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Description:

Fostering high school students' interest in hardware computing is crucial due to the industry's workforce shortage. Our study aimed to cultivate interest through an inclusive, hands-on curriculum integrating circuit simulations, FPGAs, and collaborative projects. We conducted a six-week seminar with six senior high school students, assessing their interest development through surveys and focus groups. Results showed a transition from triggered situational interest to a more sustained form.

Engaging diverse high school students in immersive learning experiences to encourage interest in hardware engineering

A matter of national security for the US is supporting the development of the semiconductor and microchip workforce to address the chip shortage and its negative consequences on the US economy. Higher education institutions are establishing programs to train the necessary workforce and address the CHIPS Act passed by the US legislature in 2022. However, high school students interested in computer engineering often fail to consider the hardware aspects of the field and opt for degrees centered around software.

To address this issue, we have undertaken a project funded by the NSF IUSE program to develop a curriculum that prioritizes meaningful and inclusive learning experiences. This curriculum integrates innovative, hands-on, technology-enhanced collaborative learning methods, with a specific focus on computing hardware fundamentals. The aim is to cultivate both situational and individual interest in computer hardware and cater to the diverse needs of students. Ultimately, our objective is to contribute to the development of a highly skilled computer hardware workforce in the US. Informed by these objectives, our study was guided by the following research questions: (1) How do inclusive hands-on activities impact high school students' situational interest in computer hardware engineering in a 6-week summer seminar? and (2) How do inclusive, hands-on activities impact high school students' individual interest in computer hardware engineering in a 6-week summer seminar?

Theoretical Background

Renninger and Hidi (2016) framed the concept of interest as a dynamic interplay between an individual's engagement with a particular content and their enduring motivation to engage with it over time. Since interest evolves over time, researchers commonly differentiate between situational interest, which is short-termed and influenced by external factors, and individual or personal interest, which is intrinsic and long-lasting (Romine et al., 2014).

Drawing from these two distinct forms of interest, Hidi and Renninger (2006) proposed a four-phase model of interest development depicted in Figure 1. In this study, our focus lies in understanding whether and how hands-on activities initiate situational interest and the factors that facilitate the transition towards a more enduring individual interest.

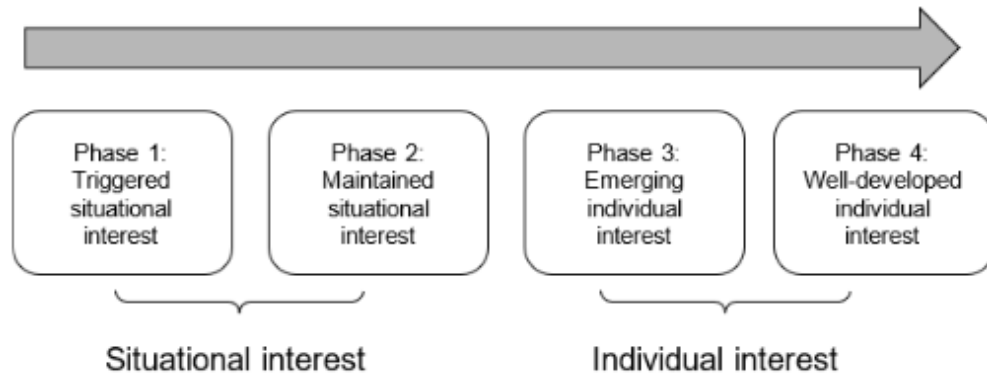


Figure 1. Interest development model

Methods

Study context and participants

The study included high school seniors in an honors seminar during a summer residential program at a large southeastern R1 institution. The seminar met twice weekly for ninety-minute sessions over six weeks. Ten students participated, with six, including two girls and four boys, giving informed consent. These students came from different high schools across the United States.

Instructional module

Traditionally, hardware principles have been taught through lecture-based methods, where instructors deliver information in a one-way manner (Helps, 2015). Yet, there's increasing recognition of the necessity for an inclusive, immersive, hands-on approach, particularly to aid diverse students in understanding and applying hardware design concepts in real-world situations (Ackovska & Ristov, 2013; Rotgans & Schmidt, 2011). Hence, our approach integrates Universal Design for Learning (UDL) principles and Culturally Responsive Pedagogies (CRP) within an inquiry-based, experiential framework, using educational tools like Field Programmable Field Arrays (FPGAs) and digital circuit simulations.

