

Strategies for Teacher Comfort Aimed at Sustainability

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Abstract

Tufts University's Center for Engineering Educational Outreach received a GK-12 grant from the National Science Foundation (NSF) in 1998 to place graduate engineering students and computer science students into local public school classrooms. Through this fellowship the graduate students were partnered with teachers with the purpose of introducing engineering in Massachusetts' primary and secondary schools. The graduate fellows serve as a "real-time" resource for the teachers as an engineering activity is implemented. The project has met with many levels of success and the focus has become how to make the work and accomplishments achieved sustainable. The most promising aspect has been to increase the teacher comfort level with the material. The challenge comes in presenting the teacher with the right amount of relevant material. The process of increasing teacher comfort is outlined. The benefits of offering engineering education to elementary students became apparent with a 21% gain in standardized test score values.

Tufts CEEO GK-12 Outreach Project

The Tufts University GK-12 project is a three-year project focused on pairing graduate-level engineering and computer science students with classroom teachers. The CEEO has 8 graduate fellows working in the classroom. Selection for program participation involves a yearly application process subsequent or concomitant to admission to the School of Engineering. Students complete an application with essay and submit it to the Center for Engineering Educational Outreach for consideration. Top candidates are then identified from the applicant pool and offered individual interviews with the grant's principal investigator. Throughout the application process, assessment is made of individual experience, understanding of Center's mission and vision for the development of primary and secondary engineering education, and ability to work effectively with teachers and children involved with program.

Within the graduate academic program, GK-12 graduate fellowships take the place of a traditional research assistant (RA) or teaching assistant (TA) position at the School of Engineering providing tuition and stipend. Fellows spend 20 hours per week on the project, with 16 hours (2 full school days) per week spent in the classroom of their partnering teacher. The remainder of the time allotted by fellows is spent taking part in seminars relating appropriate educational pedagogy, discussing classroom strategies for learning, and interacting with undergraduates working to support curricula ideas. Informal support takes place with similar numbers of social studies classes in crossover activities, although no social studies classroom teachers are formal partnering teachers. The project runs from June 1 to May 31 of the following year, allowing consistent

contact between graduate fellows, classroom teachers, and program

administration. Partner districts for this program are the Nashoba Regional School District, Malden School District, and Medford School District; all located within the greater Boston area.

Fellow Training

The CEEO believes that giving the graduate fellows experience during the first summer is very important. To this end, the fellows that enter the program often spend one week helping with a week long educational based summer camp at Tufts. The summer program accepts students entering 5th through 10th grade, so the graduate fellows get to work with a wide variety of students. The fellows also spend a couple days working with teachers on some curriculum development projects. This gives the fellows their first insight into what goes into developing a new lesson or activity for the classroom. Some educational readings are given to the fellows to read during the summer that helps address the pedagogical issues. An educational seminar is planned for future fellows that will give them an opportunity to discuss different classroom strategies and forms of instruction. At the end of the summer the graduate fellows often have a feel for which age group they would like to work with as well as some of the key components needed to develop an activity.

Fellow Placement

After the fellows have been selected for the year, a very careful analysis is then undertaken to determine where they would be best suited for placement during the academic year. During the summer the fellows work on a variety of projects including those that are student centered, teacher centered and curriculum centered. Through the involvement of the fellows on these projects fellows gain some insight into the academic environment they are about to enter. During this time program heads are witnessing the fellows' ability to handle different grade levels, and their personality when dealing with in-service teachers. Using this information and their own stated preference for grade level, the students are then partnered with one to four teachers to work with during the academic year.

The teachers that are involved in the project mainly represent a self-selected population. The district will select the grade level they wish for us to place a fellow in. The teachers in that grade level generally then self select for participation in the program. This does create a biased population with which to work; the teachers selecting to work on this program are those that have an expressed interest in the material. However we have to point out that although the teachers are interested in the material, it does not necessarily indicate that they have increased knowledge in the subject. The level of teacher enthusiasm is definitely an important aspect to consider in the sustainability of a project. If the teacher is not interested or enthusiastically involved in the project then there is little hope for the project to continue when the fellow leaves the school.

