Implementing and Facilitating Peer-mentoring During After-school Programs within STEM Areas: A Discussion of Best Practices

Douglas Lecorchick & Jennifer Houchins / Bryanne Peterson
North Carolina State University / Virginia Polytechnical University

Abstract

Using these two successful programs for discussion, this paper provides sample lesson plans, and a discussion of best practices when implementing and facilitating peer-mentoring during afterschool programs within a STEM area of concentration. The Shodor Education Foundation and Lee County's AIG STEM Club are education entities dedicated to helping youth and teens build excitement for STEM. These programs provide high school students the opportunity to contribute in the development of educational materials for elementary students. The high school students research, design, and create authentic STEM lessons and then facilitate each lesson during an elementary student after school club.

Keywords

Peer-mentoring, After school clubs, STEM education

Introduction

The Shodor Education Foundation (Shodor) is a non-profit organization in Durham, NC dedicated to helping youth and teens build excitement for STEM through hands-on and interactive, computer-enhanced activities. Similarly, the AIG STEM club in Sanford, NC is an afterschool program aimed to enrich the STEM learning experience for students identified as academically and/or intellectually gifted. Both programs provide high school students the opportunity to contribute in the development of educational materials used to improve STEM learning for (rising) middle school aged students. The high school students research, design, and create authentic STEM lessons and then facilitate each lesson during an afterschool club.

Background

Established in 1994, the Shodor Education Foundation, Inc. (Shodor) is housed in Durham, North Carolina. As a nonprofit organization, Shodor serves students and educators with curricular materials and instruction relating to computational science (scientific, interactive computing). Shodor is dedicated to transforming learning through computational thinking and develops and deploys interactive models, simulations, and educational tools through workshops and other hands-on experiences that explore new approaches to math and science education (Shodor Education Foundation, Inc., n.d.).

Shodor focuses on reaching students who are traditionally underrepresented in the STEM fields. Historically, 33% or more of Shodor's students are female and each year the programs strive to increase participation closer to 50%. In addition to a high female participation rate, African-American, Hispanic, and American Indians account for nearly 41% of all students who attend

Shodor workshops. Additionally, in an effort to never allow financial hardship to stand in the way of admittance into its programs, Shodor has a high rate of economically disadvantaged students.

In 2005, Shodor implemented the SUCCEED (Stimulating Understanding of Computational science through Collaboration, Exploration, Experimentation, and Discovery) Workshop Program as part of the NSF Cyberinfrastructure Team (CI-TEAM) funded Computing MATTERS (Mentoring Academic Transitions Through Experiences in Research and Service) Initiative. SUCCEED workshops introduce middle and high school students to a wide variety of computer-enhanced scientific topics, such as modeling and simulation, forensic science, and explorations in engineering. These workshop students often become participants in the Internship Program at Shodor and contribute to the development of authentic lesson plans and the peer-mentoring of future workshop students.

Lee County School District (Sanford, NC) serves a student population in need of additional supports, specifically regarding English as a Second Language (ESL) identified students and students from low socioeconomic identified households- over 65 percent of students receive free/reduced lunch in this district. The AIG STEM Club was developed to serve students across the district, regardless of what (rising) middle school they will attend. The club membership was opened to all current 5th grade students who were identified as academically and/or intellectually gifted (AIG) and could commit to two hours each month of peer-led integrative STEM activities.

The AIG STEM club increased awareness of student diversity with STEM fields, enhanced the understanding of technological applications, and became the framework of how to implement integrative STEM activities in informal environment throughout the district. This club finished the 2017-2018 academic year by receiving a $2,998 Buroughs-Wellcome grant that provided material, food, and a paid internship for the mentors over a 3-day STEM camp. In preparation for the camp, all content was designed and developed by the high school students and during the camp each student facilitated the learning of a new technology each day.