FPGAs, shown in Figure 2 – left, are versatile integrated circuits ideal for learning computer architecture. Although powerful as educational tools, FPGAs might hinder basic understanding of circuits and microchips. To address this, we added interactive digital circuit simulation activities using the web-based platform Tinkercad (Figure 2 – right). Additionally, students completed an open-ended project solving real-world problems tied to their culture, implemented with FPGAs. Our objective is to enhance interest and engagement by offering diverse means of representation and expression, taking into account students' cultural backgrounds to meet their varied needs. During the AECT presentation, we will engage the audience by highlighting the breadth and specifics of the FPGA and digital circuit simulation activities.

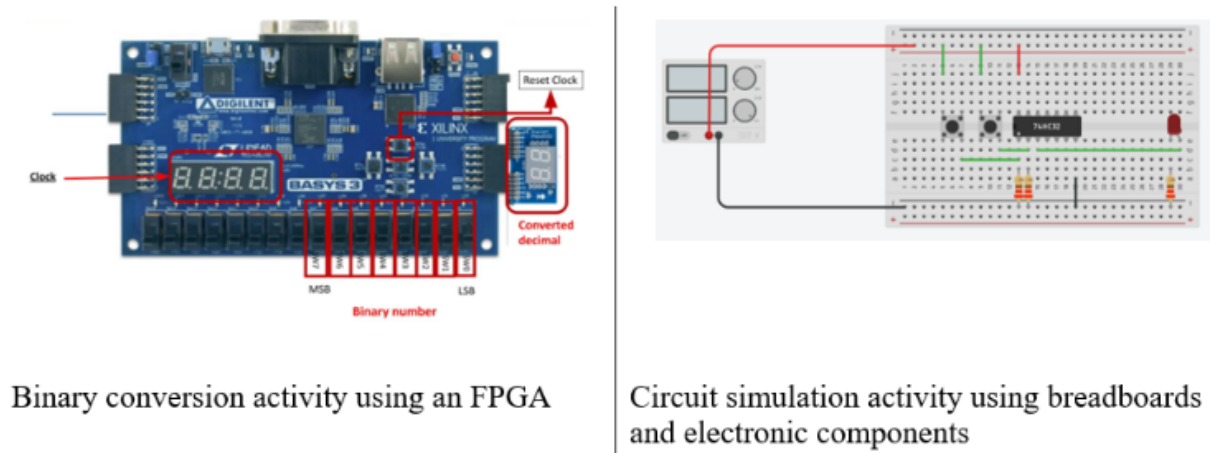


Figure 2. Hands-on activities

Measures and data sources

Students participated in a semi-structured focus group at the end of the seminar. The focus group protocol was designed to explore students' perceptions of the activities and whether they triggered **situational interest**. The participants' responses were coded using an a-priori codebook developed based on the learner characteristics, feedback wants, and feedback needs outlined by Renninger (2009) in the first two phases of interest development (Hidi & Renninger, 2006).

To explore **individual interest**, we adapted Romine et al.'s (2014) instrument to measure Student Interest in Technology and Science (SITS), specifically to understand students' ideas about learning, careers in science and technology, and computer engineering. Participants completed the same survey pre- and post-seminar.

Results and Discussion

Situational interest

The qualitative coding of the focus group transcriptions indicates that students showed signs of moving from triggered situational interest to a more lasting state of situational interest. For instance, one participant stated, "I'm interested in engineering. And so like, there's definitely lots of different things in FPGAs that can be used for in engineering. So it is relevant to what I want to do." This quote exemplifies the progression observed, as the student's interest transformed from character identification to a sustained personal engagement (Renninger, 2009).

Individual interest

Because of the small sample size, we opted not to perform inferential statistical analyses of the survey data. Instead, we utilized descriptive statistics, which indicated that the six-week seminar increased participants' overall individual interest. The results for ideas about careers and computer hardware portrayed the greatest increase between pre and post. This finding indicates that the hands-on activities with FPGA boards and simulated circuits may be an effective approach for improving students' inclination to pursue further studies in hardware-related topics.

During the AECT presentation, we will delve into the qualitative findings and descriptive statistics from the survey to further engage the audience.

Significance

With industry and government urging greater student involvement in hardware development and manufacturing, effective strategies are vital. This study's findings reveal that immersive, hands-on experiences—incorporating educational tools like FPGAs and digital circuit simulations, along with culturally relevant real-world projects—significantly enhance diverse students' interest in computer hardware engineering. Future research should delve into the longitudinal evolution of interest development and identify methods to offer continuous support to students aspiring to enter the engineering field.