Once the fellow and the teacher combinations are made the fellow enters the classroom near the first day of the school year. By placing the fellow with the teacher on the first day of the academic year, a relationship can develop between the teacher, the fellow, and the students. As the fellow becomes established in the class, they are able to relate to the instruction style of the teacher, the performance of the students, and the environment of the school. This facilitates the

development of lessons that fit the need of the teacher and the classrooms in which the fellows are working.

Placing the fellow with one or a set of teachers for the entire school year also allows for a sustained effort in technology/engineering education. Other GK-12 projects have developed “showcase” type projects. These projects involve developing an attention getting demonstration along with a well developed set of worksheets and handouts. This method of presenting the material to the students and teachers is great at peaking interest but, in our experience, does little to promote continued learning after the presentation has left. The Tufts University program has chosen to have their fellows work with the same teachers instead of hopping from program to program to promote interest in technology/engineering throughout the entire school year. The program is structured so that continued contact with science teachers allows for successful integration of technology engineering. If the teacher does not see how the material being presented links with their existing curriculum then the chances of continued presentation of the material is reduced. The continued contact between student and teacher builds the teacher’s comfort with the material which is the critical step in the process. If the teacher cannot relate the integrated engineering material to something already being taught in class, then a connection to the state educational standards needs to be explicitly outlined. The end result is that the teachers need to see relevance for why they are working on a given project. If they are coerced into inserting a project that has little relevance to their standard curriculum or takes time away from an established project, then they are much less likely to continue the activity once the GK-12 Project has ended.

Fellow Instruction

The method of instruction that takes place in the classroom can take several forms. One of these is where the fellow does the majority of instruction for the class. Within this model there are several different approaches. The first is that the teacher tells the fellow they will have 20 minutes each day to present an engineering topic to the class. The fellow prepares a lesson – trying to tie it in with what the class has been working on – and then presents it to the class. The teacher is in the room primarily to maintain control of the students and has very little interaction with the fellow as they are presenting the content. This model of instruction generally takes place when the teacher is unfamiliar with engineering, the material is not related to current curricula, or the teacher is simply disinterested. This is the worst use of the fellow as far as sustainability issues are concerned. There is very little dialogue between the teacher and the fellow prior to developing the unit as well as after the lesson. The teacher is disconnected with the engineering activity trying to be infused.

Lack of teacher involvement was noticed in one of the classrooms in which we worked the first year of the program. The teacher was not enthusiastic about the project. The fellow tried to work with teacher and was met with a lot of resistance. The fellow continued to work with that teacher and the other math teachers in the middle school. For the second year, the fellow worked with only two of the math teachers and did not work with the third teacher. That teacher did not try to integrate any of the lesson plans that had been developed during the previous year. There was friction between the fellow and the teacher resulting in a very poor program outcome.

However sometimes the format is better when the teacher and the fellow actually plan what the topic should cover in the class. The teacher states that what they have been doing in the class is good or what they are planning to cover in the next section would make for an interesting integration of an engineering activity to introduce the science concepts. In this situation the teacher does not feel comfortable instructing the students in the lesson, but does have an interest in increasing the technological literacy of their students. The fellow then takes it upon themselves to develop a lesson to instruct the class. They review this with their teacher who will try to aid input about the developmental appropriateness of the lesson. The fellow then assumes the role of instructing the class. Being able to deliver the same lesson to multiple classes makes it easier for the fellows to tweak what they are teaching so that it becomes more appropriate and/or accessible for the students. Based on fellow feedback, in these situations, the teacher generally tries to ask questions of the students related to the information presented. The teachers are taking a semi-active role in the activity, but they are not actively engaged in the instruction of the students. For obvious reasons, such a model has very limited potential as far as sustainability is concerned.

Teacher-Fellow Instruction

Another major form of instruction is teacher-fellow model. This format provides a stronger arena to develop the teacher's familiarity with the material; it can also take on two main sub formats. The first format includes the teacher presenting the science aspects and the fellow the technology aspect. This model may be assumed to occur in the fellow instruction model, but it does not. The teachers who have the fellow instruct the majority of the lessons generally do not feel comfortable with the science material either and prefer to have someone else present all the information. When the fellow presents the technological information, the teacher does tend to absorb some of the material. In multiple sessions of the same class the teacher will often begin to incorporate some of the technological material into their introduction.

