learning disabilities in a least restrictive environment. This means that students with learning disabilities should be educated in general education classrooms

as much as possible in order to promote not only academic achievement but also positive social skill development (Individuals with Disabilities Education Act, 2004). It is therefore the duty of educators to ensure that all students in their classrooms, including those with learning disabilities, learn and master the content to the best of their ability. Due to the importance of ensuring a high-quality education in a least restrictive learning environment, it is of value for science educators to examine the relationship between PBL in science classrooms and students with learning disabilities. To examine such a relationship it must be asked: How can science educators ensure that students with learning disabilities benefit from PBL approaches in a science classroom?

Although PBL approaches are widely accepted in science education, is it possible that students with learning disabilities are somewhat excluded from the benefits of these techniques, and if so what kind of strategies can educators use to ensure this kind of exclusion does not happen in their classrooms? Is it possible that students with learning disabilities are not able to fully contribute to PBL activities and therefore do not fully benefit them? To avoid possible exclusion of students with learning disabilities, it is important for science educators frequently using PBL approaches to learn more about the relationship between these educational methods and these students so they can ensure all of their students fully benefit from this types of learning.

This article seeks to answer the previously mentioned questions on common science educational approaches and students with learning disabilities. It will examine what PBL is and explain the benefits of this technique to students with learning disabilities. It will also provide useful strategies for PBL activities for students with learning disabilities in science classrooms. By examining these aspects of PBL methods, this article will provide solutions for how science educators can ensure that all of their students, including those with learning disabilities, are able to benefit from these common learning approaches in a science classroom setting.

Problem-based Learning

Problem-based learning in science classrooms is described the National Research Council (2003) as: "activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world." (para. 1). This instructional technique is thought to be extremely effective in developing critical thinking skills and is based off of the "5 E's" model of learning in which student engagement, exploration, explanation, elaboration, and evaluation are heavily stressed (Bybee, 2006). Additionally, PBL has been heavily influenced by the ideas of educational philosopher John Dewey. Dewey (1938) believed that learning how to problem solve is how to learn, and PBL is centered around this idea of learning by doing and experiencing.

Problem-based Learning and Students with Learning Disabilities

The learning disabilities present in special education students found in general education classrooms vary greatly in their presentations and needs (Elliot, 2000). Some of these students have language-based difficulties, difficulties with attention and

concentration, issues with knowledge organization or self-regulation, or problems using cognitive strategies for problem solving (Elliot, 2000). Additionally it has been noted that a lot of general education teachers have historically doubted the abilities of students with learning disabilities to meet the requirements of problem solving and inquiry learning that are central to science education (Sullivan-Palincsar et al., 2001). Therefore due to the challenges facing students with learning disabilities and the perception of the abilities of these students, it is important to determine whether or not PBL techniques are compatible with these students in the context of a science classroom.

Many studies have examined the association between PBL and academic achievement in students with learning disabilities. The majority suggest that PBL instructional approaches have a positive effect on academic achievement in students with learning disabilities (Scruggs et al., 1993; Barron et al., 1998; Fillippatou & Kaldi, 2010; Abels, 2014; Han et al., 2014). One such study by Scruggs et al. (1993) focused on the effectiveness of using PBL approaches compared to textbook-based approaches in science classrooms for students with learning disabilities. It was found that on average, the students with learning disabilities scored higher on content knowledge after being taught using the PBL method (Scruggs et al., 1993). Additionally, researchers documented that the students preferred the PBL method and wanted to do that type of learning again (Scruggs et al., 1993). A potential explanation for the positive effect of PBL on academic achievement in students with learning disabilities is that these approaches focus heavily on learning by doing and discussing rather than through reading, which is an area that many of these students struggle in (Scruggs et al., 1993; Elliot, 2000).

Another aspect of PBL that is often discussed is the effects on engagement and attitudes towards learning in students with learning disabilities. PBL is thought to be an effective way to engage students with learning disabilities (Filippatou & Kaldi, 2010). In fact, engagement in students with learning disabilities increases as a result of the implication of PBL activities and students have a more positive view of learning when these techniques are used (Barron et al., 1998; Wurdinger et al., 2007; Filippatou & Kaldi, 2010). It is often found that students with learning disabilities prefer a style of teaching using PBL and see a high value in the tasks they are assigned during these activities (Filippatou & Kaldi, 2010).