Peer Mentoring

Mentoring interventions target social contexts and exchanges rather than isolated skills through a participation-based framework[1]. Unfortunately, those who are most likely to need mentors—disadvantaged youth with few personal, familial, and environmental resources—are least likely to have them[2]. While certainly not the only reason, one impediment to mentor programs reaching students is that face-to-face mentoring programs are historically labor intensive and difficult to scale, especially in rural areas[3]. Having a mentor is correlated with students reporting better grades, higher educational attainment, and greater attachment to the labor force following schooling[2,4,5]. As such, it is particularly important for students from traditionally disadvantaged backgrounds to have access to programs like the AIG STEM Club and Shodor.

By utilizing high school students to lead mentoring programs in a structured format, such as those used by AIG STEM Club and Shodor, programs shift the preparation from a few over-burdened adults to a shared system where all the mentors take on responsibilities, making it more sustainable. In Lee County, ten high school students would meet for one hour each week to discuss, plan, and develop STEM lesson plans with oversight from the district STEM Specialist. These high school students would meet before school, during their lunch, and/or afterschool for a total of 1-hour weekly. The AIG STEM Club would then meet monthly for one 2-hour session at

a rotating Elementary school within the district. Dinner was provided along with snacks and drinks. In addition to the practicality of feeding the students due to the meeting time, access to meals as part of the programming is an important draw for families that struggle with food insecurity in the region and it provided an unstructured time for peer mentors and mentees to talk. There was no cost associated with the club membership and all material was provided for from the district's Career and Technical Education (CTE) fund toward furthering the STEM involvement of young students.

In comparison, students in the Internship Program at Shodor receive a scaffolded peer-mentoring training before interacting with younger students. In the 2017-2018 school year, this training began with students assisting staff mentors as workshop "shoulder-surfers" where they provide support to student workshop participants throughout instruction. Once students felt comfortable with workshop content and mentoring other students, they move on to develop new and authentic lessons in STEM with the guidance of expert staff mentors and finally lead the instruction for those lessons in future workshop offerings. As they gain more experience, these interns provide further peer-mentoring to new interns, helping them to also develop authentic STEM lessons.

Authentic Lesson Plans

Below is a sample lesson plan designed by high school interns for Shodor's Explorations in Engineering workshop. This lesson plan was developed by the students in a collaborative planning session with oversight of the Engineering staff mentor at Shodor.

Lesson Title:	High Seas Adventure!
Duration:	2 hr. 30 min total.
Materials:	Dry erase board markers, Scissors, Marbles, Scotch Tape or plastic boxing tape, Aluminum Foil, Cardstock, Pencil and paper, Rulers, Small trash can, Paper towels, Fish Tank with water, Small box with removable lid (e.g., a shoe box), Plastic or Styrofoam cups or small bowls, 1 Graduated beaker for each group (250-500 ml), Varying density material set
Procedure:	1. Students listen to lecture and view demonstrations from peer mentors about the relationships between mass, density, and volume. 2. Peer mentors introduce students to Archimedes' Principle from fluid mechanics and lead exploration through a Density simulation applet: http://phet.colorado.edu/sims/density-and-buoyancy/buoyancy_en.html 3. Students explore buoyancy and floatation with objects from the varying density material set. 4. Students collect materials needed for a boat design challenge titled "High Seas Adventure!". 5. Students collaborate in groups to design and construct a boat from cardstock and other materials that will hold a cup into which marbles will be placed.

	6. Student groups take turns testing their designs with marbles and the boat that holds the most marbles without sinking wins the challenge.
Peer-Mentoring Interaction	The peer-mentors facilitate the challenge from the lecture at the beginning of the lesson throughout the final design challenge. All student questions and fabrication inquiries are answered by the peer-mentors. All revision and design suggestions are filtered and expanded upon by the peer-mentors as well.

Below is a lesson plan designed by Lee County high school students aiming to create an authentic and exciting learning opportunity for the club members. This lesson plan was developed over the course of four 1-hour long meetings which were student led with oversight from the STEM Specialist.

