Integrating Social Problem Solving with Programming to Enhance Science Agency Through Creation of Mobile Apps in Middle School

Noora F. Noushad, Jooeun Shim, and Susan A. Yoon
noora@gse.upenn.edu, jshim@gse.upenn.edu, yoonsa@upenn.edu
University of Pennsylvania

Abstract: The study investigates the potential of integrating Social Problem Solving with programming to enhance science agency among middle school students. Science agency has been emphasized as an important skill to support an understanding of the real-life applicability of science. Educators find it challenging to develop action-oriented mindset among students. In this paper, we evaluate a curriculum that encourages middle school students to identify problems that interfere with their daily lives and take action by creating mobile apps to resolve them. We analyze reflections of 13 students over a series of twenty-four classes, to create mobile apps using App Inventor. Our findings suggest that enabling students to create socially relevant mobile app can be a precursor to developing an action-oriented mindset.

Keywords: science agency, app inventor, programming in middle school

Introduction

Emphasis has been made by educators to enhance science agency among students to encourage them to become thinkers and doers of science (Basu et al., 2009; Repenning et al., 2015). Initiatives continue to be taken to bring science agency to schools through curricula that support conceptual understanding of science while encouraging students to take action in their community. Most of these initiatives report an enhanced understanding of science, however, the challenge in linking student knowledge with action remains (Buxton, 2010; McNeill & Vaughn, 2012). Scholars continue to express difficulty in enabling students to perceive themselves as agents of change, in other words, capable of causing or preventing issues that affect their environment. Our paper attempts to address the challenge of enhancing student agency by engaging students in a project that provides them with the tools to carry out action at an individual or community level while equipping them with the knowledge of social issues that affect their environment. We use the Social Problem Solving (SPS) framework to help students identify problems that interfere with their daily functioning and App Inventor (AI) to enable them to carry out actions to address these issues. The aim of the paper is to determine the potential of integrating SPS and programming to enhance science agency among middle school students. Specifically, the paper seeks to answer the following research questions 1) Does SPS and programming result in the creation of mobile apps that address relevant social problems? 2) Does SPS and programming aid in the development of science agency among students?

Theoretical framework

The curriculum design for this study is guided by research on science agency (Basu et al., 2009; McNeill & Vaugh, 2010), SPS (Buxton, 2010; Chang, et al., 2004), and use of discourse-intensive pedagogy to introduce computational concepts to students (Grover & Pea, 2013). We used AI to enable students to carry out actions. AI is a blocks-based programming tool, which allows novice programmers to make apps for Android devices (Wolber et al., 2015).

The science agency literature emphasizes creating a "doer" mindset where learners perceive themselves as capable of advancing the world by taking action at an individual or community level (Basu et al., 2009; McNeil & Vaugh, 2012). Research on creating critical science agency with high school students show that they are more likely to take action when (a) issues are personally relevant to them (Skamp et al., 2004); and (b) when conceptual knowledge is accompanied by means for the learner to carry out impactful action (McNeill & Vaughn, 2012). Our curriculum encourages agency by enabling students to create mobile apps that address personally relevant issues.

The SPS literature defines social problems as issues that may interfere with the functioning of individuals in their lives (Chang et al., 2004). SPS is a strategy used to help individuals determine coping strategies for these specific problems (D'Zurilla & Nezu, 1999). These problems may vary in degree of relevance to the learner (i.e., from personal issues to issues in one's community). Programming with AI was selected as the tool in our study to enable students to carry out the action of addressing social problems due to

its portability and visual drag & drop programming features. Features such as GPS, location sensor, and barcode reader allow students to develop innovative ways to address context relevant issues (Kumar, 2014). Snapping together graphical blocks of code also makes it easier for novice programmers to emulate the creation of mobile apps in real life (Wolber et al., 2015).

Methods

The curriculum was carried out as a choice class entitled, "App Inventor for Science," at a neighborhood school in West Philadelphia. The curriculum was designed for 7th-grade and ran twice a week for 45 minutes over 12 weeks. The curriculum was delivered in 3 blocks.

Programming with AI: This block aimed to familiarize students with the programming tool. Students were taught to program through a combination of instruction and guided discovery to foster understanding of core programming concepts (Grover & Pea, 2013). Students worked in pairs to solve mini app challenges, where they tinkered with programs that had software bugs (i.e., intentionally placed errors in programming code) to make the apps function, while exploring core programming concepts. This provided room for discourse around student misconceptions of variables, control structures, procedures, and so on. Support in the form of app cards was also provided which was designed to gradually decrease scaffolding as learners become more capable with AI (Repenning et al., 2015).

Selecting social problems: During this block, students were guided through SPS's problem-solution framework (Chang et al., 2004) to identify issues that affected them at personal (e.g., cognitive issues), interpersonal (e.g., issues at home or school), and community levels (e.g., issues in one's neighborhood). Focus was placed on engaging students in conversations that enabled them to critically question how events took place in their communities. After identifying a social problem, students were encouraged to think about ways that an app could resolve the issue.

