Value of Informal Learning Environments for Students Engaged in Engineering Design

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ABSTRACT

A focus group study was conducted with purposefully sampled student participants solving an engineering design challenge during a one-week engineering summer camp held at a research-intensive university in the southeast. The goal of the study was to further understand the student experience and ascertain the perceived value of an informal learning environment for students engaged in an engineering design challenge. Emergent themes are provided to illustrate the primary challenges related to the engineering design challenge and the aspects of the engineering summer camp that were beneficial to the student participants. It is anticipated that the results of this study will constructively add to the literature on learning and teaching in engineering design across informal and formal learning environments.

Keywords: informal learning environments, engineering design, focus group studies

INTRODUCTION

Education in the Science, Technology, Engineering, and Mathematics (STEM) fields has many economic and national security implications, making the issue of STEM education reform and access one of national concern (Kuenzi, 2008). At the forefront of this reformation is the need to attract a larger and more diverse student population to STEM fields (Chubin, 2005). The challenge of meeting the nation's demands for increased diversity is exacerbated by the inability of formal learning environments to introduce underrepresented students to STEM professions (Denson, 2012). This highlights the importance of informal learning environments and Martin (2004) suggests informal settings will be instrumental in the reformation of STEM education. Currently, there is a dearth of literature articulating the ways in which these informal learning environments are having an impact on students in the STEM fields.

This paper reports on a focus group interview conducted with students from an engineering summer camp held at a research-intensive institution in the southeast. The focus group interview helped identify the value of an engineering summer camp for students interested in STEM fields. In an effort to identify aspects of the informal learning environment that were particularly beneficial for students, the researchers felt it appropriate to utilize qualitative research methodology to satisfy the goals of the study.

INFORMAL LEARNING ENVIRONMENTS

It is estimated that during the school years of students, 85% of these learners' time will be spent outside of a classroom (Gerber, 2001). This illustrates the importance of providing opportunities for learning that are outside of the traditional learning environment. Informal learning environments provide these opportunities and have been an integral part of education for years (Martin, 2004). The continued study of informal learning environments may provide insight into ways the nation can begin to attract a STEM workforce that is more diverse. The merits of informal learning environments are known, yet the research is not clear on how such experiences benefit students (Gerber, 2001). Beyond anecdotal reporting on informal learning environments, little has been reported that documents the capacity of informal learning environments to influence learning and student development. The researchers' efforts are part of a broader study, which investigated and measured the impact of informal learning environments.

SETTING

Informal learning environments can be categorized into three major settings: (a) everyday experiences, (b) designed settings, and (c) programmed settings (Kotys-Schwartz, 2011). The informal learning environment framing this study was a one-week summer engineering camp held at a research-intensive university in the southeast and is categorized as a programmed setting. Programmed settings are characterized by structured programs that take place at a school and/or community-based organization and science organizations (Kotys-Schwartz, 2011). Founded in

1999 as an extension of the Women in Engineering Program, the engineering summer camp featured in this study offers a week-long engineering camp each summer for 9th-10th grade male and female students interested in experiencing science, technology, engineering, and mathematics.

PARTICIPANTS

Participants for this study attended a multidisciplinary session for rising 9th and 10th grade students. Student campers must pay to participate in the engineering summer camps, with financial aid provided to those in need. Approximately 90 students were placed in design teams of three students, providing the study with 30 student groups. Participants were not provided remuneration for their participation in this focus group interview study.

Participants were selected for this study using a strategy of purposeful sampling. Purposeful sampling is an effective strategy of sampling that allows for the collection of "information rich" data (Glesne, 2006). The participating teachers recommended participants for the focus group interview based on the students' performance, attendance, and overall engagement in the engineering design challenge. A total of eight students participated in the focus group interview with equal representation between males and females. The Engineering Summer Camp does place an emphasis on underrepresented student populations however their camp is available to *all* students. The focus group sample provided a mix of demographics that was reflective of the camp's broader population. For the purposes of this study, members of the focus group are entitled "participants" in this paper.

INSTRUCTORS/ADVISORS

Three high school teachers with backgrounds in science and/or math were selected as instructors for the engineering summer camp. Instructors were responsible for 30 students each equaling 10 student groups. The instructors provided guidance and instruction for the student teams while facilitating the engineering design experience. Undergraduate students as well as high school students who supported the engineering summer camp assisted instructors. It is important to note that the student participants were engaged in an engineering design challenge as part of their experience. The engineering design challenge was a central theme for the summer camp and helped frame this particular informal learning environment and the experience of the student participants.

ENGINEERING DESIGN CHALLENGE

The summer camp challenge was to design, build, and test a working model of a green roof on campus. The students were allowed one full week to complete the design challenge. The campers were given many scaffolding activities to promote engineering design habits and to practice, which included the following: problem-formulation activities (identification and scoping), developing and engaging in the investigation of green roof substrates, and were given guided field trips of local green roofs. The campers had access to a "materials resource room," which included soil, hydraulic pumps, model building materials, supplies, and tools. Participants were also allowed to submit a request for additional materials that could be purchased mid way through the week.

