Development of Educational Artifacts on Wetlands by an Undergraduate, Interdisciplinary Design Team

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Abstract

A National Science Foundation DUE Scholarship program was used to assist in the development of an interdisciplinary team of 19 students spanning five different engineering (Biomedical, Chemical, Civil, Computer, and Electrical) disciplines, chemistry, and biology. The scholarship enables the teams to be comprised of the same students from their freshmen to senior year to facilitate learning of effective team building skills, as well as serve as a longitudinal study. This paper will discuss the approach and activities used over sophomore year.

The major concept used to tie the cohort together for the 2016-2017 academic year was wetlands. The students spent the first semester conducting a literature review pertaining wetlands and were able to take a field trip to nearby restored wetland, Panzner Wetland Wildlife Reserve. This afforded all students the opportunity to see a wetland first hand, as well as to learn how to collect basic field data. During the spring 2017 semester the students used the knowledge from the field trip and literature review to design and construct an educational artifact on wetlands for a junior

level high school class. The students self-selected into three different artifacts: an informational video on wetlands, a board game and a diorama depicting a healthy and unhealthy wetland.

The overall objective was to assess if these activities could enable the students to develop into an effective interdisciplinary team and to address the potential lack of interest in core STEM classes; a common reason cited in literature for students leaving STEM fields. In addition to describing the students' key activities, we will describe issues faced by the students and faculty mentor in completing the project, as well as provide possible solutions for future team activities.

Introduction

In 2006 researchers projected that by 2014 there would be a 20% increase in healthcare and social services sector and a 22% increase in science, technology, engineering and math (STEM) related jobs[1]. The need for women and minorities in STEM related fields is even more pronounced,[2,3] with women only comprising 30% of the engineering field.[4-6] Despite an overall 34% increase in undergraduate enrollment to 17.6 million between 2000 and 2009[7], the need for STEM workers had already surpassed the projection by 2013. To achieve the goal of 60% of working Americans with an associate degree or higher, the U.S. needs 23 million more STEM graduates than the current pace.[8] Statistics for Ohio are exacerbated by 'brain drain' and the impending retirement of baby boomers. Currently only 35% of Ohio workers hold a college degree, and the impending retirement of the baby-boomers will increase the number of jobs that require a college education to 64%.[9]

The shortage of STEM workers has resulted in that those that do graduate end up having to do more work than their predecessors. One way to 'do more with less' is to develop effective teams, which are a practical solution for problems that require expertise from multiple areas.[10] The use of interdisciplinary teams at the undergraduate level can help to create meaningful connections across disciplines[11] as well as provide new graduates with the skills and creativity needed for global solutions.[12,13] Having the cohort develop something that required skills across all of the disciplines (i.e., the educational artifacts) assisted with team building and effective learning. The open-ended aspect of the approach challenged students, which has been shown to assist with learning.[14] Using a problem that required the cohort to ultimately create meaningful materials for younger students helped to expand their own knowledge base as in order to effectively convey a core principle to another, one must have solid understanding in the concepts.[1] The development of educational artifacts also utilized team-based learning in that it incorporated productive conflict resolution, mature communication, role clarity, goal clarification, accountable interdependence and common goal.[15,16] Furthermore, enabling the cohort to decide what form the educational artifact would be gave them ownership as well as let them be creative, an aspect often underutilized in STEM disciplines. Providing students with a creative outlet and ownership of a project has been shown to maintain interest and relevance.[17] This paper will briefly describe the key activities used each semester, the issues faced by the student cohort and mentor as well as possible solutions for the obstacles. This information will also be used to assess if development of an educational artifact facilitated the cohort's development into an effective interdisciplinary team and if it addressed the lack of interest in core STEM classes.