Creating context relevant apps: In the final block, students created mobile apps for the problem identified. The process began with paper-prototyping, where students selected AI components they wanted to use in their design and sketched their app screens on paper. The prototypes were then reviewed for their feasibility by the instructors and peers. Once reviewed, students began programming the apps. Additional app cards were provided based on each team's needs. Students tested their apps and revised them based on feedback they received from prospective app users. Final apps were presented through poster presentations that included descriptions of the social problem, app solution, and limitations of the app.

Participants and data collection

In this pilot study, we worked with 13 middle school 7th-grade students. Six students were girls and seven were boys. All students had little or no programming experience. Students worked in pairs except for one team where a student had to drop out due to personal reasons. Semi-structured exit interviews that were focused on capturing student learning, served as the primary data source for this study. Student's poster presentations and mobile applications served as secondary sources of data. Responses from interviews were coded by two researchers (first two authors) for two pre-set codes–learner's selection of the social problem, and the development of an agency mindset. Interview questions which probed for descriptions of mobile apps and selection of context relevant issues were triangulated with ratings provided by participants on the general usability of each team's app to determine the relevance of social problems selected by participants (research question 1). In addition, each mobile app was checked for its functionality by the researchers. To analyze the development of an agency mindset among participants (research question 2), participant responses to the following interview question was analyzed, "*Has the way you understand technology or the way you perceive issues that affect people around you changed as a result of participating in this course?* The analysis revealed three emergent themes: (a) Change in student perceptions about being capable of creating technology for social good; (b) Increased awareness of the role one plays in contributing to social issues; and (c) Perceptions of technology as a way to advance one's creativity.

Findings

Artifacts created and social problems selected

Out of 13 students, 11 were able to create fully functioning mobile apps that catered to various social problems in their environment. Students created apps to address issues of nutrition, fitness, energy consumption, recycling pollution, and distraction. Out of seven apps created, six apps directly addressed various issues in the learner's'

context and one did not (i.e., *RealCreatureFinder* app). Table 1 shows students' descriptions of their apps along with their environmental usability and motivation behind selecting the issue.

Table 1: Description of student's apps along with team member's motivation behind selecting the social issue

(Title) Issue	App Solution	Motivation
(Weightless) Students are bullied due to their weight and appearance.	The app provides a diet and workout plan along with videos of workout sessions based on the selection of time period within which he/she would like to see the desired months.	"*Well, I know a lot of people who would like to loose weight and who get made of and have a lot of anxiety dieting and stuff because of their weight and their appearance because people get bullied on how, how fat they are or how skinny they are in school.*"
(PAS) Students aren't aware of the food being served at school and waste food when they pack food from home.	The app allows users to access and view the breakfast and lunch menu served at school and displays the nutritional value of selected items.	"*Some kids may like some lunches and not like other lunches and they may want to save some food by not bringing lunch everyday to school if they know the lunch being served that day.*"
(No time to play) Students are easily distracted when they log in to complete their home assignments.	Users can log into any online resource assigned by school to complete their assignments for a set time. Once the time is completed, the app makes a celebratory noise and displays, "You have done it!"	"*Usually when I do my homework I usually get distracted so most of the time I never get my homework done on time. So I just thought making an app would help me, help other people like me who get distracted when doing homework.*"
(Energy) Unmonitored usage of appliances results in energy wastage.	The user can record the time spent on various appliances and generate an electricity bill based on usage.	"*A lot of people wanted to do air pollution and water pollution and stuff like that. But not a lot of people look at electricity and say that is a problem.*"
(Pollution) Children aren't aware of the harmful effects of pollution.	The provides users with animated videos that explain the long-term and short-term dangers of using pollutants.	"*We can always see trash when there is a trash can like right next to it. People are the main source of pollution and I think if you…raise awareness around it then people will try to stop it more."*
(RealCreatureFinder) There is a lack of creativity among adults and teens.	The app allows users to summon various mythical creatures by using spells. Each of the characters have separate screens with detailed information about them.	"*We have an obsession with unicorns and other mythical creatures so we decided to make an app about it.*"
(TrashBro) Students have only limited knowledge about recycling.	The app provides information on various kinds of trash. It has a game that sorts' random trash correctly into 'recycle', 'compost', and 'trash' bins.	"*I have trouble recycling, like at home, when I use a tissue I throw it into the recycling, but I found out it can't go into recycling. This way I learned more about it which will make the environment cleaner.*"

The degree of usability varied with the apps. Among the apps created, No time to play and PAS resonated most highly with participants in terms of usability. Out of 13 students, seven stated that they would use the No time to play app as it helped them deal with the issue of getting distracted while doing assignments online. Six students stated that they were more likely to use PAS because the app provided a way for them to track the lunch being served at school, which helped them decide whether or not to bring lunch from home. About the apps that dealt with social problems at a community level (i.e., the Energy app and Pollution apps), five students stated that although they found the apps to be a good solution to relevant issues such as energy wastage and recycling, they did not see themselves using the app. Eleven students rated RealCreatureFinder as a non-useful app. The reasons included the impracticality of the app, as 'those creatures don't exist' (seven out of eleven students) and the inefficiency of the app in addressing the 'issue of enhancing imagination' (four out of eleven students). The analysis of post interviews indicated the significant role self-expression played in identifying app ideas. Eleven students said that they were motivated to pick a social problem that they or their friends had experienced at home or their school. While two students mentioned that they wanted to create an app that aligned more with their interests with less focus on addressing a social problem. The developers of the *RealCreatureFinder* app decided to pursue the topic that appealed more to their personal interest when a conflict arose between picking a relevant social problem over a topic that was more interesting to them (i.e., unicorns).