PURPOSE OF THE STUDY

The purpose of this study was to determine the factors of the engineering summer camp that were particularly beneficial to students. As a secondary goal, the researchers sought to investigate the biggest challenges students faced in realizing the engineering design challenge-which framed the informal learning environment. To accomplish this goal, a focus group interview was conducted with eight summer-camp participants who purposefully were selected for the study (Dey, 2004). Participants were asked two open-ended questions:

1. What were some of the hardest challenges you had to overcome in completing the engineering design challenge?
2. What do you feel you are gaining by participating in the engineering summer camp?

METHODS AND METHODOLOGY

The research team used a focus group protocol to guide the interview session. Focus groups are used to gather opinions. Focus group are unique because the interactions among participants enhances the quality of the data through a checks and balances process (Patton, 2002). These

consisted of a series of interviews, conducted with five to ten participants, wherein the researcher attempts to gain a certain perspective from a particular group (Krueger, 2009). Members of the group conducted member checking, expounding on participant responses, and adding clarity to group responses. Focus groups typically have four characteristics: they include people who (a) possess certain characteristics, (b) provide qualitative data (c) are in a focused discussion, and (d) help understand the topic of interest (Krueger, 2009). In order to ascertain a perspective that was reflective of the engineering summer camp it was important to establish a "consensus" among group members. Regarding this study, researchers believed that focus group interviews were appropriate.

A semi-structured interview technique was employed to unpack the variables of the summer camp that were particularly challenging and distinguish those from which the students benefitted. This technique allowed the interviewer to digress in order to capture richer descriptions of activities before returning to the interview protocol in an effort to maintain the integrity of the interview process (Krueger, 2009).

The facilitator posed the two open-ended questions. After the first question was posed (What were some of the hardest challenges faced in completing the engineering design challenge?), the facilitator asked additional questions stemming from received answers for the purpose of clarification and confirmation. This allowed the participants to answer a multitude of questions with minimal probing from the facilitator. After a number of supplementary questions had been pulled from the first question, the second main question was then posed as a concluding question (What do you feel you are gaining by participating in engineering summer camp?). Again the process was repeated and the facilitator listened carefully to answers and pulled additional information through follow-up questions. Notes were taken to ensure that data could be crosschecked with the audio recording.

Interviews were recorded digitally and transcribed at a later date by a professional transcriptionist. The interviews were conducted using two researchers; one who led the interviews while the other researcher took field notes. The interview lasted approximately 40 minutes.

THEORETICAL FRAMEWORK

To build towards theory of impact and influence relative to the camp's activities and student participants, the researchers looked for emergent themes that were present. Focus group interviews are well suited for qualitative investigation including those that employ emergent theme analysis (Webb, 2001). An emergent theme analysis approach was used to arrive at an understanding of the value of an informal learning environment for students engaged in an engineering design activity (Ayres, 2003). This strategy is useful when striving to render a conceptual understanding from the data (Charmaz, 2003). This approach yields themes that are formed from the grouping of codes according to conceptual categories that reflect commonalities among coded data (Glaser, 1967).

In this study, the researchers searched for emergent themes formed from the focus group participants' responses. This was accomplished by looking at the transcribed recordings and notes that were taken during each interview session. Initial data examination and coding were conducted independently by one researcher, and this process was repeated using the services of another qualitative researcher prior to coming together to discuss the themes that were prevalent. After individual analysis, the researchers came together to identify themes and correlate results in order to establish inter-rater reliability. The researchers met with a third party to discuss emergent themes and to establish consensus among the findings. The emergent themes presented in this study are the result of themes identified by both coders and agreed upon by the third researcher. Individual researchers reviewed collected responses and gradually went from coding to categories, and eventually theory building; leading to the development of emergent themes (Harry, 2005).

FINDINGS

The guiding question for this study is as follows: What is the value of an engineering summer camp for students engaged in an engineering design activity? In order to understand students'

value of the engineering summer camp, focus group interviews were conducted with purposefully selected student participants. The following themes formed from the focus group interview fell into the two distinct categories, *biggest challenges faced*, which included (a) dealing with constraints, (b) lack of time, and *benefits of the summer camp* which included, (c) use of mathematical modeling (d) field experience, and (e) teamwork.

