

## **Board 304: HighSchoolers' Understanding about "Engineering" and Their Perception of the Coding-Engineering Relationship**

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In this poster, we report about a study which was conducted during the implementation of an ongoing project entitled "Building a Youth-Led Learning Community through Automating Hydroponic Systems" funded by the NSF-ITEST program. Historically, engineering is rarely taught in K12 school settings; and when it is offered, it is usually only in more affluent school districts as a separate elective course. This approach, unfortunately, has led to engineering not being seen as an integrated part of a traditional K12 science curriculum [1]. Consequently, many students, even at the high-school level, possess a relatively naive understanding of "Engineering". For instance, many middle and high schools lack separate "Engineering" classes, leading teachers to embed the concepts of engineering within existing science classes. This situation often leads students to see engineering as an isolated discipline rather than an interdisciplinary one that draws upon concepts, skills, and ideas across the science and technology spectrum.

In this interdisciplinary project, high-schoolers and middle-schoolers participated in a week-long vacation camp in February 2022, where they learned block-based coding using Micro:bit, built a table-top automated greenhouse, used different sensors to gather environmental data, and then used these data to control different aspects of the greenhouse to keep plants healthy. Additionally, they learned fabrication techniques such as 3D printing and laser cutting/engraving, which were applied in the greenhouse setup. Thus, the students got exposed to the physical computing aspects of coding and also gained hands-on experience on engineering. Within this context, we wanted to investigate what kind of understanding the incoming high-school students had about the term "Engineering". Furthermore, we wanted to see whether (and how) those students associated coding with engineering. Since our intervention primarily focused on coding with a minor engineering component, we chose not to assess the change in their understanding of "Engineering" following the camp.

In some previous studies in the context of "Engineering-focused" programs, where most of the participating students possibly had existing interests in engineering to sign-up, it has been found that those students usually associate engineering with objects. For example, in some other settings, students associated "Engineering" with "building and improving objects" [2], or with "improve, develop, design, and create" [3], or with "making or creating, technology, and machines" [4]. In one study, it was found that a significantly higher number of senior engineering students compared to first-year students showed more interest in improving the quality of life and preserving the environment [5]. As high school students are closer in age to first-year undergraduates, we wanted to examine the understanding of "Engineering" among the high schoolers attending our camp, which was not advertised as an engineering-based program.

Twenty-Five (25) high-schoolers participated in this camp at a Middle School situated in a semi-urban area in the North-East part of the US. We collected responses from fourteen (14) high-schoolers in a pre-interview session after procuring informed consent and assent from them. During the interviews, among other questions, we asked one set of questions concerning how the students understood the term "Engineering" and whether/how they acted as an engineer in their daily lives. We decided not to conduct the post-interviews as we felt that asking the same set of

questions after just five days may feel a bit redundant to the participating students, and may not provide useful insights because of the short intervention period.

Afterwards, we transcribed interviews of the students and extracted the responses related to engineering and coding from the transcripts for further analysis. Two researchers analyzed the utterances of the students separately and did the initial level of coding. After comparing initial findings, we decided that the responses could be divided into two major criteria: “Associating Engineering with Objects” and “Associating Engineering with People”. Whenever students talked about building, fixing, constructing, improving, innovations, or used similar words, we considered that as “Associating Engineering with Objects”. Otherwise, when students talked about problem solving, helping people, making the world or the environment better, or being a leader or planner, we considered that as “Associating Engineering with People”.

From our analysis, we have found that among 14 high-schoolers that we interviewed, five students associated engineering only with “Objects”, two students associated engineering only with “People”, and six students associated engineering both with “Objects” and “People”. One remaining student shared her unfamiliarity with the word “Engineering”, and her response could not be categorized into any of the available ones. Two students specifically talked about making the world and the environment better. For instance, one student said: “I think engineers, they make plans to build stuff so that they could be better for the environment sometime.” Another student remarked: “I’m pretty sure that they (Engineers) come up with a lot of solutions to problems in the world.” Among 14 students, only two students explicitly associated coding with engineering, and another student mentioned “program”, which can be considered as associating coding with engineering. When asked about engineers, a student’s response was: “...maybe it’s someone that, all that stuff of coding, and like, fix computers or things that has [*sic*] to do something with computers.”

From the results, it can be said that the high-schoolers who signed up for our program, who were not necessarily engineering-focused, had a slightly greater or almost similar tendency of seeing engineering as a more hybrid concept of both object- and people-centric, compared to seeing engineering just as object-centric. Another important aspect is that students did not associate coding as one of the ways of engineering, and many of them showed preconceived notions of associating engineering only with building or improving physical objects. These findings suggest that we need to find out how to support youth in better understanding how engineers can use coding and other computational tools to conduct their work. Though our sample size was small, our findings provide data on how high-schoolers within our research context understand about “Engineering”. More studies across different contexts may provide better insights to provide a broader understanding of high-school students’ conceptions and beliefs about engineering.

## **Acknowledgement**

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