Board 109: Integrating a Teacher Professional Learning Experience into the GEAR UP Engineering Summer Camp (Work in Progress)

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Introduction

For one week in the summer of 2018, students and teachers from several school districts throughout the state of Utah participated in the Engineering Summer Camp. The camp is part of a 7-year grant funded by the Department of Education as part of the GEAR UP program. The main purpose of the Engineering Camp was to increase interest in and knowledge about engineering among middle-school and high school students. The 2018 camp was specifically targeting students entering the 10^{th} grade and their teachers. During the camp, both students and teachers were able to participate in authentic engineering experiences led by engineering faculty related to water and air quality.

Because of the Next Generation Science Standards (NGSS) and the framework for K-12 science education, science teachers are being asked to incorporate engineering into their science classes. But research shows that it has been difficult for many science teachers to do this [1] [2] [3]. This could be a result of a limited understanding of engineering concepts [4], insufficient background in engineering [5], or a lack of self-efficacy [3] [6] [7]. Because of this gap in the ability and confidence of science teachers to teach engineering, there is a need for improved professional learning opportunities for these teachers.

Instead of having the eight participating STEM teachers be only chaperones, they were given the opportunity to experience the engineering activities with their students and were able to participate in several evening workshops led by the researchers. In these workshops, the teachers were able to reflect on and discuss their engineering experiences in the camp, participate in activities related to implementing engineering in their classrooms, and were given time to work on engineering-related lesson plans that would then be implemented in the following school year. The participating STEM teachers were also given materials including simple ROV (Remotely Operated Vehicles) submarines they had assembled on the first day of the camp and quadrotor drones that they could then use in their own science or math classes to do the same or similar activities that were done at the camp with their own students. The embedded workshops along with the student-centered engineering activities from the camp served as an integrated professional learning experience for the STEM teachers. The goal of the professional learning experience was to help the teachers incorporate engineering standards from NGSS and the framework for K-12 science education into their science classrooms.

Participants

Eight STEM teachers participated in the professional learning experience of the GEAR UP Engineering Summer Camp. Of these eight teachers, one was a middle school teacher and the other seven were high school teachers. There was one math teacher and the other seven were science teachers teaching a variety of science classes. The teachers were from seven different school districts and eight different schools. There were two female teachers and six male teachers. One of the teachers was a first-year teacher while the other teachers had more experience.

Methods

The eight STEM teachers participated in a professional learning experience that was incorporated into the primarily student-centered GEAR UP Engineering Summer Camp for one week in July 2018. The main purpose of the summer camp was to increase interest in engineering among middle-school and high-school students. An additional purpose of the camp was to allow the teachers to participate in authentic engineering experiences alongside the students in order to help them to incorporate engineering into their science classes. For these authentic engineering experiences, the teachers and students were divided into four different groups. These groups rotated between four different activities: using simple ROV submarines to obtain underwater data, collecting stream data, using drones and sensors to obtain air temperature and air quality data, and analyzing data about crops and trees obtained from drones. After rotating through each of these activities over a two-day period, the groups of students and teachers then selected one of the activities to do more in depth work with on the fourth day of the camp. The teachers and students obtained data on this day to answer a chosen research question, and then created a research poster showing the question and the results of the data analysis.

In addition to the engineering experiences, the teachers participated in several workshops focused on the aspects of the NGSS and the framework for K-12 science education in the evenings that were led by the researchers. These workshops included an activity similar to what teachers could use in their own classrooms to implement the framework for K-12 science education, discussion and reflection on the authentic engineering experiences in which the teachers participated with their students, and time to create engineering-related lesson plans, which were implemented in the following school year. A portion of the last workshop was focused primarily on the engineering design process and how it can be implemented and taught in a middle-school or high-school science class. However, because of time constraints due to unforeseen circumstances related to camp logistics, the workshop that was specifically related to the engineering design process was shorter than intended.

Data Collection and Analysis

In order to collect qualitative data, one researcher observed the participating teachers implementing the lesson plans that had been created at the camp (or similar lesson plans related to engineering) in their own classrooms. During the observation, the researcher took field notes on how well the teachers were able to implement what they had learned from the professional learning experience into their classes. Immediately following the observation, the same researcher conducted a semi-structured interview with each of the teachers. This interview included questions about the GEAR UP Engineering Camp specifically and more general questions regarding professional learning experiences.

Of the eight teachers who participated in the GEAR UP Engineering Camp, only four of the teachers completed both the interview and the observation. One teacher was interviewed but not observed because at the time of the schedule interview, he had already taught all his engineering related content and was unable to include more in his class because of time constraints. The other three teachers withdrew from the study after participating in the GEAR UP Engineering Camp and were not interviewed or observed.

Transcriptions of audio recordings from the interviews enabled an efficient analysis of the data. There were no recordings made of the observations. After the completion of the data collection, the data was analyzed as a whole, and some conclusions were made. The data analysis was done by the researchers using two phases of coding. First, the researchers found general themes, and then broke down those general themes into sub-codes that are more specific. Because this is a pilot study, the results and conclusions that came from this coding process will be used to improve future iterations of the professional learning experience and to refine the observation and interview process for data collection.