Lesson Title:	Gremlin on the Loose (a device to capture a mobile object given contour dimensions).
Duration:	1-hour total. 45 minutes (fabrication) 15 minutes (presentation)
Materials:	4 full sheets of newspaper, 2 pieces of construction paper, 2 feet of twine, 4 pipe cleaners, 3 feet of masking tape. All material is per group of 4 students.
Procedure:	1. Students listen to the lecture and view a demonstration from the peer mentors about the design challenge titled “Gremlin on the Loose”. 2. Students collect all material needed for the challenge (per group). 3. Students begin to sketch their ideas and collaborate (brainstorm) ways to ‘catch’ the gremlin. 4. Students begin to fabricate their agreed upon design with guidance from the peer mentors. 5. Student demonstrate their design with a ‘talk out loud’ presentation and engage in a group think dialog with any member of the club that has input regarding the design etc…
Peer-Mentoring Interaction	The peer-mentors facilitate the challenge from the lecture at the beginning of the lesson throughout the final presentation and group dialog. All student questions and fabrication inquiries are answered by the peer-mentors. All revision and design suggestions are filtered and expanded upon by the peer-mentors as well.

Best Practices

While the Shodor and AIG STEM Club structures vary somewhat, some things remain constant across both of these successful programs. First, the near-peer mentoring partnerships are important as the more informal relationship that develops in near-peer mentoring between students not only reduces anxiety, it also leads to students feeling safer to disclose areas of uncertainty and ask questions, as compared to mentoring projects where students are paired with adults[6]. Second, both programs benefit mentors as well, helping them improve important skills such as while simultaneously helping ensure mastery of STEM Content[7,8]. Mentors also have improved self-esteem, social skills, and experience in public service as a result of participating in programs like these[9]. Additionally, both the AIG STEM Club and Shodor facilitate youth agency by fostering intellectual investment, self-confidence, and long-term future orientation. Research shows these items are important for student agency,[10–12] which, in turn, is positively associated with educational and career success[13–15]. Finally, both programs provide structure and support for mentors to learn what successful mentoring is, which aligns with current best practices as well[16].

Outside of alignment to literature, several other best practices were identified in a review of the AIG STEM Club and Shodor programs. First, faculty members need to remain upbeat and engaged when overseeing the peer mentors as they respond well to positive interaction similar to the students, they are facilitating the lessons for. Building and facilitating a peer-mentoring culture in STEM programs relies on providing expert guidance and scaffolded support. Students who have the opportunity to develop authentic lessons to teach STEM concepts that they have particularly enjoyed benefit from expert guidance from program staff that models the collaborative dynamic necessary to provide successful mentoring to near peers. Moreover, allowing students to gain comfort in developing instructional materials by collaborating with one another bolsters the practice of peer-mentoring and prepares them for mentoring younger students.

Scaffolding support from expert program staff so that students take on more responsibility and instructional leadership as their own comfort as a peer-mentor grows further models the peer-mentoring approach. This approach facilitates the just-in-time support needed to help engage novices in STEM programs and build their own confidence, particularly with complex engineering and design focused activities. By modeling for peer-mentors when and how much support is appropriate in the activities they develop, these students can become stronger mentors for their near peers.

Implications for Engineering Education

Peer-mentoring is a valuable, practical, and proven way to engage young students in engineering design focused activities in formal and informal education settings. Schools stand to benefit from implementing more peer-mentoring initiatives by ways of increased enrollment of female and minority students in STEM fields. This increased enrollment is a result of early engagement experienced as a result of interaction with a peer-mentor. Further research could address the long-term impact that early engagement and interaction with a peer-mentor has on students and their decision to enter in and continue studying in a STEM field.

References

1 Karcher, M. Increases in Academic Connectedness and Self-Esteem Among High School Students Who Serve as Cross-Age Peer Mentors. *Prof. Sch. Couns.* (2009). doi:10.5330/PSC.n.2010-12.292

2 Erickson, L. D., McDonald, S. & Elder, G. H. Informal mentors and education: Complementary or compensatory resources? *Sociol. Educ.* (2009). doi:10.1177/003804070908200403

3 Neely, A. R., Cotton, J. & Neely, A. D. E-mentoring: A Model and Review of the Literature. *AIS Trans. Human-Computer Interact.* **9**, 220–242 (2017).