This leads into the second type of teacher/fellow interaction in which the teacher and the fellow share the instruction during the unit. In this format the teacher often communicates to the graduate student what the next unit will focus on. The graduate student will then research several engineering activities that could be presented to the class. The fellow then lets the teacher know what ideas they have come up with and they discuss the activity the teacher selects. The fellow provides the teacher with information on the project and how it will work as well as background information. The teacher then presents the majority of the material to the students, occasionally leaving the most technical concepts information for the graduate student to explain.

While working with the Teacher-Fellow instruction model the fellows must be aware of the teachers comfort and ability level concerning the unit being instructed. This setup actually requires tact and finesse on the part of the graduate student to make sure that they do not overstep the boundaries of the teacher while at the same time they do not restrain their influence to the point of making the teacher nervous or uncomfortable. It is our experience that when the teacher and fellow present the material in a combined effort about 35% of the material will be incorporated by the teacher without a supporting fellow in the class. This number represents the estimate provided to us by teachers who worked with a fellow in year one but decided to try

teaching the material alone in year two.

Teacher Instruction

The Tufts University GK-12 project has determined that the instruction method containing the best potential for success is when the teacher provides the instruction to the students by themselves. This method of instruction contains elements of the previous models in that the teacher and the fellow discuss what the upcoming unit will be and the fellow then researches the topic. The teacher and fellow discuss what ideas or topics could be introduced to the class and a concept is agreed upon so that the fellow can begin researching the material and can build any appropriate prototypes. The research the fellow completes is often assisted through the efforts of undergraduate fellows that work at the university as a line of support for the graduate fellow. The graduate fellow relays to the head undergraduate fellow what the upcoming needs of their classroom are. The undergraduate fellow then coordinates with the other undergraduate fellows and the graduate fellow during the research or development of the material. The material that has been developed is then brought back to the teacher for their review. The fellow then explains the project to the teacher thoroughly so that they are able to give the lesson to the class.

One of the problems that may arise during this process is the variation in complexity and depth of the information presented to the teacher and to the student. Often teachers feel as though the material presented to them is too complicated for the students to understand. This is understandable given that engineering graduate students with limited training in effective pedagogy are developing the units for the classroom. The teachers, when reviewing the material, will state that this material is often too complex for their students. The problem arises when the teacher has trouble distinguishing the material developed for them and the material that should be presented to the students. Simply put, this is an issue of “Content for Whom.” In providing the material necessary for the teachers, it is often beneficial to provide more material or content that is in greater depth than the students might need. This will allow the teacher to feel comfortable understanding the concepts involved and provide a resource for answering questions that might arise and taking certain aspects further with gifted students.

An example of this from a 5th grade classroom has to do with discussing parallel and series circuits. Many people are familiar with miniature holiday lights and they are generally used to explain the difference between series and parallel circuits. Older light sets would all go out if a single bulb was broken, a classic example of a series circuit. The common understanding is that today’s light sets are built in parallel so that if one bulb burns out the remaining bulbs on the string stay lit. An issue arises, however, because many sets produced now are generally comprised of multiple sets of series lights connected in parallel. This information may be something that is more complex than the students need to understand, but the teacher should be aware of this information so that they don’t use miniature holiday lights as an example of parallel circuit construction. The example appears black and white when in reality a student might observe a different occurrence than taught, resulting in a misconception that can easily be avoided with excess information provided to the instructor.

The teachers that work with the Tufts University’s GK-12 project have relayed that they are

relatively comfortable teaching the concepts of circuits to their students. This information has proven very valuable to the fellows as they have worked to identify engineering projects to integrate into the existing electricity curriculum. In year one of the project, the circuitry unit was a heavy focus as a prime area to introduce the engineering concepts of design and build. One of the successful projects was the integration of designing a bulb holder instead of using the provided, factory manufactured versions. Students had to understand the properties of conductors as well as understanding how to deliver power to the bulb in order to make it successfully light. The teachers were comfortable with the technical information needed for the transfer of electricity from the battery to the bulb, so they were willing to integrate the engineering design process into a standard unit. In the first year this project was implemented, the fellow did most of the instruction while by the third year the fellow served more as an observer and rescue resource the class, having little to do with the instruction. The teacher was comfortable with the material in this lesson, they had been given an alternative way of looking at the material they presented in a preexisting lab, and they were able to see how the information they were presenting to the students in science class could be applied more broadly to an engineering design problem.

