Blended Learning Training for Mentors of STEM Team Competitions

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Abstract: This paper describes the findings of a research study of a blended-learning approach to train mentors of teams in the Botball® Educational Robotics Program. Botball is an international team-based robotics competition for secondary students designed to build skills in computer programming, robotics, teamwork, and problem solving. For this study, we recruited new teams comprising 8-10 middle school students per team and a mentor. Teams were randomly assigned to one of three treatment groups or a control group. Mentors of teams in the experimental groups received training in one of three types of mentor practices: best practices, mentoring for self-efficacy, or a combination of best practices and self-efficacy. The training format consisted of web-based self-paced tutorials, a face-to-face workshop, and webinars. Dependent variables were student post-test scores on three assessments: Efficacy for Science-Related Jobs, STEM Achievement-Related Choices, and STEM Self-Efficacy. A priori statistical analyses showed no difference between the groups; however, post hoc analyses showed that the use of self-efficacy techniques was positively related to the three dependent measures. Post-competition surveys of mentor practices indicated that students in the treatment groups did not appear to receive distinctly different treatments, revealing some of the potential challenges of the blended learning approach for professional development of teacher-mentors.

1 INTRODUCTION

Science and engineering competitions offer the potential to generate interest in STEM (science, technology, engineering, and mathematics) among K-12 students (Dabney et al., 2012), identify and develop STEM talent and influence choice of postsecondary major (Sahin, 2013), and foster participation by historically underrepresented groups (Alvarez et al., 2010). Existing competitions vary in scope, format, and learning goals; some of the most popular range from academic Olympiads (e.g., Science Olympiad), to math contests (e.g., MATHCOUNTS), to science fairs (e.g., Intel International Science and Engineering Fair, Google Science Fair), to robotics competitions (e.g., FIRST®, Botball®, VEX®). Each of these activities involves a mentor, often a school teacher, who guides a student or group of students to successfully complete a project or intense program of study in preparation for a competition day. In addition to aiming for high academic performance, mentors who work with groups of students must manage team dynamics so as to ensure a positive experience for all. "Group mentoring" for academic competitions has not been well studied, and very few advice guides are available for mentors. Given the ongoing interest in academic competitions, further research is needed to determine which approaches to group mentoring lead to positive student outcomes.

This research study examined the components of effective mentor training for an out-of-school robotics program for middle-school students. The training used a blended learning approach that included a one-day face-to-face workshop, 3-5 Web-based tutorials, and interactive webinars. Blended

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learning was chosen for its flexibility in delivering content to mentors who were not co-located (e.g., Garrison and Kanuka, 2004). A total of four STEM educators served as training facilitators: two facilitators co-led the face-to-face workshop for groups of mentors at two sites in the U.S., and three facilitators shared responsibilities for leading the webinars. The mentor training took place over a 10-week period, beginning 6 weeks before the robotics competition season started and ending 3 weeks prior to the culminating competition day. This position paper (work in progress) describes the benefits and challenges of using blended learning to train team mentors and reports initial research findings on training outcomes.

2 THEORETICAL FRAMEWORK

The number of published studies of blended learning has continued to increase since 2000 (Bliuc et al., 2007). While several meanings for the term "blended learning" have been proposed, a widely accepted definition is that blended learning is a combining of face-to-face instruction with web-based instruction where learners are not co-located (Garrison and Kanuka, 2004; Owston et al., 2008). Furthermore, these researchers have argued that effective blended learning is not simply the addition of a technology-mediated component to an existing traditional course, but rather an intentional integration of face-to-face and web-based components that capitalizes on the strengths of each format. The online experience can add value by allowing time for student reflection, extended discussions, and personalization of content (Ausburn, 2004; Bonk and Graham, 2006; Laurillard, 2014). Researchers have reported that compared to traditional courses, the blended learning format promotes faculty-student interaction (Owston et al., 2006), increases student satisfaction (Dziuban et al., 2006), and increases student engagement (Ziegler et al., 2006).

Much of the published literature on blended learning focuses on university courses; however, blended learning has also been applied to K-12 in-service teacher professional development (e.g., Berger et al., 2008; Owston et al., 2008; Matzat, 2013; Eshtehardi, 2014; Ho et al., 2014). A primary challenge of any teacher professional development is to design a program that will facilitate lasting change in teacher practice (Loucks-Horsley et al., 2009). Using blended learning, facilitators can offer support for teachers between face-to-face meetings through structured online activities that enable deeper reflection on their practice (Berger et al., 2008). Blended learning is recognized as a promising approach for working with in-service teachers and other professionals because it can extend the duration of the professional development, allowing more time for teachers to try out new practices in the classroom and receive immediate feedback from the online community (Owston et al., 2008b). Owston et al. have called for additional studies that examine ways to better sustain teacher participation in the online component and determine the impact of blended programs on student learning.