In addition to effects on academic achievement and engagement, the relationship between self-efficacy and PBL is important to consider regarding students with learning disabilities. It is widely stated that students with learning disabilities often exhibit lower self-efficacy in academics than students without these disabilities (Hampton & Mason, 2003). This is likely due to the fact that students with learning disabilities often have fewer successful academic experiences, less support from teachers, and less access to information or successful models of peers with learning disabilities (Hampton & Mason, 2003). There is a strong suggestion that PBL instructional approaches increase self-efficacy in students with learning disabilities (Barron et al., 1998; Wurdinger et al., 2007; Filippatou & Kaldi, 2010; Abraham et al., 2011; Abels, 2014).

It has also been observed that collaboration during PBL activities helps with the social acceptance of students with learning disabilities by their peers (Gillies & Ashman, 2000). Social skills can sometimes be additional obstacles to students with

certain learning disabilities and these students can often feel ostracized or unaccepted in general education classroom settings (Elliott, 2000). The use of collaborative PBL approaches can help mitigate social skill issues for students with learning disabilities (Morocco et al., 1990; Matlock et al., 1991; Gillies & Ashman, 2000; Filippatou & Kaldi, 2010). It is widely thought that the benefits of collaborative PBL in science classrooms on both academic achievement and social skill development is due to interactions between students with learning disabilities and general education peers that provide feedback and clarification to help build understanding (Gillies & Ashman, 2000). It is also suggested that non-learning disabled peers are sometimes better able to explain concepts or activities in language and terms that can easily be understood by students with learning disabilities better than their teachers (Filippatou & Kaldi, 2010).

Problem-based Learning Strategies for Students with Learning Disabilities

Once the question of whether or not problem-based learning strategies are truly beneficial to students with learning disabilities has been evaluated by science educators, it is important to examine different strategies for implementing these techniques. Research suggests that PBL approaches are effective ways to engage students with learning disabilities in the content but makes note of the importance of special strategies for students with learning disabilities, such as differentiation and scaffolding (Fillapitao & Kaldi, 2010). The implementation of such strategies should be beneficial not only for students with learning disabilities but for all students participating in these activities in the science classroom.

Many sources of literature on the topic stress the importance of the inclusion of special needs students in science classrooms and providing the proper supports in order to allow them to succeed in PBL activities (Barron et al., 1998; Häkkinen, 2003; Banchi & Bell, 2008; Abels, 2014). Due to the fact that inclusion is an important focus for making PBL activities accessible to students with disabilities, a lot of strategies are suggested to achieve proper inclusion and make these activities successful. One such strategy is the use of scaffolding. When scaffolding is used (along with proper teacher training), a positive learning environment is achieved and all students, including students with learning disabilities, are able to increase their scientific literacy and gain a deeper understanding of the content (Barron et al., 1998; Abels, 2014).

A common scaffolding strategy for PBL approaches in the science classroom is known as structured guided inquiry. This manner of scaffolding is used either before the PBL activity is implemented to prevent misunderstandings and confusion or during the activity when students appear to encounter difficulties to help avoid failure in the activity (Häkkinen, 2003). When using a structured guided inquiry approach, teachers provide the questions and procedures for the activity (Banchi & Bell, 2008). It is then up to the students to generate explanations that they support with evidence they collect during the activity itself (Banchi & Bell, 2008).

Another slightly more advanced way that structured guided inquiry can be used in the science classroom is with research questions. In this type of PBL activity, the students are given a specific research question by the teacher and asked to plan their

own methods and/or design their own experiments in order to answer the question (Banchi & Bell, 2008). This method of structured guided inquiry is slightly more difficult but provides students opportunities to act like real-world scientists and actively participate in the scientific method (Banchi & Bell, 2008). This type of scaffolding in PBL activities has benefits for both general education students and students with learning disabilities because it establishes clear goals and provides guides for students to follow during the activity (Häkkinen, 2003; Banchi & Bell, 2008).