Results

Though only four of the teachers completed both the observation and interview and one teacher completed only the interview, there are some emerging themes and some results that will lead to changes to the professional learning experience. One of the emerging themes from the interviews is that there is a lack of time available in their existing classroom and that this lack of time is a significant obstacle to teachers' ability to apply what they learned in professional learning experiences such as the GEAR UP Summer Camp. The teachers mentioned this lack of time in several different contexts. Some mentioned that they do not have time to plan new lessons that apply things they learned in professional learning experiences. One teacher mentioned that he does not have class time to do new activities because his curriculum is already loaded with other things. One teacher said that in order to apply some of the activities specifically from the GEAR UP Camp, he would need to take the students on a field trip and he did not have time or funding for that. One teacher said that he did not have time to do more hands-on activities because he felt pressured to teach things that are on the standardized tests. Another significant obstacle to applying things they had learned in professional learning experiences that one of the teachers mentioned was that they had to coordinate curricula with other teachers and the other teachers didn't always agree.

All the teachers also mentioned in the interviews that they enjoyed participating in the engineering activities with their students and that it was good to see these activities being done with students. The teachers said that this helped them to be able to implement similar activities in their own classrooms. Most of the teachers indicated that they enjoyed the parts of the camp that were more hands-on. Another thing that was mentioned by most of the participating teachers was that they enjoyed the opportunity to collaborate with other teachers from other schools and to see and hear their ideas about how to incorporate engineering in science classes. One teacher mentioned that this was one of the most valuable parts of the professional learning experience but that there was not enough time for collaboration and brainstorming with their fellow teachers.

During the observations, only one of the four teachers used the materials or activities that were done at the camp. This teacher replicated an activity that was done at the camp using a quadrotor drone to take measurements of temperature and air pressure, however he did not use the quadrotor drone that he was given at the camp because he was unable to stabilize it. He said this was because he had only spent less than an hour using the drone, without instruction. Because this teacher was a math teacher and not a science teacher, he then had the students statistically analyze the data that was obtained from the drone. The one teacher who was only interviewed but was not observed also replicated the drone activity but was able to use the quadrotor drone

that he was given at the camp. The other three teachers did incorporate some concepts from the camp such as the engineering design process. These three teachers had the students go through the design process, or at least parts of it, but only two of the teachers either reviewed or introduced the engineering design process before doing the engineering activity with the students. The third teacher said the words "engineer" or "design" when referring to what the students were doing for the activity but did not specifically introduce the engineering design process. The researcher observed that the students in all three of those classes did not have as much flexibility in their design as would be in a normal engineering design project, but that was done in order to be able to complete the activity in the time that they had set aside for it. It was clear that the two of the teachers either already had or would have other engineering activities that would allow for more flexibility and would focus on other parts of the engineering design process. The third teacher, the one who had not specifically introduced the engineering design process, asked for feedback after the class and said that he would incorporate the engineering design process in that specific activity and others in future classes.

After the remaining interviews and observations have been completed, it is expected that there will be additional emerging themes and additional changes that will need to be made in future iterations of the GEAR UP Engineering Camp professional learning experience. It is also possible that changes will need be made to the interview questions in order to get additional and clearer data.

Conclusions

From the results of the interviews and observations, it would appear that there is a need for the GEAR UP Engineering Camp and professional learning experience to include a few key features. First, there needs to be an increased focus on the hands-on activities in the engineering experiences. For two of the activities that were a part of the camp, the students and teachers spent too much time in a classroom listening to presentations or too much time sitting at a computer analyzing data that they were not involved in collecting. Most of the teachers mentioned that they would prefer more hands-on activities because those are the kinds of activities that they would want to implement in their own classes. Changes have already been made to these activities for the next GEAR UP Engineering Camp.

The second change that needs to be made to the professional learning experience is that there needs to be an additional focus in the workshops on the engineering design process and how the process can be implemented in a K-12 science classroom. One of the teachers mentioned that this was the only part of the workshops that he implemented in his science class. In this camp, only about an hour during the workshops was related to the engineering design process specifically. The remainder of the workshop, including the main activity that was done by the teachers, was more focused on the science aspects of the framework for K-12 science education rather than the engineering aspects. In future camps, the teachers will participate in an activity that will serve as an example of how to implement the engineering design process in their own classrooms.

Since most of the teachers were not able to use the materials that were given to them as a part of the professional learning experience, there is something else missing. For the next camp, it has been decided that there will be an additional emphasis on helping the teachers to come up with ideas of how they can use the materials that they are given (i.e. ROV submarines and drones) to

teach engineering in their classes. The teachers will also be taught how to operate the quadrotor drones so that they can safely use them on their own outside of the camp. Otherwise, the expense of giving the materials to the teachers would be wasted.

While there are changes that need to be made to the GEAR UP Engineering Summer Camp professional learning experience, it was clear that all the teachers that were interviewed enjoyed having a professional learning experience incorporated into an otherwise student-focused engineering summer camp. Although it is different from most other professional learning experiences that are available to teachers, having the teachers participate in authentic engineering experiences with their students and giving them time to reflect on these experiences during the workshops, is clearly beneficial to the teachers. With the changes that are being made to the next GEAR UP Engineering Summer camp, it is expected that the benefits of having the professional learning experience as a part of the camp will continue and that there will be additional benefits as a result of the improvements made to the professional learning experience.

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