Paper ID #35674

Summer Engineering Education Program: Formal-Informal Model

Dr. Suzanne Keilson, Loyola University Maryland

Suzanne Keilson is a faculty member at Loyola University Maryland. Her background and degrees are in Applied Physics and her research interests include signal processing, biomedical and materials engineering, design and STEM education. She has served in administrative positions and has taught for the past twenty years, including in special cross-disciplinary first year programs. She is a frequent presenter at a variety of conferences and venues, is an active member of ASEE, the Mid-Atlantic section as well as ASME and IEEE.

Informal Engineering Education Summer Program: Beat The Streets Baltimore

ABSTRACT

Beat The Streets Baltimore is a program that combines sports with STEM content. The STEM segment was conducted for six weeks during the Summer of 2021. The program was held at Cherry Hill Elementary/Middle School and was for one hour (10 – 11 A.M.) Monday – Thursday. This allowed for 24 contact hours in person between the students and instructor. Students used their personal or school provided laptops to access materials in class. The coding environments were intentionally online, and web based to minimize complexity and the need to download software.

The six weeks were divided into two three-week segments. The first three-week segment introduced students to programming in both Python and Scratch formats. Python coding was introduced in the context of Computer Science Unplugged Programming challenges (www.csunplugged.org). This provided students with an introduction to binary numbers and command line text-based programming challenges that introduced them to fundamental concepts of computer science such as loops, conditionals, and data types. The students were then presented with a programming challenge in the Scratch platform. (www.scratch.mit.edu). They created their own accounts on this web-based platform and used 'drag and drop' and object (sprite) centered programming to create their own versions of the classic Pong game. At the end of the first three weeks students presented their programs to the group.

In the second three weeks students were provided with Arduino Uno development kits (https://www.arduino.cc/). They were introduced to the hardware of the Arduino microcontroller which included breadboarding with switches, resisters, potentiometers, LEDs, phototransisters, and an LCD screen. They completed or attempted eight different projects that were detailed in a projects book that accompanied the kits. This reinforced their exposure to software environments and fundamentals of programming as well as introducing them to the frustrations, care and patience required for breadboarding circuits. On the last day of the program, they again presented what they had accomplished and were asked to provide a 'lesson learned'. Most of the

lessons learned in both the first and second segment of this summer program focused on the need for care, attention to detail and the challenges of troubleshooting a project.

INTRODUCTION

The lack of representation of African American males in the STEM educational pipeline is a recognized ongoing problem for STEM higher education [1]. Research suggests that approaches which improve teacher-student relationships, provide meaningful learning, and develop community can improve student perceptions and engagement with STEM subjects. Beat the Streets Baltimore is a program that utilizes sport (wrestling) as an entry to engage Baltimore students both after school and in the summers with sport training, financial literacy, and STEM education. It is a non-profit youth development program that combines amateur wrestling with mentoring and academic development. The overarching aim is to enhance personal development, discipline, and sense of self-efficacy along with concrete skills and knowledge in areas relevant for overall career and life success. The summer STEM (and financial literacy) program draws primarily minority male students who are already high school athletes. The program typically enrolls 30 students between the ages of 14-18. All participants attend Baltimore City Public High Schools. The six-week summer program has elements of sport conditioning and competition, character development, financial literacy, and informal STEM learning. In reengaging with the community prior to the summer of 2021, families were surveyed about their interests in STEM content areas. The top draws were computers, programming, electronics, and robotics (as well as the components of financial literacy). It was felt to be especially important to engage and reengage the young men in the program after the year of virtual and co-vid learning with hands on and in person experiences. A site was located and secured, following Baltimore City Public Schools co-vid protocols, at Cherry Hill Elementary/Middle School. In addition, funding was secured for AmeriCorps VISTA volunteers to work with the students and for the students to receive their own summer funding from Baltimore City YouthWorks. Both of these components contributed significantly to the overall success of the program, and the recruitment and retention of participants. There were 20-30 high school students in the program. Attendance and completion of the program was variable, with perhaps a low attendance of 12 -15 on any given day. Although the structure of web based and browser-based materials was intended to make it possible for students to continue working on projects and home and participating in self-guided learning, this is a very rare occurrence. The same can be said for the traditional college students of the instructor who rarely have the confidence or undistracted time to go beyond or deeper in their studies as a personal endeavor. However, it is also clear that summer engagement is vital to prevent or slow the learning loss of summer. This is not so much the actual forgetting of fact and content as it is a slow degradation of motivation for learning unless it is externally supported. This was the first summer for the implementation of the STEM curriculum described here and so is very much a works-in-progress. By disseminating the details of the curriculum, it is hoped that dialogue, feedback, assessment, and improvement in engaging students with STEM, especially young minority men, will be promoted.

CURRICULUM

The STEM segment of Beat The Streets was conducted for six weeks during the Summer of 2021. The program was held at Cherry Hill Elementary/Middle School and was for one hour (10 – 11 A.M.) Monday – Thursday. Friday was reserved by the site as a deep cleaning day, required by co-vid protocols. Thus, this allowed for 24 contact hours in person between the students and instructor. Students used their personal or school provided laptops to access materials in class. The coding environments were intentionally online, and web based to minimize complexity and the need to download software. This also allows for the potential of easy access and additional time outside of in person class hours.