Cohort information

The cohort was initially comprised of 22 students (14 direct admit and 8 college ready). Seventeen (77%) were male, five (23%) female with five (23%) being from the Appalachia area. Three were pursuing biology or biochemistry degrees from the college of College of Arts & Sciences. Nineteen of the students were in the College of Engineering (Biomedical, Chemical, Civil, Corrosion, Computer, and Electrical). One of the cohort was Hispanic, four (18%) were African American and one Asian American. By the end of Spring 2016, five students had left the program. Two of the students had decided to attend another university, two had decided to pursue a major not covered by the scholarship (but stayed at the university) and one had not maintained academic eligibility. Since four of the students who left the program were college ready, potential college ready students were interviewed for receiving the scholarship from those who were already attending and had completed their freshmen year. This purposeful selection was done to ensure that the student cohort was of the same basic academic level (i.e., sophomores) for the start of the 2016–2017 academic year. From the new candidates, two were on track in their academic discipline and were academically eligible. As a result, the makeup of the cohort ultimately consisted of biomedical engineering (5), biology (1), chemical engineering (5), chemistry (1), civil engineering (4), computer engineering (2), and electrical engineering (1).

Activities and Educational Artifacts

Fall semester

During the freshmen year the cohort had researched oil spills, fracking and harmful algal blooms as the team building activity. One of the topics that intersected all three areas was wetlands. Wetlands was the topic used to tie the cohort together during the sophomore year and was selected in part since it built upon what the cohort had learned during the freshmen year. This extension of topics provided an example that previous knowledge is translatable into other areas and can be built upon. Another reason it was selected as the unifying topic was that Ohio has wetland related issues that would help maintain the cohort's interest as it encompasses issue(s) in their home state. However, most of the cohort had never been to a wetland. Therefore, the class took a field trip to Panzner Farm Wetland and Wildlife preserve at the start of the fall semester. The field trip provided the cohort with two different examples of wetland areas, as well as the basic water quality sampling techniques used to evaluate the health status of a wetland. Another key activity during the fall semester was a literature search. After a few weeks, several different categories arose based on student interest: what is a healthy wetland/ecosystem, approaches for wetland restoration, beneficial uses of wetlands, use of wetlands to remediate a contaminated area, and regulations associated with wetland conservation. After additional research the cohort held several brainstorming sessions as to what form the educational artifact would take. Based on interest, three artifact types were selected to work on during the spring semester: a diorama depicting a healthy/unhealthy wetland, a mini informational video on wetlands, and a board game. Permitting students to select their own group/topic had the added benefit of often increasing motivation.[18,19]

Spring semester

The semester was devoted to developing the artifacts, and details of each artifact are below. Two threads were common to all of the teams. First, the cohort continued with finding at least one new bibliography entry each week. During the spring semester, the literature search to complete the bibliography assignment was focused an area that was missing or needed additional depth for his or her specific artifact task. In completing the bibliography entry, each student had to specifically identify how the information would be used in the artifact and by the team. Second, the teams utilized the entire cohort for feedback, practice and troubleshooting. These skills are critical to any team, and the utilization of the class time for project enhancement and team meetings was important in fostering these skills.

The video team outlined the key topic areas they thought would be important to provide a general background on wetlands and then wrote the script. They then practiced by presenting it to the rest of the cohort and received feedback. The script was rewritten and practiced several times before reaching a final version. As video-taping could not occur until later in the semester, the students helped the other teams with their projects. Two of the students helped with the diorama and two helped with the board game. The video was filmed at Panzner Wetland and Wildlife Preserve when weather permitted.

The diorama was first mapped out on paper. Three different concepts were presented to the rest of the cohort. The advantages of each were discussed prior to selecting the final design. The size of the diorama was changed in to stay within budget constraints. In addition, it was decided to have the unhealthy and healthy wetland next to each other in the same box to facilitate an easier visual comparison (Figure 1).

Figure 1. Diorama of healthy & unhealthy wetland.