The process that the teacher went through revealed increasing levels of comfort with the material. They were dependent on the fellow the first two years of integration and by year three they had assumed ownership of the project and were offering it on their own. This is indicative of the tenet of this paper; when teachers become comfortable with the material they are teaching, there is greater success of it becoming sustained in the curriculum.

One method used by the fellows to increase this teacher comfort level is to obtain the material for the teacher and present the essential information to them for review. This alleviates strain on the teacher to research, read, and assimilate necessary information. It is also beneficial for the teacher to be given exposure to multiple views on solving a problem. The impact that engineering was having on the students was revealed when one school analyzed their state standardized test scores. Their scores went from 72% to 93% of students scoring in the advanced & proficient range while the state averages went from 48% to 62 %⁽¹⁾. The impact engineering was having on the students became brutally clear to the teachers. This also contributed to the sustainability issues of offering engineering education by justifying years of effort with admirable results.

Discussion

Sustainability issues surrounding engineering education are beginning to become clarified in the Tufts University GK-12 project. The major factor contributing to continued implementation of engineering activities is directly related to the comfort level the teacher obtains with the material. Everyone involved with the project, including teachers, fellows, and project directors, have been working on how best to get the teachers comfortable with the material. The project has been focused on how best to communicate the material to the teacher. It has been a fine balance between providing sufficient information to the teachers for adequate instruction and providing too much information such that the teacher becomes overwhelmed. This has been a problem with other outreach activities we have conducted and those that we've investigated. Even with solid intent, teachers are sometimes given too much or poorly organized information that they do not

understand how to tackle. The other issue that needs to be avoided is telling the teacher how they should be instructing the course. Providing significant amounts of material to the teacher can be construed as guiding the direction of the class without proper respect given to the role of the teacher. This can create issues and thus open lines of communication must be present throughout the process in attempts to avoid these situations. Also, when someone working with the teacher presumes to know more about how to run the classroom, the actions taken by that person often tend to be counterproductive to the work they are trying to accomplish.

Another crucial step in achieving total teacher comfort and thus sustainability is ability of the teacher to have input prior to implementation on the project. Having the teacher work with the fellow to co-develop the next project or topic that can be used to integrate engineering design is very important. When a fellow creates a project that they believe ties into classroom material without teacher input, there is high likelihood of misconceptions and misunderstandings to arise concerning intent and activity goals. Therefore in our experience, it is crucial to have teacher input through the open lines of communication while developing the activity in order for it to be successful.

Making the engineering design project relevant to the material being taught by the teacher has also been an important part of addressing the sustainability issue of this grant. Most of the teachers that we work with do not have extra space in their curriculum to insert even a brief well developed engineering design project. Therefore in order for them to undertake offering a design project for their students, they need to relate it to material they are already teaching to make a more complete project. Relating the engineering design project to existing material for logistical and implantation reasons is important, but so is relating the material to real world experience. This relevance factor helps the teacher see the big picture and how material the students are learning in science and the engineering projects they are doing mimic problems that exist outside of school. Students become enthused about the real world projects resulting in teacher excitement and satisfaction, thus reason to continue efforts in engineering activities and design projects.

Conclusion

Although we have discussed teacher comfort levels as a major facet of sustainability the authors of this paper do not wish to imply that it is the only factor. The availability of resources to the teachers also plays a major part. Access to the resources including materials necessary for the projects and money to purchase these materials must be available to the teacher for obvious sustainability concerns. Administrative support is another major factor that can contribute to the continuation or condemnation of innovative programs. Although we have discussed increasing teacher comfort through the use of graduate engineering fellows, most of the findings apply to other outreach efforts. The Tufts University GK-12 project has provided a window through which to gain some insight into what can contribute to making a project sustainable once funding ends.

Reference:

¹ <http://www.doe.mass.edu/mcas/2000/results/9800sd/sch9800.html>

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