3 TRAINING DESCRIPTION

The goal of this project was to develop a training (professional development) program for robotics team mentors that would give them knowledge and skills necessary to effectively guide students through the process of participating in a competition. Weinberg et al. (2007) found that students participating in the Botball robotics program who have positive perceptions regarding their mentor's effectiveness tend to have increased positive perceptions towards STEM careers. However, the components of effective mentoring are not well understood, including the role that mentors might play in increasing student self-efficacy for STEM. Through an experimental study, the project sought to determine which mentoring practices would be most effective in increasing students' self-efficacy in STEM as measured by three assessments.

Mentors were teachers or administrators in the students' school, but they were not necessarily the students' STEM classroom teacher. New teams of 8-10 students were recruited from 45 schools that had never participated in the Botball program. Mentors had a range of years of classroom experience and most had no prior experience with robotics teams. The study assigned teams to a control group or one of three experimental groups. One group of mentors received mentor training using best practices, a second group of mentors received training in mentoring for self-efficacy, and a third group received training that combined best practices and self-efficacy. Mentors were then expected to apply these mentoring practices with their robotics teams as they prepared for the Botball tournament. Surveys administered to students before and after the competition measured changes in students' self-efficacy and career-related choices.

The professional development for the best practices group focused on team-building theory (Tuckman, 1965) and practical issues such as team member roles, goal-setting, creating cohesion, managing interpersonal dynamics, and celebrating success. The mentoring for self-efficacy professional development focused on the theory of self-efficacy and its four components: mastery experience, vicarious experience, social persuasion, and physiological reaction (Bandura, 1977, 1997). Mentors in the third experimental group received training that combined best practices and self-efficacy. Mentors in the self-efficacy and combined groups were given practical suggestions on how to build students' sense of mastery of technical and communication tasks, provide students opportunities to observe and learn from role models, offer targeted feedback, and teach students strategies for managing physiological responses to stress. The self-efficacy techniques were drawn from the literature on STEM and self-efficacy (Rittmayer and Beier, 2008).

The training program was well-suited to blended learning because it required that mentors a) learn theories with which they might be unfamiliar, b) reflect on their own previous mentoring experiences, c) practice team-based skills, and d) monitor and discuss their mentoring practice throughout the competition season. Mentors came from two different geographic regions of the U.S., and they were all based at different schools. The mentors' widely varying and busy schedules meant that it would have been difficult to schedule multiple face-to-face workshops during a 10-week time span. Self-paced Web-based modules gave mentors flexibility to learn new content at a time and place convenient for them. The tutorial modules also facilitated personalization of learning by prompting mentors to connect their learning to prior experience through responses to open-ended questions. The complementary face-to-face session promoted group cohesion, which is critical to the development of a community of practice, whether in-person or online (Garrison and Arbaugh, 2007).

The training proceeded in a logical sequence that began with an introduction to mentoring theory and practice through the Web-based modules and webinars. Prior to the face-to-face workshop, mentors attended two facilitated webinars where they were introduced to other mentors and provided time to share and discuss their open-ended responses to the tutorial questions. During the fourth week of the training, mentors attended an on-site workshop that included small-group activities and role-playing to reinforce targeted concepts. Each mentor also developed a written mentoring plan to help them structure their team's activities through the competition season. Following the face-to-face workshop, the mentors attended two webinars at 6 weeks prior and 3 weeks prior to the Botball tournament. These webinars reinforced mentoring concepts and addressed questions or problems concerning the mentoring implementation. Total mentor training contact hours were 17 hours for the best practices and self-efficacy groups and 20 hours for the combined group. Mentors in the control group attended a technical workshop led by the Botball organization, but did not receive any additional training. Mentors in the experimental groups also attended the technical workshop.

4 RESULTS

To examine the impact of the mentor training, students in the four treatment groups (control, best practices, self-efficacy, and combined) completed three assessments pre- and post-competition: Efficacy for Science-Related Jobs, STEM Achievement-Related Choices, and STEM Self-Efficacy. In addition, students evaluated their mentor's performance and reported on their mentor practices, and mentors self-reported on their mentoring practices. The reports on mentor practices were intended as a check on implementation, since the project facilitators were not present during team practice sessions. Student reports of mentor practices were considered alongside the mentor self-reports.