The board game was the most demanding of the three artifacts. As with the diorama, several different types of games and associated supplies (game pieces, routes, number of die, etc.) were discussed with the entire cohort before selecting the final theme and game route. Three sets of cards were developed with questions pertaining to wetlands. Green cards corresponded to easy questions worth one point if answered correctly. Yellow cards had slightly harder questions worth two points and red cards were the hardest questions and were worth three points. The game also had a set of playing instructions and an answer key. Since the artifacts would be left with the high school, the game instructions contained both a short version (game could be completed in ~20 minutes) and long version (~1 hour) as the time available to play would vary. Once the game pieces were completed, the group invited some classmates from outside of the cohort to test the game to assure that the instructions were clear and if the questions matched the answer key.

All three artifacts were taken to Woodridge High School. The cohort introduced themselves and then showed the video and diorama. This display was followed by cohort moderating the game as the high school students played it (Figure 2). All three artifacts were well received. In fact, the artifacts have already been used in another science class at Woodridge High School.

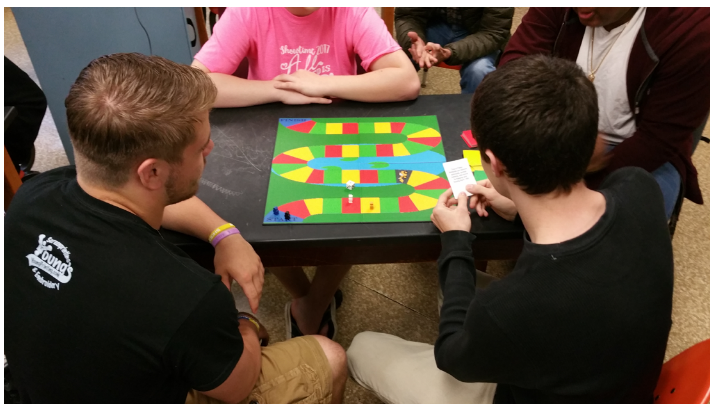

Figure 2. High school students playing wetland board game (students' faces were purposefully obscured).

Project issues

A key issue faced by many teams is knowing when to start on a prototype or preliminary design. Too often students get stuck in the 'literature review rut' where they keep looking up background information. This issue is often attributed to the fact that the students had started a new tangent of study and were not confident in what they have learned to date. As this group had sufficient background in literature searches, continuing this task was easier for them, and they wanted to keep looking up journal articles as it did not take up much time.

A problem with most team work is that at least one member does not pull his/her weight. Some educators refer to this situation as 'social loafing.'[18] In this project the issues were addressed in several ways. If the situation was not critical to the other team members, it was addressed by a one-on-one meeting with the faculty mentor. If this meeting did not change the behavior, or if the missing assignment was an essential element for the entire team, another team member often volunteered to complete the task(s). For this project, the student that performed the extra work earned extra credit. Another aspect that arose with the game team was that the shiest members often were content to get 'lost in the crowd.' We found that a successful approach was for the faculty mentor to facilitate participation by having each group member state what was the most interesting item that he/she learned over the past week. The update was done at the beginning of the class so that the information could be shared with the entire cohort.

Within the context of this project, students soon found that each discipline could use different terminology to describe similar phenomenon. These terminology differences led to some initial confusion between team members. Yong et al.[20] found that communication issues from discipline jargon was a key issue in team conflicts. During project updates the team member was required to define what he/she meant by a term before continuing with the discussion. By the end of the spring semester, the faculty mentor observed several of the cohort using the same approach during informal updates.

A common issue with any open-ended project is that there is 'not enough time' to work as a group. Team members must actually have time to collaborate if they are going to effective teams.[18] The one credit class was essential in providing time for each team to meet. Allen et al.[21] reported that using a portion of class time for team work enabled students to put more time into the project and advanced team's vested interest. However, supervising the team was essential to ensure that the time was used productively, especially for larger teams. For the faculty member, this led to the issue of how to be in more than one place at a time. To address this, the meeting location was changed while the diorama was being constructed so that game team could still advance on their artifact. Although the responsible members of each team would work regardless of whether the mentor was present or not, providing supervision helped minimize the amount of social loafing done by less dedicated team members. Finding additional time outside of the scheduled class time was difficult for both the students and faculty mentor.

