

MainSTREAM

Science

A RESEARCH-BASED
SUPPLEMENTAL CURRICULUM





INTRODUCTION

In 2011, the push for STEM education began. Although STEM has made its way to the forefront of education, it still has a long way to go. Science and mathematics test scores in the United States remain in dire need of improvement (Desilver 2017). Additionally, fewer college graduates are pursuing careers in STEM fields. As a nation, we are at risk of falling behind the rest of the world in terms of innovation.

Thus, there is a need for STEM education to continue its march forward. Placing emphasis on STEM does not have to be at the exclusion of other subject areas. An integrated curriculum has much to offer. It helps students see the larger picture as well as the real-world application of the skills they are learning. It shows them how all the pieces fit together. In recent years, the acronym STEM has been expanded, first to STEAM to include art, and more recently to STREAM to include reading. Studies suggest that collaboration across disciplines increases student motivation and confidence, while reducing anxiety and disruptive behavior (Schwartz 2015).

COLLEGE AND CAREER READINESS

The goal for all students is to be ready for college or a career by the end of their education. According to the Partnership for 21st Century Skills, this means that students are equipped with the following skills:

- Communication
- Collaboration
- Critical Thinking
- Creativity

In 2021, a study funded by Lucas Education Research provided evidence that project-based learning worked for all students, including those from low-income households. Students in project-based learning classes outperformed students in traditional classes by 8 percentage points on the AP test (Saavedra et al., 2021). *MainSTREAM Science* uses a project-based learning approach to interweave multiple disciplines, meet various content standards, and give students ongoing opportunities to develop college and career readiness skills.

Research has also shown that the use of manipulatives has positive outcomes on the retention of math concepts versus teaching that uses only abstract mathematical symbols and concepts (Carbonneau, Marley, & Selig 2013). Using tools has also been linked to more positive thoughts about the subject of math, especially when students receive instruction with concrete materials delivered by teachers who know how to expertly use the materials (Sowell 1989, Leinenbach & Raymond 1996). The use of manipulatives benefits English Language Learners (ELLs) by providing visuals to support the introduction of new concepts and new vocabulary.

The use of manipulatives allows teachers to reach all modalities of learning, including kinesthetic learning. As defined by the Institute for Learning Styles, kinesthetic learners are those who want to “try things out and like to manipulate objects.” While using manipulatives, students are also able to move their bodies rather than simply listening to new information. Studies have shown that conceptual retention is improved when learning is connected to body movements. These body movements provide cues for retrieving information at a later time (Carbonneau et al. 2013, Lindren 2015).

Additionally, inclusive education classrooms aim to provide the necessary resources and support for all students, regardless of background, abilities, or deficiencies to learn together. For students with special needs, manipulatives can play an important role in helping these students understand mathematical concepts and engage with the subject. Evidence shows that manipulatives can increase student’s attention and involvement in math lessons. (Tjandra, 2023).

PROJECT-BASED LEARNING

Project-based learning, or PBL, involves learning about a topic over an extended period of time via different disciplines. *How* the information is taught becomes just as important to the content that is taught (Drake 2000). It takes an active approach to learning in which a real-world problem is identified and students must work together to find a solution to that problem. This method of instruction is also most aligned to how people learn in a twenty-first century working environment (Wilkinson 2014).

PBL is open and evolving, asking students to follow a series of thoughtful steps: analyze a problem, ask questions, pose hypotheses, identify information needed to solve the problem, and find information in texts and scientific investigations (McConnell, Parker & Ederhardt 2018). It is not about the end product—the presentation of the proposed solution—but rather about the journey it takes to get there.

With PBL, students take on the bulk of responsibility. Teachers serve as coaches—guiding and motivating from the sidelines as students find their own paths toward a solution. Teachers provide the content and parameters, but it is up to the students to take responsibility for much of their own learning (Aldabbus 2018).

Collaboration is crucial with PBL—collaboration amongst team members, collaboration amongst teams, and collaboration between students and teacher. Research shows that “a significant relation was found between the PBL method and collaborative learning, disciplinary subject learning, iterative learning, and authentic learning, which, in turn, produced student engagement” (Almulla 2020).



One of the biggest challenges with implementing PBL is the thoughtful and thorough planning the tasks require (Habok & Nagy 2016). The *MainSTREAM Science* series readily solves this problem for teachers. Teachers are provided with units of lesson plans that take the guess work out of how to guide students toward solving a real-world problem.





COOPERATIVE LEARNING

Countless studies have shown that people learn through interactions with others. Concepts become more solidified when students have opportunities to discuss learning and work together to practice their learning. Ultimately, students are more actively engaged in learning (NEA). When working together, students typically have higher achievement rates and greater productivity (Johnson & Johnson 1989). Cooperative learning situations also benefit ELL students. These students become actively engaged in cooperative groups, and have authentic opportunities to discuss key concepts and use academic vocabulary (Haynes 2014).

The lessons in the *MainSTREAM Science* series require students to work together in cooperative groups. The group members work together and rely on each other to work through and discuss how to solve the problems presented in each unit. Working in small groups allows teachers time to walk around the room and assess student understanding. Teachers can listen to group conversations and see how effectively students discuss ways to solve real-world problems and their reasoning behind the solutions.

Working in small groups also offers students a chance to see how other students come up with solutions to the presented problems. There is often more than one way to solve a problem, and it helps students to see and understand this concept. Furthermore, cooperative learning can increase student achievement and develop social skills (Siegel 2005).