336 student and 41 mentors completed pre- and post-surveys. Students who reported attending less than 25% of their team's meetings were excluded from the statistical analysis because the treatment was considered insufficient. It was expected that mentor training that included self-efficacy would result in higher student STEM self-efficacy and STEM achievement-related choices compared to best practices and the control. If that were the case, then the study would provide evidence of the benefits of including practical strategies that support students' self-efficacy in mentoring for STEM competitions.

The proposed statistical approach was a mixed analysis of variance (ANOVA) to test the hypothesis. However, the implementation check (student reports and mentor self-reports of practices) suggested that students in the different treatment groups did not receive distinctly different treatments. With this confound, we were unable to explicitly analyse the effect of mentor training on student outcomes.

To further investigate the possible relationship between effective mentoring practices and student outcomes, the statistical team next conducted a post-hoc analysis of covariance (ANCOVA) using the student reports of mentoring practices. The student-reported practices were categorized by student-perceived amount of mentoring strategies applied (low, mid-low, mid-high, and high groups). The overall group effect of student-reported mentor activities was significantly related to STEM Self-Efficacy and to STEM Achievement-Related Choices. The overall group effect was not significantly related to Efficacy for Science-Related Jobs. However, not using mentoring practices (low group) had significantly lower outcomes than the mid-low, mid-high, and high groups combined. Thus, if only student-reported mentor practice groups are considered, there was a significant relationship for all three dependent variables. Mentor practices do have a significant impact on student STEM self-efficacy and achievement-related choices.

In the next section we posit some of the possible reasons for the lack of distinction between treatment groups and provide recommendations for refining the training using our qualitative evidence and findings reported in the blended learning and teacher professional development research bases.

5 DISCUSSION

The training program included many of the design elements important for successful blended professional development, including attention to building a community of practice (Wenger et al., 2002; Garrison and Vaughan, 2008); inclusion of activities before, during, after, and in preparation for face-to-face workshops (Berger et al., 2008; Garrison and Arbaugh, 2007); flexibility (Owston et al., 2008); and opportunity for extended discussion (Bonk and Graham, 2006). During implementation, however, mentor practices did not significantly differ across treatment groups. Despite receiving training in specific strategies targeted to best practices and/or self-efficacy, similar mentor practices were reported for all groups, including the control. We hypothesize that a combination of factors influenced these results, and that further refinement of the training program could improve the impact of training on student outcomes. Important factors appear to be time constraints, balancing group mentoring with technical tasks, malleability of teacher practices, cohesiveness of the community of practice, and the need for additional structure in online activities.

Time and Scheduling: Webinar discussions revealed that mentors faced significant challenges in finding meeting times that would work for all team members, in resolving conflicts with other student activities such as music and athletics, and in moving the team through the robotics design challenges according to the Botball schedule. The relative short competition season (7 weeks) meant that some mentors struggled to simply keep the team on schedule, and this may have prevented them from implementing specific strategies discussed during the mentor training sessions. Inconsistent student attendance exacerbated some mentors' efforts to apply what they had learned.

Balancing Mentoring and Technical Guidance: For mentors with limited exposure to robotics, and those outside the fields of STEM, the need to help students with the technical aspects of building a robot was sometimes overwhelming and superseded the mentoring implementation goals. One mentor, an early-career English teacher, expressed frustration with her inexperience with computer programming. Although the Botball program is designed to carefully scaffold the process of designing and building a robot, mentors' negative emotions might interfere with their implementation of group mentoring techniques. Allotting more time for mentors to prepare for the technical aspects of the program might build their own confidence levels, enabling them to refocus attention to mentoring strategies.

Malleability of Teacher Practices: When faced with time limitations, teachers would be more likely to revert to coaching and guiding the team in ways that are familiar to them from classroom or other experiences. For example, mentoring for self-efficacy should include attention to all four sources of self-efficacy (mastery, vicarious experiences, social persuasion, and physiological response), but some mentors were unable to schedule visits by role models who could interact with students, a strategy associated with increased self-efficacy. Alternatively, experienced teachers might unconsciously or even consciously resist changing their practice. In one case in our study, a mentor appeared to be resistant to trying new approaches, stating that with "many years of teaching experience" they were confident they knew the best ways to work with their team.

