Work-In-Progress: Hands-on Activities to Improve Student Engagement and Learning in an Introductory Programming Course

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Introduction

Engineering students often struggle making connections between programming and physical applications. Hands-on activities have been implemented to varying degrees at other institutions to improve student success in introductory programming courses [1]. The aims of this research are to investigate the following questions: (1) how do hands-on activities influence students' interest in computer programming, (2) do hands-on activities influence students' understanding of specifically targeted programming concepts, and (3) does a students' interest, confidence, and understanding in translating code into a different programming language change after experiencing these hands-on programming activities?

Methodology

Three physical, hands-on activities were integrated into an introductory programming course at West Virginia University in Morgantown, WV, USA. 97 students fully completed all hands-on activities and the associated surveys developed for the course. These activities take place at the end of the semester and include a simulated home security system, an object/candy sorter based on color, and an obstacle-avoiding robot. Matlab is the primary language used in this course and Arduino is briefly taught at the end of the semester and is used specifically for these activities. This paper presents the preliminary results of a mixed-method approach in which two surveys were administered to all students completing the course, one before and one after the hands-on activities. Likert and open-ended questions were developed to evaluate how hands-on activities influenced student interest in, confidence in skills related to, and knowledge of programming. Information was collected in the Spring 2024 semester and will continue to be collected in future semesters, as new activities are developed. Students were required to complete both surveys for course homework credit. The surveys were approved by the Institutional Review Board (IRB).

Results

Students were asked to rate their interest, knowledge, understanding, and confidence in areas relating to general programming, specific programming structures, physical (hands-on) programming applications, as well as applying programming skills to new problems and new languages before and after three physical (hands-on) programming activities. The average results of their responses are shown in Figure 1. Each of the questions was a Likert scale response from 0 to 5, where 5 indicates the highest level of interest, knowledge, understanding or confidence. Figure 2 shows the differences between the average response before and after the physical (hands-on) programming activities. Note that all of these are positive, indicating that the average response after the activities was higher than the average response before the activities. These were also sorted from highest to lowest difference from left to right in this Figure. Three "Yes", "Maybe", or "No" questions (see the results in Figure 3) were also asked, as follows:

Question 1 - Do you see yourself using a programming language in your career?
Question 2 - Are you interested in using a programming language in your career?
Question 3 - Are you interested in using a programming language in your personal life?

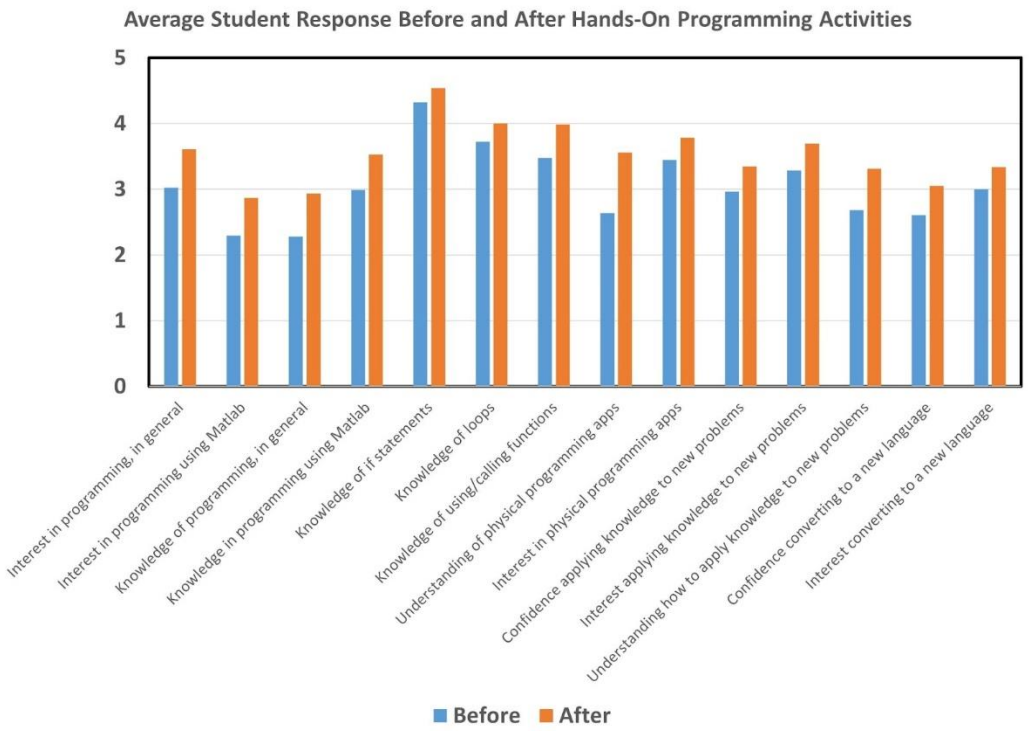

Figure 1: Average Student Likert Scale Responses Before and After Physical (Hands-On) Programming Activities