SOCIAL EMOTIONAL LEARNING

Project-based learning offers an authentic opportunity for students to build their social-emotional learning skills. Communication, teamwork, and even empathy are all key parts of PBL. During a 2020 case study, researchers found that PBL provided students with the opportunity to meet specific SEL goals, such as self-awareness, reflection, and collaboration (Fitzgerald, 2020). Because *MainSTREAM Science* is a project-based learning program, working well with others is a must. Students who are socially aware are able to work constructively with others to solve problems and resolve conflicts.

Throughout the course of the project, students will have multiple opportunities to practice and strengthen social and emotional skills, such as:

- adapting to different social environments
- open-mindedness (awareness and appreciation of different perspectives)
- compromising and negotiating
- conversing with others (verbal and nonverbal)
- empathy for others
- integrity
- responsibility to others and oneself
- self-awareness
- solidarity
- understanding diversity

A strong set of social and emotional skills, both inside and outside the classroom, is essential for students' academic success and overall well-being (Weissberg et al. 2003). Being socially aware will better prepare students for college and a career.

DEVELOPING GLOBAL AWARENESS

The interconnectedness of the world today—thanks to technological advancements—makes global citizenship more important than ever. Developing a global mindset is another critical way that students become twenty-first century thinkers.

Elementary school students often learn about being a good local or national citizen, but they rarely develop an understanding of what it means to be a good global citizen. Good global citizens strive to make the world a better place. They want to create a positive global impact. Global citizens possess:

- a concern for the environment
- a curiosity about global affairs
- a desire to take action and help others
- critical-thinking and problem-solving skills
- cultural sensitivity
- social awareness

MainSTREAM Science challenges students to think on a global level. Students are guided to think about how the problem they are seeking to solve help the global community. Students gain valuable experience in working with a team to achieve a goal. They cultivate their social skills, bolster their critical-thinking skills, and expand their knowledge of the world at large. *MainSTREAM Science* encourages students to think critically, globally, and for themselves. It requires cooperation, collaboration, and communication. As students come together to solve a problem, they will grow intellectually and emotionally (Braskamp 2008). Teamwork will lead to independence. Knowledge will expand. Friendships will form.

OPPORTUNITIES FOR FORMATIVE ASSESSMENT

Decades of research has shown that formative assessment is a highly effective way to gauge students' understanding, modify teaching, and ultimately increase student learning (Black & Wiliam 1998). Having students perform formative assessments, such as 3-Way Summaries or 3-2-1 Countdowns, provides teachers with the opportunity to see what students are thinking and how they are processing the information. It allows teachers to see the individual strengths and weaknesses in students' understanding and adjust their pedagogical approach accordingly.

CONCLUSION

The *MainSTREAM Science* series is aligned with state and national standards and uses a project-based learning approach to solve real-world problems. This approach allows students to work collaboratively, to discuss their ideas in a safe environment, and become more socially aware of the world around them. These factors and more will ultimately help students successfully increase their problem-solving skills and create twenty-first century thinkers.





REFERENCES CITED

- Aldabbus, Shaban. (2018). Project-based learning: Implementation & Challenges. *International Journal of Education, Learning and Development*. Vol 6(3): pp. 71–79.
- Almulla, M. A. (2020). The Effectiveness of the Project-Based Learning (PBL) Approach as a Way to Engage Students in Learning. *SAGE Open*, 10(3). <https://doi.org/10.1177/2158244020938702>
- Black, P., & Wiliam, D. (1998). *Inside the black box: Raising standards through classroom assessment*. London: Granada Learning.
- Braskamp, Larry. (2008). Developing global citizens. *Journal of College & Character*. Vol. X(1).
- Desilver, Drew (2017). U.S. students’ academic achievement still lags that of their peers in many other countries. Pew Research Center. <https://www.pewresearch.org/fact-tank/2017/02/15/u-s-students-internationally-math-science/>
- Drake, Susan M. (2000). *Curriculum Handbook: Integrated Curriculum*. Association for Supervision and Curriculum Development.
- Fitzgerald, M. (2020). Overlapping opportunities for social-emotional and literacy learning in elementary-grade project-based instruction. *American Journal of Education*, 126(4), 573–601.
- Habók, Anita & Nagy, Judit. (2016). *In-service teachers’ perceptions of project-based learning*. SpringerPlus. Vol 5
- Haynes, Judie. (2014). *Six Strategies for Teaching ELLs Across Content Areas*. TESOL International Association.
- Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and research*. Edina, Minn.: Interaction Book Company.
- McConnell, T., Parker, J., & Eberhardt, J. (2018). *Problem-based learning in the physical science classroom*. Arlington, Virginia: National Science Teachers Association Press.
- National Education Association. *Research Spotlight on Cooperative Learning*.
- Saavedra, A.R., Liu, Y., Haderlein, S.K., Rapaport, A., Garland, M., Hoepfner, D., Morgan, K.L., & Hu, A. (2021). *Knowledge in Action efficacy study over two years*. University of Southern California Dornsife Center for Economic and Social Research.
- Schwartz, Katrina. (2015). How integrating arts into other subjects makes learning come alive. KQED News.
- Siegel, C. (2005). Implementing a research-based model of cooperative learning. *Journal of Educational Research*, 98(6), 339–349.
- Weissberg, R.P., Kumpfer, K., & Seligman, M. E. P.(Eds.). 2003. Prevention that works for children and youth: An introduction. *American Psychologist*, 58, 425-432.
- Wilkinson, J. (2014). The role of project based learning in promoting environmental stewardship: A case study of Bahrain Teachers College. *Journal of Sustainability Education* Vol. 7.