THE BESSIE COLEMAN PROJECT: USING COMPUTER MODELING AND FLIGHT SIMULATION IN INFORMAL STEM SETTINGS

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Abstract. This research report presents the pilot-year results of a three-year research project on computer science and technology. The Bessie Coleman Project, named for the first African-American and Native woman to receive a pilot's license, provides underrepresented students with opportunities to learn about STEM-related careers by participating in computer modeling and flight simulation. Three-dimensional computer modeling and flight simulation was used as interventions to increase underrepresented students' CT skills, motivation, and persistence. Project staff and facilitators at Boys and Girls Clubs and local schools implemented the project at six sites in Wyoming in 2018. A total of 124 participated in the pilot study: 29 (summer); 95 (fall). Descriptive evidence from survey data suggest that students had sustained interest in technology and qualitative data suggest students had interest in STEM careers.

Keywords: Computer Modeling, Flight Simulation, Computer Science, Technology

The Bessie Coleman Project (BCP) is designed to expand learning opportunities for elementary and middle grade students in the Rocky Mountain (Wyoming and Denver, Colorado) and Mid-Atlantic regions of the U.S. (Philadelphia and Baltimore) by leveraging Universal Design for Learning principles and strategies. It incorporates lessons and activities in 3D modeling, flight simulation, and piloting drones which are designed to bolster students' interest and engagement in mathematics and science learning. Indeed, the overarching purpose of the project is to create new STEM Pathways that provide unique learning opportunities for underrepresented students.

The work of the BCP involves research and development of cutting-edge professional development for teachers that is connected to culturally relevant learning activities for students. This report describes our Year 1 pilot, which allowed the research team to field test the intervention in two different types of informal settings: summer camps and afterschool programs. In this project, we engage students in project-based learning through computer modeling (i.e., upper-elementary students) and flight simulation (i.e., middle-school students) as an entrée to STEM and STEM awareness. Using computer modeling to help children learn to code (grades 4-5) and flight simulation with applications to learn how to use drones for data collection (grades 6-8) builds new knowledge and understandings of complex systems and contributes to the extant literature on STEM education and workforce readiness.

Two of the core research questions that guide the BCP project are:

1. What learning experiences involving emerging technologies (i.e., computer modeling, flight simulations, and drones) effectively enable diverse populations of students to gain familiarity and relevant competencies with these technologies, and what factors influence the outcomes of the learning experiences?
2. What culturally-responsive instructional and curricular practices and models (including place-based education) used by teachers enhance student understanding of and interest in STEM occupations, and what factors influence the outcomes of the practices and models?

Theoretical Framework

The theoretical frameworks that guide **The Bessie Coleman Project** are **Constructionism** (Papert & Harel, 1991) and **Expectancy-Value Theory** (Wigfield, 1994; Wigfield & Eccles, 2000). Constructionism focuses on students' ability to *build knowledge structures* regardless of the learning environment (Papert & Harel, 1991). In this context, the learner has a great deal of autonomy as he/she is guided by the work that proceeds rather than a protocol. The concept allows students to be active learners as they *think* about ideas, investigate that idea, discuss it with peers, and make adaptations within a complex system. The constructionist principle is well suited for teaching computer modeling and flight simulation since students learn to construct various types of models while using a project-based approach. In terms of Expectancy-Value, theorists argue that "individuals' choice, persistence, and performance can be explained by their beliefs about how well they do on [an] activity and the extent to which they value the activity" (Wigfield & Eccles, 2000, p. 68). The expectancy-value framework has been applied to the subject of mathematics and can be adapted to technology. The value a student puts on a subject or task is predictive of future intentions to participate in similar tasks (e.g., enroll in courses, pursue careers, etc.) While self-efficacy measures students' beliefs about success on very specific tasks, expectancy beliefs are measured more broadly with questions such as "How well would you expect to do if you had to learn something new about…" a given topic. Assessing ability-beliefs and values among rural and urban, African-American, Latinx, Native, and female students will add to the literature on broadening participation in STEM.

Methodology

Mixed methods (i.e., field notes, interviews, photographs, and videotapes) were used to collect qualitative data on the nuances of culture and place in after-school clubs and summer camps (Creswell, 1998). One hundred twenty-four students participated in the BCP during summer and fall 2018. The size of the sites varied from seven to 47 students. Recruitment yielded levels of diversity that were somewhat more robust than the general population in Wyoming or the racial composition of school children. About 72% of the study sample were White students and 66% were males. Combined, about 18% of the sample were Black, Latinx, and Native students. More diverse students will participate in Years 2 and 3 in Colorado and Pennsylvania. Finally, most of the participants are elementary students (grades 3, 4, and 5), who were also younger than 11 years old.

Baseline and post-intervention surveys were administered to students, prior to the beginning of the intervention and afterwards. Project staff designed and administered paper surveys for student participants which, in addition to a section on student background characteristics, contained a battery of items in the following three areas: (1) participants' use of technology; (2) participants' feelings about science; and (3) participants' opinions about technology. The various components of the survey were pulled and adapted from instruments in the public domain, including value expectancy (Eccles & Wigfield, 2000), self-efficacy in technology and science (Ketelhut, 2010), and STEM attitudes (Friday Institute, 2012).