Building the Community of Practice: Zhao and Rop (2001) emphasized the importance of meaningful discourse in virtual communities, so that teachers participating in professional development feel they have a reason to stay connected to each other. Using this principle, the interactive webinars in this project provided opportunities for mentors to reflect on their team's progress, receive feedback on specific problems, and experience emotional support when faced with challenges beyond their control. Although all webinars were scheduled well in advance, as the program progressed many mentors had trouble attending during scheduled times and had to reschedule in smaller groups or in one-on-one sessions with facilitators. This negatively impacted the cohesion of the mentors within a treatment group and reduced opportunities for reflective group discourse. Owston et al. (2008) also found a decline in participation rates for online biweekly reflective tasks in a blended learning professional development program for science and math teachers.

Structure of Online Activities: Owston et al. (2008) suggested that shorter online tasks and skilled online facilitators may help prevent weak participation rates in blended learning environments. For example, they found that teachers were more motivated to post reflective online journals if they received helpful feedback from facilitators. While the mentoring webinars were an opportunity for real-time feedback, the facilitators' questioning was generally open-ended. Our experiences and the findings of Owston et al. suggest that the mentor training might be improved by adding opportunities to post online reflections and receive feedback more frequently. For example, an online discussion board would provide space for mentors to post the implementation plans they developed during the face-to-face workshop, revisit and revise them periodically, and receive feedback from an online facilitator and peers. The more frequent contact would serve as a reminder to mentors to continually integrate group mentoring principles into their team's activities.

6 SUMMARY AND CONCLUSIONS

Team-based robotics competitions provide students with the opportunity to learn technical skills such as engineering design and computer programming, while also enhancing problem solving, team work, and communication—21st Century skills that are valued by employers. Mentors for youth robotics teams and other academic competitions may be school teachers, university faculty and students, or STEM professionals who have varied experiences and skill levels in working with youth and guiding teams. Despite the critical role these mentors play in creating a positive experience, there are limited resources available to mentors to help them effectively guide their teams. To fill this gap, we developed a training program for group mentoring that is grounded in theory and empirical evidence of mentoring best practices and sources of self-efficacy. The training program was tested in a robotics educational program, but the mentoring concepts and strategies are applicable in any learning environment where an adult mentor is guiding a group of students through a team project.

The training used a blended learning approach because mentors were not co-located and because a long-term project goal is to make the training available to a wide audience. The program integrated Web-based tutorial modules on mentoring, a face-to-face workshop, and interactive webinars that reinforced the content and provided time for group reflection and discussion.

The project tested three approaches to mentor training using four groupings: control, best practices, self-efficacy, and a combination of best practices and self-efficacy. No differences were found in student self-efficacy outcomes among the groups; however, student and mentor reports of implementation suggest that mentors in the four groups did not differ significantly in their approach to mentoring, despite the training. This finding is not inconsistent with the teacher professional development literature, which has noted the difficulty of designing professional development that leads to a sustained change in teacher practice (Borko, 2004; Loucks-Horsley et al., 2009). We suggest that both external factors (time and scheduling) and training design features (the need for additional structured online activities) influenced the outcomes. Also, given the short duration of the robotics competition season, it may be that mentoring training is most effective with mentors who have had at least one year of experience with the robotics program, or who are sufficiently familiar with the technology that they are able to remain focused on evidence-based mentoring strategies. In the next phase of this work we plan interviews with a select group of mentors to determine ways in which the online portions of the training could be enhanced.

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REFERENCES

Alvarez, C. A., Edwards, D., and Harris, B., 2010. STEM specialty programs: A pathway for under-represented students into STEM fields. *NCSSSMST Journal*, 16(1), pp.27-29.

Ausburn, L.J., 2004. Course design elements most valued by adult learners in a blended online learning environment: An American perspective. *Educational Media International*, 41(4), pp.327-337.

Bandura, A., 1977. Self-efficacy: Toward a unifying theory of behavioural change. *Psychological Review*, 84(2), pp.191-215.

Bandura, A., 1997. *Self-Efficacy: The Exercise of Control*. Freeman. New York.

Berger, H., Eylon, B.S., and Bagno, E., 2008. Professional development of physics teachers in an evidence-based blended learning program. *Journal of Science Education and Technology*, 17(4), pp.399-409.

Bliuc, A.-M., Goodyear, P. and Ellis, R.A., 2007. Research focus and methodological choices in studies into students' experiences of blended learning in higher education. *Internet and Higher Education*, 10, pp.231-244.