Although scaffolding would appear to be one of the more important strategies in ensuring that PBL activities are effective for all students in a science classroom, there are a few other strategies that have been suggested in the literature. When specifically focusing on strategies for students with learning disabilities, there is an emphasis on varying instructional strategies through differentiation and employing consistent behavior management strategies in the classroom (Morocco et al., 1990). It is also suggested that heterogenous grouping of students during PBL activities is more beneficial for students with learning disabilities rather than homogenous grouping which tends to favor the learning success of already high-achieving students (Chen et al., 2008).

Finally, the literature implies that teacher attitudes can have an effect on the success of PBL activities (Lumpkin, 2007). Having a positive and supporting attitude can be an effective strategy for a teacher to use during these types of learning activities (Lumpkin, 2007). All students, especially students with learning disabilities, are more motivated, persistent, and put forth more effort when they view their teachers as not only supportive but also as caring (Lumpkin, 2007). These changes in effort, motivation, and persistence lead to an increase in the academic success of all students (Lumpkin, 2007).

Conclusion

Based on the information provided in this article, it would appear that problem-based learning approaches have a large number of benefits for not only students with learning disabilities, but all students in a science classroom. PBL methods have positive effects on academic achievement, student engagement and attitudes, classroom environments, self-efficacy, and social skills for both students with learning disabilities and general education students in the science classroom (Scruggs et al., 1993; Barron et al., 1998; Gillies & Ashman, 2000; Akinoğlu & Tandoğan, 2007; Wurdinger et al., 2007; Baran & Maskan, 2010; Chung, 2010; Fillippatou & Kaldi, 2010; Kaldi et al., 2011; Abels, 2014; Han et al., 2014; Hugerat, 2014; Khaddage et al., 2016; Huysken et al., 2019). It can therefore be concluded that students with learning disabilities are able to fully benefit from PBL approaches in the science classroom as much as, if not more than, their non-learning disabled peers when supports are provided. With this conclusion in mind, it is important for science educators to recognize the benefits of these learning approaches and to provide the proper supports, scaffolding, and differentiation to ensure that all of the students in their classrooms are able to achieve.

References

Abels, S. (2014). Inquiry-based science education and special needs- Teachers reflections on an inclusive setting. Sisyphus *Journal of Education, 2*(2), 124-154.

Abraham, R. R., Fisher, M., Kamath, A., Izzati, T. A., Habila, S. & Atikah, N. N. (2011). Exploring first-year undergraduate medical students' self-directed learning readiness to physiology. *Advances in Physiology Education, 35*(4), 393–395.

Akinoğlu, O. & Tandoğan, R. O. (2007). The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia Journal of Mathematics, Science & Technology Education, 3*(1), 71-81.

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and Children, 46*(2), 26.

Baran, M. & Maskan, A. (2010). The effect of project-based learning on pre-service physics teachers electrostatic achievements. Cypriot Journal of Educational Sciences, *5*(4), 243–257.

Barron, B. J. S., Schwartz, D. L., Vye, N. J., Moore, A., Petrosino, A., Zech, L., Bransford, J. D. & The Cognition and Technology Group at Vanderbilt. (1998). Doing with understanding: Lessons from research on problem- and project-based learning. *The Journal of the Learning Sciences, 7*(3&4), 271–311.

Bybee, R.W., (2006, August 15). *Enhancing science teaching and student learning: a BSCS perspective*. National Research Conference 2006, 12-20. Colorado Springs, CO.

Chen, R. W., Lam, S. F. & Chan, J. C. (2008). When high achievers and low achievers work in the same group: The roles of group heterogeneity and processes in project-based learning. *British Journal of Educational Psychology, 78*, 205–221.

Chung, H., & Behan, K.J. (2010). Peer sharing facilitates the effect of inquiry-based projects on science learning. *The American Biology Teacher, 72*(1), 24-29.

Dewey, J. (1938). *Experience and education.* A Touchstone Book, Kappa Delta Pi.

Elliott, J.G. (2000). The psychological assessment of children with learning difficulties. *British Journal of Special Education, 27*(2), 59-66.

Filippatou, D., & Kaldi, S. (2010). The effectiveness of project-based learning on pupils with learning difficulties regarding academic performance, group work and motivation. *International Journal of Special Education, 25*(1), 17-26.