The six weeks were divided into two three-week segments. The basic curricular structure is illustrated in Table 1.

	Table 1. Basic Curriculum	
Week 1	Computer Science	Binary Numbers
Week 2	Python Programming	Scratch
Week 3	Scratch Project	First Presentation
Week 4	Electronical Engineering	Computers
Week 5	Arduino Projects	Arduino Projects
Week 6	Arduino Challenge	Second Presentation

The first three-week segment introduced students to programming in both Python and Scratch formats. Python coding was introduced in the context of Computer Science Unplugged Programming challenges (www.csunplugged.org). This provided students with an introduction to binary numbers and command line text-based programming challenges that introduced them to fundamental concepts of computer science such as loops, conditionals, and data types. The students were then presented with a programming challenge in the Scratch platform. (www.scratch.mit.edu). They created their own accounts on this web-based platform and used 'drag and drop' and object (sprite) centered programming to create their own versions of the classic Pong game. At the end of the first three weeks students presented their Pong game programs to the group. They were also asked to provide insights into troubleshooting and their own 'big idea' learning. As might be expected, the majority of the comments were about the meticulous and unforgiving nature of computer programming. An informal observation by the instructor is that students had good skills of mimicking or copying example code, but it was not clear how much deep learning was achieved. This is a general challenge in the assessment of student learning, one that can be akin to questions in artificial intelligence or machine learning about the nature of conscious understanding. However, one of the goals of the program is to excite in students a vision of how they can see themselves and their futures and in that it is reasonable to hope that this exposure to programming and discussion of software in society and careers will be what students retain for a long time.

In the second three weeks students were provided with Arduino Uno development kits (https://www.arduino.cc/). They were introduced to the hardware of the Arduino microcontroller which included breadboarding with switches, resistors, potentiometers, LEDs, phototransistors, and an LCD screen. They completed or attempted eight different projects that were detailed in a projects book that accompanied the kits. This reinforced their exposure to software environments and fundamentals of programming as well as introducing them to the frustrations, care and patience required for breadboarding circuits. On the last day of the program, they again presented what they had accomplished and were asked to provide a 'lesson learned'. The prompt was broad, suggesting that a lesson learned could be about what they enjoyed, learned about themselves, or what frustrated them. The general framework for such reflection is the three questions of what went right, what went wrong, and what might be done differently. Most of the lessons learned again focused on the need for care, attention to detail and the challenges of troubleshooting a project. The question of troubleshooting a project is an interesting one that does not seem to be much researched in educational literature. The logical chain of deduction about where to look for problems, what to check first, is often a matter of implicit understanding and heuristic rules developed through experience. It would be useful to have an explicit set of rules and experiences to pass on to students. For example, it was at first a humorous comment to try turning the computer off and on again, but one that turned out to solve problems a significant fraction of the time. It was observed that some students dealt with those frustrations of non-functioning hardware or software by giving up, becoming passive and simply awaiting help. We need to provide more environments where young people can explore and even play with the physical world without fear of damaging expensive items. The reasons or the passivity or hesitance are not clear, but it is common among many high school and college age students being exposed to STEM topics. Many do not have the exposure that we assume they may. They are digital natives only in the narrowest sense as consumers of social media but without a good mental model of the underlying technology. It is that mental model of how a system operates that is a central implicit part of effective troubleshooting. If one does not have a theory of how something is put together and what its mechanisms are, it is difficult to mentally walk through the system and think about where things may be broken. Experience may teach which components are most vulnerable to damage, but an overall mental model of the system is required as well.

CONCLUSION

The range of achievement among the students and groups was broad. One group was able to successfully complete the projects in both hardware and software while other students had difficulty with either implementing the code or learning to breadboard a circuit. Approximately 15 kits were purchased for a class of 30 at a cost of approximately $1500. This was the main supply cost. All of the other costs for the STEM portion of the program were primarily labor related. If such a program is offered over several years, the main Arduino kit can be reused, though there will be minor replacement costs for some of the consumables (lost or damaged electronic components).

The instructor found that the primary goals that can be achieved in such an informal educational setting are ones related to identity formation and self-efficacy. That is, not to expect the students to take away specific knowledge or understanding of circuits or programming, but to develop their general confidence as well as self-conception as a potential member of the STEM community of practice. Secondary achievable goals are to provide students with an understanding of the relevance of their academic studies and optimism in addressing challenges, personal and societal. A love of learning and STEM inherent in and of itself is worthwhile to inculcate but may be paired with presentation and discussion of pragmatic career possibilities. Reiterating those ideas can shift expectations and attitudes, which in turn can reinforce motivation and discipline. This report presents the basic outline of the curriculum for the six-week program with limited in person hours of contact. The informal observations suggest a few avenues for assessing the efficacy of the program and improving its outcomes. It is also anticipated that with the established of this curriculum and program structure the next steps would involve more formal qualitative and quantitative assessments of impact.

REFERENCES

[1] S. T. &. D. J. Coleman, "Using asset-based pedagogy to facilitate STEM learning, engagement, and motivation for Black middle school boys," *Journal of African American Males in Education (JAAME),* vol. 11, no. 2, pp. 76-94, 2020.