Team development and potential lack of interest in core STEM classes

The NSF project has an external assessment each semester. Part of the assessment evaluated the cohorts' perception of their collaboration and team work. The scholarship cohort had a higher average perceived frequency of collaboration than the control group (non-scholarship students with similar discipline and academic standing). As part of the assessment, the faculty mentor logged observation ratings of collaborative skills in terms of preparation for collaborative work, meaningful contribution to the group discussion, and respect for others. During the spring semester, the cohort was observed as increasing their level of preparation for collaborative work, with the highest number of students (63.2%) demonstrating that they were very well prepared for collaborative work. Likewise, the cohort was observed as increasing the meaningfulness of their contribution to group discussion as the semester progressed, with the highest percentage of students (73.7%) demonstrating a strong contribution by the end of the semester. Finally, scholarship cohort students were observed as demonstrating respect during collaborative work throughout the semester. During the informal discussion with the external assessment team, students said that "*having more opportunity to work on a team and with people in STEM fields*" and "*allowing me to work with engineering students outside my major*" was a benefit to the program. Table 1 contains some of the specific comments students had on the skills they gained in teamwork and in researching a new area.

Table1. Qualitative comments from student cohort on the teamwork and research skills they gained during the sophomore year.

Comments on teamwork skills	Comments on research skills
Have been able to practice delegating work on projects	Exposed to new information and research
Experience working with a group on a project	Developed critical thinking and research skill
Group work experience	It's improved my methods of conducting research
Working with a group on a project	Gained experience in making a professional poster
Working well and mixing with other groups	Creating posters in an educational way
Connections with other students in my major or similar courses as myself which is extremely beneficial as you can help each other out in subjects that maybe troubling for you or them	Introduced research habits

This information in conjunction with the fact that the video team helped with the other artifacts speak to cohort's growth toward becoming an effective team. More time is needed for team development. This fact was not surprising as a multi-disciplinary team often takes longer to "solidify" than teams from the same discipline.[15] With time and as team roles solidify, they will assume greater responsibility and require less faculty supervision.[12]

Although most of the cohort liked working on the educational artifact one stated that he "*did not like that it was an artifact for high school seniors*." It is not clear if the respondent attended the demonstration at the high school. During the demonstration, one of the high school students had asked how the activity helped them (the cohort) with school. Two of the cohort answered that they "*liked the creative outlet*." The biology undergraduate answered that "*some of the researched information was useful in another class*." One of the biomedical engineering students answered that she found that having to specifically identify how she would use a bibliography entry in the project or be used in her discipline very helpful for other classes as she "*could see connections between classes*" and it required "*focused reading*." Other researchers have found that many female STEM students prefer cooperative learning over the competitive and impersonal classroom dynamics of a 'traditional' lecture structure.[19,22]

Conclusions

The overall goal was to assess if the approach assisted with improving the cohort's formation into an effective interdisciplinary team and with reducing the potential loss of interest in core STEM classes. The external assessment and observations showed that the cohort is forming into effective teams. However more time is needed for the collaborative skills to fully develop. The scholarship and course grade was an important component for some non-working team members. As with most open-ended problems, the educational artifact was time consuming. Although the majority of time needed to construct the artifacts was purposefully scheduled to be during the scheduled class time, some of the time was wasted by individual members when they were not being supervised. Overall the use of an educational artifact was more time consuming for the faculty mentor than the student cohort. Even with these issues the activity was still beneficial for team development and helping to maintain the interest of some of the students. A benefit of the approach is that the key activities of a literature search and the development of educational artifacts can be easily duplicated at any university. The cost of making the artifacts can be very inexpensive to costly, depending on what form it takes and the total number that are needed.

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