Results

Descriptive data from student participants at six intervention sites are presented. This brief report emphasizes the use of technology survey for analysis and discussion.

Students Self-Reports of STEM

Student survey items reflected self-reports of their use of technology. Descriptive statistics are shown for each item. This includes the number of cases, baseline means, and post-intervention means, along with the mean differences between the two. However, in order to more accurately measure gains, the fourth and fifth columns subtracts baseline values from post-intervention values for the same participant. The fourth column shows adjusted gains that have valid data at both time points, while the fifth column depicts the Ns. The purpose of the tables is to examine general patterns across the survey data, rather than to reveal significant differences. There were modest pre- to post-intervention gains on most items (see Table 1).

Qualitative data were also collected during the summer STEM camps on students' perceptions and experiences. To field test the intervention, flight simulation was implemented at a Boys & Girls Club in southeastern Wyoming and computer modeling was implemented at a Boys & Girls Club in western Wyoming. Student comments during a focus group interview included comments such as: "I liked how we could 3D print things and I have never…actually got to do that and do new things on the computer;" "I liked flight simulation;" and "I liked drones." Figure 1 depicts one of the student's designs during the computer modeling camp.

Discussion

Preliminary findings in the Bessie Coleman Project reveal that students gained familiarity and competencies with computer modeling and flight simulation, especially when modeling was tied to 3D printing and flight simulation was tied to flying drones. Students were enthralled as they saw the images they created on the computer come off the print bed. Moreover, they were intrigued with the capabilities of the drones. Mean differences on the use of technology survey items ranged from M= 0.07 to M=0.47. However, students had the lowest gains on how to use data to solve problems, building computer programs, designing computer games, and problem solving in general. Culturally relevant strategies included use of guest speakers and place-based themes (i.e., animal crossovers) to help Wyoming students decide what images to create during computer modeling tasks. Field trips to museums also provided cultural and place-based experiences that students identified during focus group interviews. While this project is ongoing, these preliminary results are promising. In future study years, we will use the drones to collect data to create additional problem-solving opportunities such as geocaching. Cultural relevance will also include the history of Black and female aviators in addition to guest speakers.

Tables and Figures

Table 1: Participants' *Use* of Technology

Variable		Baseline Mean	Post-Interv. Mean	Mean Diff	Adj Gain†	Adj N†
Q1.1	Even if I try very hard, I cannot use the computer as easily as paper and pencil	2.24	1.77	0.47*	*0.53**	*104*
Q1.2	I can use a computer to graph what I found out in my experiment	3.43	3.67	0.25	*0.24*	*103*
Q1.3	I can use a computer to help me know what the results of an experiment means	3.73	3.92	0.18	*0.20*	*103*
Q1.4	When I do an experiment, it is hard for me to figure out how the data I collected answers the question	2.43	2.36	0.07*	*0.09**	*102*

Variable		Baseline Mean	Post-Interv. Mean	Mean Diff	Adj Gain†	Adj N†
Q1.5	I am good at building computer programs	2.97	3.12	0.14	*0.16*	*96*
Q1.6	I am good at fixing computer programs	2.55	2.89	0.34	*0.41*	*102*
Q1.7	No matter how hard I try, I do not do well when playing computer games	1.74	1.47	0.27*	*0.31**	*104*
Q1.8	I am very good at building things in games	3.95	4.23	0.28	*0.31*	*104*
Q1.9	I can use a computer to control toys and tools	3.51	3.85	0.34	*0.39*	*102*
Q1.10	I can learn how to design a computer game if I do not give up	4.11	4.25	0.14	*0.13*	*103*
Q1.11	When solving a problem, I can create a list of steps to solve it	3.66	3.84	0.17	*0.20*	*99*
Q1.12	When solving a problem, I can see patterns in the problem	3.31	3.53	0.22	*0.23*	*102*
Q1.13	When solving a problem, I can break the problem into smaller parts	3.73	4.05	0.32	*0.35*	*102*
Q1.14	When doing an experiment, I can use a computer to help me collect data	3.87	4.14	0.27	*0.25*	*103*
Q1.15	When solving a problem, I can figure out several ways to solve it	3.73	3.88	0.15	*0.21*	*98*
Q1.16	When solving a problem, I can figure out what is the best solution	3.89	4.07	0.18	*0.22*	*104*

Response categories: 1=Strongly Disagree; 2=Disagree; 3=Somewhat; 4=Agree; 5=Strongly Agree
** Gain represents the absolute value since some items are negatively worded.*
†Adjusted values include only participants with valid non-missing data on both baseline and follow-up surveys.

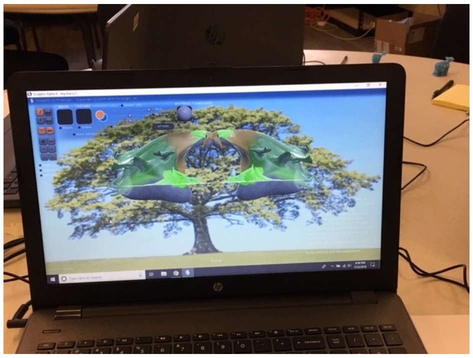

Figure 1: Computer Modeling Task

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