Gallagher, S.A., Stephien, W.J., Sher, B.T. & Workman, D. (1999). Implementing problem-based learning in science classrooms. *School Science and Mathematics, 95*(3), 136-146.

Gillies, R. M., & Ashman, A.F. (2000). The effects of cooperative learning on students with learning difficulties in the lower elementary school. *The Journal of Special Education, 34*(1), 19-27.

Greenwald, N.L. (2000). Learning from problems. *The Science Teacher, 67*(4), 28-32.

Häkkinen, K. (2003). Progressive inquiry in a computer-supported biology class. *Journal of Research in Science Teaching, 40*(10), 1072–1088.

Han, S., Capraro, R., & Capraro, M.M. (2014). How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: the impact of student factors on achievement. *International Journal of Science and Mathematics Education 13*, 1089-1113.

Hampton, N.Z., & Mason, E. (2003). Learning disabilities, gender, sources of efficacy, self-efficacy beliefs and academic achievement in high school students. *Journal of School Psychology, 41*, 101-112.

Hugerat, M. (2016). How teaching science using project-based learning strategies affects the classroom learning environment. *Learning Environment Resources, 19*, 383-395.

Huysken, K., Olivey, H., McElmurry, K., Gao, M., & Avis, P. (2019). Assessing collaborative, project-based learning models in introductory science courses. *Journal of the Scholarship of Teaching and Learning, 19*(1), 6-28.

Individuals with Disabilities Education Act, 20 U.S.C. § 1400 (2004)

Kaldi, S., Filippatou, D. & Govaris, C. (2011). Project-based learning in primary schools: Effects on pupils' learning and attitudes. *Education, 39*(1), 35–47.

Khaddage, F., Müller, W., & Flintoff, K. (2016). Advancing mobile learning in formal and informal settings via mobile app technology: Where to from here, and how? *Journal of Educational Technology & Society, 19*(3), 16.

Lumpkin, A. (2007). Caring teachers: The key to student learning. *Kappa Delta Pi Record, 43*(4), 158–160.

Matlock, B., Billingsley, F., Lynch, V., Haring, N. & Boer, M. U.S. Department of Education (1991). *The collaborative learning process: Peer coaching on special education.* (Research Report 143).

Morocco, C. C., Dalton, B., & Tivnan, T. (1990). *Interim report: Problem solving in science project.* Education Development Center.

National Research Council. (2000). *Inquiry and the national science education standards.* National Academy Press.

Next Generation Science Standards Lead States. (2013). *Next generation's science standards: For states, by states.* The National Academies Press.

OECD. (2006). *Assessing scientific, reading and mathematical literacy. A Framework for PISA 2006.* http://www.oecd.org/education/school/assessingscientificreadingandmathematicalliteracyaframeworkforpisa2006.htm

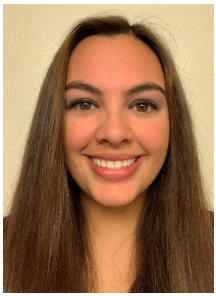
Scruggs, T.E., Mastropieri, M.A., Bakken, J.P., & Brigham, F.J. (1993). Reading versus doing: The relative effects of textbook-based and inquiry-oriented approaches to science learning in special education classrooms. *The Journal of Special Education, 27*(1), 1-15.

Slavin, R.E. (1999). Comprehensive approaches to cooperative learning. *Theory Into Practice, 38*(2), 74-79.

Sullivan-Palincsar, A., Magnusson, S. J., Collins, K. M., & Cutter, J. (2001). Making science accessible to all: Results of a design experiment in inclusive classrooms. *Learning Disability Quarterly, 24*(1), 15-32.

Treagust, D.F. & Peterson, R.F. (1998). Learning to teach primary science through problem based learning. *Science Education, 82*(2), 215-237.

Wurdinger, S., Haar, J., Hugg, R., & Bezon, J. (2007). A qualitative study using project-based learning in a mainstream middle school. *Improving schools, 10*(2), 150-161.



About the Author

Haley Meek is a high school biology teacher. She received a Bachelor of Science in Zoology from The Ohio State University and a Master of Secondary Education from the University of Toledo. She also has a master's degree in Biology and enjoys incorporating previous research experiences into her teaching.