BIGGEST CHALLENGES FACED

Dealing with Constraints

When speaking of the **biggest challenge** that the students faced in engaging in an engineering design challenge, these students agreed that *dealing with constraints* was one of their toughest challenges. One student lamented,

> *"I think that the, the weight restraint is kind of difficult because… Even all of the area can be affected by your weight limit constraint."*

The student's peers agreed with the statement adding,

> *"Yeah I agree with her 'cause like finding out which layers to put while still staying within the weight limit and figure out what drain and what didn't. But I think that a lot of it is how you use your budget instead of you know just having a number. You have to work around it just like we did."*

Time Allocation

When given the opportunity to speak about other challenges faced in the engineering design challenge participants felt that *lack of time* overall was a big challenge to overcome. One student argued,

> *"I think some of the steps required more days and even though we managed to do it, it was kind of rushed at the end…"*

Another student added,

> *"We didn't have much time on the project so I just suggest we have like some more time to do it."*

Asked if the camp was extended by a week, the group unanimously agreed that

> *"... yeah I think if this camp were longer and I did have the opportunity to stay again, I would definitely do it."*

BENEFITS OF SUMMER CAMP

When speaking to the camp participants the following themes presented themselves among the student participants regarding the **benefits of the summer camp** to include the use of mathematical modeling (application of math and science), a field experience, and teamwork.

Using Mathematical Modeling (Application of Math and Science)

Speaking about the skills that they were able to develop in the camp, the participants felt that the *use of mathematical modeling* and practical application of math and science was key

> *"… then I come to this camp and they're like make a mathematical model so you can figure out how big this thing is."*

Another participant concurred adding,

> *"… and use math for like in the real world you're more interested it's very important not saying it's boring your selling cookies so I'm not gonna care about this."*

Field Experience

Another **benefit of the summer camp** as provided by the student participants included *field experiences*. When asked about improvements for the summer camp a student suggested,

> *"… I wish we could take like more field trips I guess."*

When asked to describe the best part of the summer camp another student offered,

> *"My favorite part of this camp was the Hunt Library. It was really cool and I really liked it."*

When asked to discuss the overall experience a student participant simply offered,

> *"… I love the field trips."*

Teamwork

Overwhelming the most emergent theme that student participants presented regarding the benefits of this summer camp included the value of *teamwork*. The opportunity to work with like-minded students was a big benefit of the camp as one student attested,

> *"I think being in contact with other kids who have kind of like the same mind set as me. That's pretty cool too."*

Working with like-minded students also produced a sense of trust for the student

participants as provided in this statement,

> *"... it also makes me kind of trust people a lot more cause when you're working in groups everybody here is real smart so they can always do their part…".*

And finally the advent of teamwork led to trust building among the participants,

> *"And like you actually have other people that you can rely on to do their part and pull their own weight."*

SUMMARY

This study explored the value of a summer engineering camp for all students, including those who are underrepresented. The engineering camp was framed by the introduction of an engineering design challenge that students completed and presented at the end of the camp. Using emergent theme analysis, emergent themes were established, which allowed us to establish the benefits of the summer camp as well as the biggest challenges faced when students engaged in the engineering design challenge. Researchers found that the **biggest challenges faced** were (a) dealing with constraints and (b) lack of time, while the **benefits of the summer camp** included the use of mathematical modeling (application of mathematics and science), a field experience, and teamwork.

The findings from this study present the specific factors of an informal learning environment that held value for students engaged in an engineering design activity and their development as students. Findings from this study support Martin's (2004) notion that informal learning environments provide opportunities for school-age children to learn outside of traditional learning settings. Further, it aids in providing clarity on the ways in which informal learning environments benefit students (Gerber, 2001). The researchers' discovery of the *biggest challenges faced* and the *benefits of a summer engineering design camp* for students offers factors to consider when designing and implementing informal learning environments. Knowing such information is of importance, as informal settings are believed to hold a valuable role in reforming STEM education (Martin, 2004).

Results from this study also report on the types of activities that are particularly attractive for populations of diverse students. The need to attract a diverse student population (Chubin, 2005) has hastened the call for informal learning environments, an integral role in the reformation of STEM education at the secondary level. The results of this study strengthen the view that informal learning environments are integral to education while providing a milieu conducive to inquiry-based learning (Martin, 2004). The research results also give credence to the argument that engineering design provides a framework that supports the practical application of mathematics (Denson, 2014).

IMPLICATIONS

Findings from the focus group interviews have implications for the engineering summer camp, which serves as the context for the study and other informal learning environments. Results from this study will help inform camp organizers as to the types of learning experiences that are particularly beneficial to their students. Potential implications include highlighting the benefits of introducing engineering design activities in formal learning environments and the potential challenges instructors may face when attempting to facilitate such a learning experience. Possible future work would include looking at whether the impressions vary by gender or ethnicity and whether there are equivalent experiences.

This study also revealed many pertinent questions that should merit the need for future studies, including: Are there aspects of the camp that are perceived as more important/valuable by women compared to men or by someone from an underrepresented ethnic group? Other findings include implications for formal learning environments. Many students mentioned a benefit of learning the value of mathematical modeling. This may offer insight into ways instructors can incorporate more engineering into the formal curriculum as a way to improve math skills of students. Other questions that future studies should ascertain include: Do students' perceptions of the challenges change over the course of their engineering experience? For students who have had an engineering camp experience, are they seen differently among campers without experience? Are the skills developed in the engineering summer camp transferable to formal learning environments? In what ways are the soft skills developed, that is, is a skill such as teamwork, transferable to other academic and work environments?

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