4 DuBois, D. L. & Silverthorn, N. Characteristics of natural mentoring relationships and adolescent adjustment: Evidence from a national study. *J. Prim. Prev.* (2005). doi:10.1007/s10935-005-1832-4

5 McDonald, S., Erickson, L. D., Johnson, M. K. & Elder, G. H. Informal mentoring and young adult employment. *Soc. Sci. Res.* (2007). doi:10.1016/j.ssresearch.2007.01.008

6 Christiansen, A. & Bell, A. Peer learning partnerships: Exploring the experience of pre-registration nursing students. *J. Clin. Nurs.* (2010). doi:10.1111/j.1365-2702.2009.02981.x

7 Goodrich, A. Peer Mentoring and Peer Tutoring Among K–12 Students: A Literature Review. *Updat. Appl. Res. Music Educ.* **36**, 13–21 (2017).

8 Shields, C. Music Education and Mentoring as Intervention for At-Risk Urban Adolescents: Their Self-Perceptions, Opinions, and Attitudes. *J. Res. Music Educ.* (2001). doi:10.2307/3345712

9 Barton-Arwood, S., Jolivette, K. & Gayle Massey, N. Mentoring with Elementary-Age Students. *Interv. Sch. Clin.* **36**, 36–39 (2000).

10 Clausen, J. S. Adolescent Competence and the Shaping of the Life Course. *Am. J. Sociol.* (1991). doi:10.1039/A803038C

11 Hamilton, S. F. *et al.* Community contexts for mentoring. *J. Community Psychol.* (2006). doi:10.1002/jcop.20126

12 Larson, R. Positive youth development, willful adolescents, and mentoring. *J. Community Psychol.* (2006). doi:10.1002/jcop.20123

13 Dinovitzer, R., Hagan, J. & Parker, P. Choice and Circumstance: Social Capital and Planful Competence in the Attainments of Immigrant Youth. *Can. J. Sociol.* (2003). doi:10.2307/3341838

14 Kenny, M. E., Blustein, D. L., Haase, R. F., Jackson, J. & Perry, J. C. Setting the stage: Career development and the student engagement process. *J. Couns. Psychol.* (2006). doi:10.1037/0022-0167.53.2.272

15 Masten, A. S. *et al.* Resources and resilience in the transition to adulthood: Continuity and change. *Dev. Psychopathol.* (2004). doi:10.1017/S0954579404040143

16 Lecorchick III, D. *et al.* School-based mentoring: High school students mentor elementary students. *Elem. STEM J.* **23**, 18–23 (2018).

Douglas Lecorchick

Douglas is an Assistant Teaching Professor within the STEM Education Department at North Carolina State University and a current 21st Century Leadership Academy (ITEEA) cohort member. Engineering research interests: Engineering design process, peer-mentoring within STEM programs, and makerspace curriculum development. Education research interest: Problem formulation and framing, graphic communication and animation education in elementary schools, and engineering education curriculum design.

Jennifer Houchins

Jennifer is a Doctoral Student within the Learning, Design, and Technology program area of the Teacher Education and Learning Sciences Department at North Carolina State University. Her research interests include: Computational thinking, design thinking, increasing student interest and engagement in STEM with makerspaces, infusing STEM curriculum with computing, and peer-mentoring and collaborative learning in STEM programs.

Bryanne Peterson

Bryanne is a Research Assistant Professor in the Institute for Creativity, Arts, and Technology at Virginia Tech and a current 21st Century Leadership Academy (ITEEA) cohort member. Her research focuses on diversifying and increasing pathways to STEM careers, with a focus on PK-12 intervention strategies for students in rural areas. Specific education research interests include: Integrative STEM Education, 21st century skills, design-based learning, and career connections.