Bonk, C.J., and Graham, C.R., 2006. *The Handbook of Blended Learning*. San Francisco, CA: Pfeiffer.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, 33(8), pp.3-15.

Dabney, K.P., Tai, R.H., Almarode, J.T., Miller-Friedmann, J.L., Sonnert, G., Sadler, P.M., and Hazari, Z., 2012. Out-of-school time science activities and their association with career interest in STEM. *International Journal of Science Education, Part B*, 2(1), pp.63-79.

Dziuban, C., Hartman, J., Juge, F., Moskal, P., and Sorg, S., 2006. Blended learning enters the mainstream. In C.J. Bonk and C. Graham (Eds.) *The Handbook of Blended Learning: Global Perspectives, Local Designs*, pp.195-206.

Eshtehardi, R., 2014. Pro-ELT; A teacher training blended approach. *Advances in Language and Literary Studies*, 5(5), pp.106-110.

Garrison, D.R. and Kanuka, H., 2004. Blended learning: Uncovering its transformative potential in higher education. *Internet and Higher Education,* 7(2), pp.95-105.

Garrison, D.R. and Arbaugh, J.B., 2007. Researching the community of inquiry framework: Review, issues, and future directions. *The Internet and Higher Education*, 10(3), pp.157-172.

Garrison, D.R. and Vaughan, N.D., 2008. *Blended Learning in Higher Education: Framework, Principles, and Guidelines*. John Wiley and Sons.

Ho, V.T., Nakamori, Y., Ho, T.B., and Lim, C.P., 2014. Blended learning model on hands-on approach for in-service secondary school teachers: Combination of E-learning and face-to-face discussion. *Education and Information Technologies*, pp.1-24.

Laurillard, D., 2014. Thinking about blended learning: A paper for the Thinkers in Residence programme. *Royal Flemish Academy of Belgium for Science and the Arts*. Available at http://ethicalforum2013.fuus.be/sites/default/files/DP_BlendedLearning_Thinking-about_0.pdf.

Loucks-Horsley, S., Stiles, K.E., Mundry, S., Love, N., and Hewson, P.W., 2009. *Designing Professional Development for Teachers of Science and Mathematics*. Corwin Press.

Matzat, U., 2013. Do blended virtual learning communities enhance teachers' professional development more than purely virtual ones? A large scale empirical comparison. *Computers and Education*, 60(1), pp.40-51.

Owston, R. D., Garrison, D. R., and Cook, K., 2006. Blended learning at Canadian universities: Issues and practices. In C.J. Bonk and C. Graham (Eds.) *The Handbook of Blended Learning: Global Perspectives, Local Designs,* pp.338-350.

Owston, R., Sinclair, M., and Wideman, H., 2008. Blended learning for professional development: An evaluation of a program for middle school mathematics and science teachers. *The Teachers College Record*, 110(5), pp.1033-1064.

Owston, R., Wideman, H., Murphy, J., and Lupshenyuk, D., 2008. Blended teacher professional development: A synthesis of three program evaluations. *The Internet and Higher Education*, 11(3), pp.201-210.

Rittmayer, A.D. and Beier, M.E., 2008. Overview: Self-efficacy in STEM, *SWE-AWE CASEE Overviews*, pp.1-12.

Sahin, A., 2013. STEM clubs and science fair competitions: Effects on post-secondary matriculation. *Journal of STEM Education: Innovations and Research*, 14(1), pp.7-13.

Tuckman, B.W., 1965. Developmental sequence in small groups. *Psychological Bulletin*, 63, pp.384-399.

Weinberg, J.B, Pettibone, J.C., Thomas, S.L., Stephen, M.L. and Stein, C., `2007. The impact of robot projects on girls' attitudes toward science and engineering. *Robotics Science and Systems (RSS) Workshop on Research in Robots for Education*, Georgia Institute of Technology, Atlanta, June 30, 2007. Available at http://www.roboteducation.org/rss-2007/

Wenger, E., McDermott, R.A., and Snyder, W., 2002. *Cultivating Communities of Practice: A Guide to Managing Knowledge*. Harvard Business Press.

Zhao, Y. and Rop, S., 2001. A critical review of the literature on electronic networks as reflective discourse communities for inservice teachers. *Education and Information Technologies*, 6(2), pp.81-94.

Ziegler, M., Paulus, T., and Woodside, M., 2006. Creating a climate of engagement in a blended learning environment. *Journal of Interactive Learning Research*, 17(3), pp.295-318.