Development of an agency mindset: Perceiving self as a "doer of science"

The majority of participants were able to create a link between using the knowledge of programming and taking action to address social issues. Ten out of 13 students mentioned that learning how to program mobile apps helped them see how they were capable of creating technology that was useful to their environment while two motioned that it helped them to think of ways to advance their creativity. The developer of the Energy app

commented, “Before this class, I was just seeing technology as a place where one could do many things but when I came to this class I learned what I can actually do with technology to better the world.” A developer of the TrashBro app stated, “In science class, we learn about science and technology. We have brief descriptions of pollution and atoms and less of technology. In this class I see technology enables us to interact with science and now I can make my own app.” The remaining three students mentioned that the class helped them think critically about how their actions added to some of the issues they selected in class. A developer of the Pollution app commented, “I feel like I shouldn’t waste stuff more, before, like when I go for dinner, because I spend all of my time in that room and then when my mom calls me down for dinner I used to just leave my light on and computer till I come back, but then I turn it off so that I don't waste power now.” Overall, the analyses of student experiences show that while a majority of participants were able to critically think of ways in which they could create technology for social good, some were able to reflect on how their daily actions might be altered to address social problems.

Discussion

The study analyzed the potential for integrating the knowledge of programming with SPS to enhance the science agency among middle school students. Our findings suggest that enabling students to create socially relevant mobile applications can be a precursor to developing an action-oriented mindset. Majority of students reported enhanced awareness in terms of being capable of developing technology for social good as a result of engaging in the curriculum. These findings suggest a way to address the challenge of creating a link between conceptual knowledge of social issues and taking action at a community or individual level among learners (Buxton, 2010; McNeill & Vaughn, 2012). The reported changes in student perception of technology being used for social good also suggests a powerful way to introduce programming to promote computational perspectives – perceiving programming as a tool to create artifacts of value to oneself and others among middle school learners (Brennan & Resnick, 2012). Studies have shown that the extent to which students perceive an issue to be personally relevant influences their decision to take an action to impact an issue (Skamp et al., 2004). The majority of students were not only able to successfully select issues that were personally relevant by using the SPS framework but were also able to create apps that appealed to the interest of other users. However, our findings suggest that if a conflict of interest rises between personal interests and picking a social problem that may not be personally relevant, the learner is less likely to engage in taking action.

References

Basu, S. J., Calabrese Barton, A., Clairmont, N., & Locke, D. (2009). Developing a framework for critical science agency through case study in a conceptual physics context. Cultural Studies of Science Education, 4(2), 345–371.

Brennan, K., & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. *Annual American Educational Research Association Meeting, Vancouver, BC, Canada,* 1–25.

Buxton, C. A. (2010). Social problem solving through science: An approach to critical, place-based, science teaching and learning. *Equity & excellence in education, 43*(1), 120-135.

Chang, E. C., D'Zurilla, T. J., & Sanna, L. J. (2004). *Social problem solving: Theory, research, and training*. American Psychological Association.

D'Zurilla, T. J., & Nezu, A. M. (1999). Problem-solving therapy: A social competence approach to clinical intervention. Springer Publishing Company.

Grover, S., & Pea, R. (2013, March). Using a discourse-intensive pedagogy and android's app inventor for introducing computational concepts to middle school students. In *Proceeding of the 44th ACM technical symposium on Computer science education* (pp. 723-728). ACM.

Kumar, D. (2014). Digital playgrounds for early computing education. *ACM Inroads*, *5*(1), 20-21. McNeill, K. L., & Vaughn, M. H. (2012). Urban High School Students’ Critical Science Agency: Conceptual Understandings and Environmental Actions Around Climate Change. *Research in Science Education*, *42*(2), 373–399.

Repenning, A., Webb, D. C., Koh, K., Nickerson, H., Miller, S. B., Brand, C., & HerManyHorses, I. (2015). Scalable Game Design: A strategy to bring systemic Computer Science Education to schools through game design and simulation creation. *ACM Transactions on Computing Education*, *15*(2), 1–31.

Skamp, K., Boyes, E., & Stanisstreet, M. (2004). Students' ideas and attitudes about air quality. *Research in Science Education*, *34*(3), 313-342.

Wolber, D., Abelson, H., & Friedman, M. (2015). Democratizing Computing with APP Inventor. *ACM SIGMOBILE Mobile Computing and Communications Review*, *18*(4), 53–58.