Vertically Integrated Multidisciplinary Teaming: An Instructional Framework Adapted To A Non-Engineering Course

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Abstract - We present a case study of the use of vertically integrated multidisciplinary teams in a non-engineering general science course. We constructed our teams from students with different majors, genders, and class ranks, reflecting several of the ingredients for effective teaming discussed in the literature. This type of multidisciplinary and stratified team member distribution helped to build a sense of community and shared ownership in the learning process. Our experience demonstrates that vertically integrated teaming concepts can be successfully adapted as an instructional framework in multidisciplinary general-audience courses. In this paper, we discuss content analyses of student journal entries, self-reflection reports, and survey responses.

Index Terms – case study, multidisciplinary, teamwork, vertical integration.

OVERVIEW OF OUR APPROACH

Our overall goals in new course development and dissemination are (1) attracting and retaining high quality students, (2) improving the quality of the undergraduate experience and (3) cultivating the scholarship of teaching and learning. The adaptation of properly implemented teamwork-based instruction to first year courses is one of our initiatives. Using teamwork, especially when teams include lower and upper level students, and/or students with different interests and skills, is our approach. Through teamwork-based instruction, students are encouraged to learn independently in order to support their team. As they develop deeper understanding they also learn trust and respect for their teammates, and begin to network to form personal and professional connections. By improving the quality of their experience we increase the retention of these students. We have previously discussed how effective teamwork results in higher student success in our engineering [1,2] and Honors Physics [3 - 5] courses. In this paper we discuss the implementation of teamwork in a freshmen level general science course.

It is our hypothesis that team based learning, if implemented properly, creates a safe learning environment in which the students will learn to teach themselves. The safe learning environment results from the trust that is developed amongst team members, throughout the entire class, and with the instructor. The effective team-learning environment provides feedback on (and therefore encourages) individual effort and teaming skills, networking, and student ownership. We construct our teams from students with different majors, genders and class ranks, reflecting several of the ingredients for effective teaming discussed in the literature [6,7]. This type of multidisciplinary and stratified team member distribution helps to build a sense of community and shared ownership in students’ own learning.

It has been shown that students’ perceived creativity is related to academic confidence and that this may influence self-esteem and personal motivation to attempt difficult tasks [8]. We are also aware that getting students to think and understand concepts is difficult if they are comfortable with teaching that relies on algorithmic or information-based approaches [9]. Unfortunately, many of our general science courses fall into the latter category. However, everyday inquiry and scientific research both involve learning by doing in a constructivist view of what it means to know [10]. This is the view we take, and the research reported here is driven by the guiding question:

Will team-based instructional methodologies, used successfully with science and engineering students, enhance student participation in their own learning of physical concepts in our general education courses?
CONTEXT OF THIS CASE STUDY

The University of Akron is a metropolitan institution located in the city of Akron, Ohio, USA. It is a state-supported open-enrollment university with about 23,000 students. A completely new version of our general education course “Music, Sound and Physics” was offered in the Fall 2003 semester. Students engaged in activities and peer-instruction during lecture, group based learning in our newly remodeled lab environment, and team projects mentored by the instructor (R.D. Ramsier). Students submitted written technical reports and self-reflection journals, as well as presented team project findings to the class in a poster session.

The course met twice per week in a lecture hall with seating for 110 students. Each class meeting was 75 minutes long, and two learning assistants (one graduate student J. Comito and one undergraduate student T.A. Kittinger) assisted in the activities. Students also had one 50 minute lab per week. There were three lab sections, and students worked in randomized groups of two or three members during each lab. There was a total of ten individual lab reports due during the semester, nine covering hands-on activities and one concerning field trips to local music halls where the students studied acoustic design. Several student assistants were available to work in the lab as well.