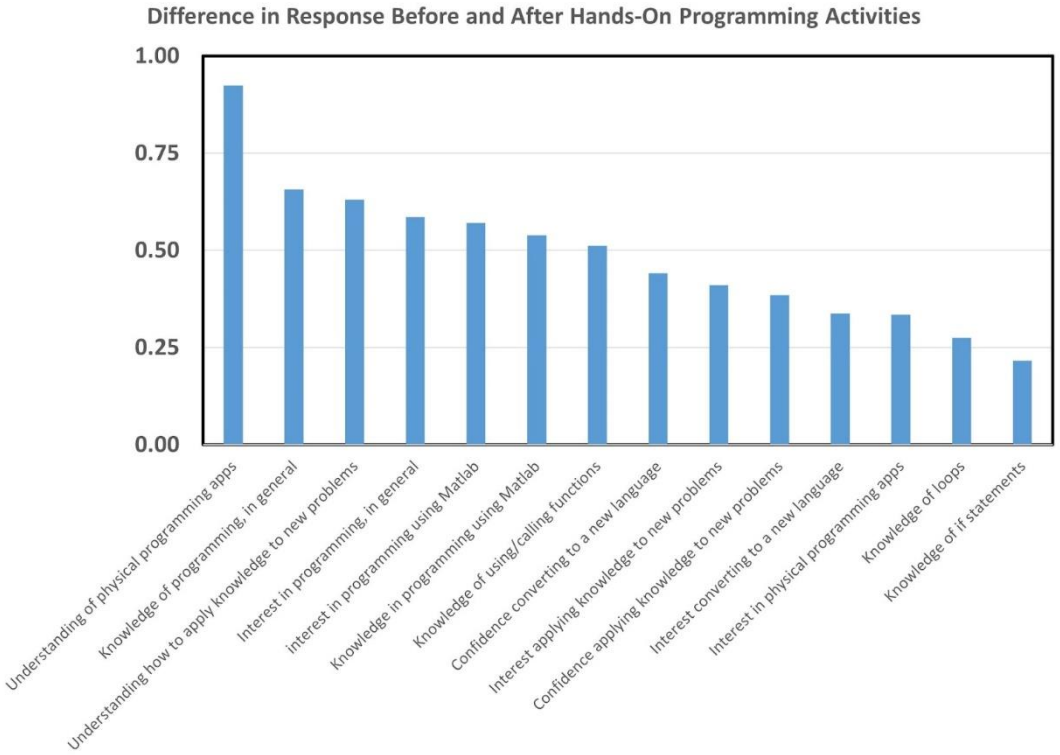

Figure 2: Difference in Likert Scale Response Before and After Physical (Hands-On) Programming Activities

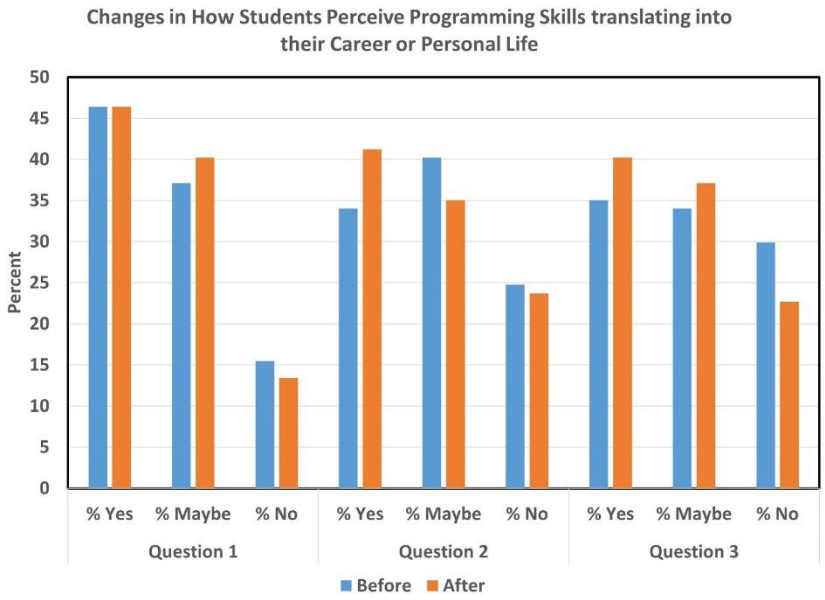

Figure 3: Changes in How Students Perceive Programming Skills translating into their Career or Personal Life

Discussion

Results show positive student responses to all Likert response questions comparing the pre- and post-survey results. As can be seen in Figure 1, all the 'after' (orange) columns are higher than the 'before' (blue) columns. In Figure 2, the difference in Likert scale responses before and after the activities shows that student understanding of programming applications, general programming knowledge, and understanding of how to apply knowledge to new problems had the greatest increases. This is what the authors hoped for but is reassuring to see in the preliminary data. Figure 3 also gives insight into the positive impact of these activities on student perception. According to Figure 3, the percentage of students interested in using a programming language in their career (Question 2) and in their personal life (Question 3) increased because of these hands-on experiences.

Conclusions

Programming courses can be challenging for students with no prior experience and allowing them to make connections between their code and physical applications can be impactful. It has been shown that the activities developed as part of this research can make a positive impact on student interest in programming, understanding of concepts, interest, confidence, and understanding of translating programming knowledge from one language to another, and their perceptions of translating skills into their career and personal life. The authors intend to develop hands-on activities involving the use of Matlab and Python in future semesters. In the future, the authors also intend to compare these results to trends in the literature and perform a statistical analysis using a t-test on pre- and post-survey data to evaluate the impact of these activities. These hands-on activities could be used by institutions not currently implementing these types of activities in introductory programming courses to improve student engagement and learning.

Reference

[1] R. Whalen and J. L. Hertz, “What to Teach First, Hardware or Software? Improving Success in Introductory Programming Courses,” *Paper presented at 2023 ASEE Annual Conference & Exposition, Baltimore, Maryland. 10.18260/1-2--44620, June 2023.*