Fifty six students participated in the course. Of these, 66% were male and 34% were female; 7% were African American and 93% were white Caucasian. The class rank of the students was as follows: Freshmen 57%, Sophomores 25%, Juniors 7%, Seniors 7%, and post-secondary high school 4%. Their distribution by college was: University College (entry college for nearly all students) 59%, Fine Arts 13%, Arts & Science 11%, Business 11%, Engineering 2%, and 4% (the high school students) that were not officially members of a college. At least 9% of the students in the class were only enrolled part-time, and 18% had transferred to The University of Akron from other universities and colleges.

There were 25 group activities during the semester. These occurred during class time, and groups were sometimes formed by random selection. Performance on group work was based on a “met/did not meet expectations” rating. The class averaged an overall “met expectations” rating in 23 of these 25 activities (92%). Some of the group problems involved the formulation of rules and power law dependencies through which students can understand functional relationships [11]. Dimensional analysis and proportional reasoning was also emphasized in class. These types of problems are difficult for students to wrestle with at first, but provide students a chance to develop a positive physics-related self-concept and to link physics with situations outside the class [12].

Fourteen teams of four members each were assigned by the instructor in the third week of class. The construction of the teams was based on students’ journal entries and academic transcripts, as well as the recorded in-class work. There were 21 total team activities/assignments performed/due during class. These were distinct from the 25 group activities discussed in the previous paragraph. The class averaged an overall “met expectations” rating in 19 of these 21 activities (90%). Many of the early team activities were team-building exercises adapted from reference [6], but students were given no formal instruction concerning teamwork. The final team project consisted of a study of environmental effects on the performance and lifetime of strings for musical instruments. Teams designed their own experiments and often worked outside of class. Teams studied various effects and properties of strings made of different materials, such as wear, mechanical and thermal fatigue, corrosion, and tensile/shear strength. A poster presentation culminated the semester. Project- and experience-based learning is a well-known concept [13 – 16], but is generally not used at the freshmen level in general science courses at large universities. This gives us a unique perspective from which to study the influence of teamwork.

CASE STUDY OF “SALLY”

Here we present a case study of one student’s experiences in this course via purposeful sampling. “Sally” is a pseudonym for the female student we will be discussing. Sally has rich journal entries that make her an exemplary candidate for study. Sally is a freshman in the University College, is white Caucasian, and enjoys singing and performing. She wants to major in broadcast journalism. Sally was placed on a team with Bill (pseudonym), who is a freshmen in the University College, is white Caucasian, and who likes computer programming for video games. Joe (pseudonym) is a sophomore also in the University College, but is a part time student (less than 12 credit hours per semester) with a child to care for. Joe wants to be a musician. The final member of Sally’s team is Amy. Amy is an African American student majoring in business. She is a senior, and has a busy life taking 23 credits (a normal full load is 16 credits) and a child to care for as she prepares to work in real estate or tax accounting. This team’s individual scores on the in-class group and teamwork are, respectively, Sally: 100%, 100%, Bill and Joe: 96%, 95%, and Amy: 84%, 81%. Thus the most junior members of the team performed above the class average, whereas the most senior member performed below the class average.

Sally’s journal entries on the first day of class in response to prompts include:

Prompt: Describe what kind of career you are pursuing or thinking about pursuing, and explain why these are appealing to you.

Response: “I am a performer. I love to sing, but it is not the easiest way to make a living; that’s why I am here. I would like to major in communications, something along the lines of broadcasting journalism. I am in this particular class though because of the general requirements I need.”
Prompt: Describe what type of person you are, and what personal goals you have set for yourself.

Response: “I am overall a fun person. I love to laugh and make others laugh as well. A goal of mine is to become a better student academically. I am an average student but I really could try a lot harder and not get frustrated so easily. I have no motivation to do well with school. To be honest I hate the stress it gives me.”

Prompt: Explain why you are at The University of Akron and how you expect your experiences here to prepare you, on not prepare you, to meet your own personal and professional goals.

Response: “I chose The University of Akron because it was the closest school to commute to besides Cleveland State [University]. I would never be able to live the “dorm life”. I really don’t know what to expect from my experiences here. I just assume that I will get the education necessary to move on in my life as far as a job or career goes.”

Prompt: Explain why you are in this particular course, Music, Sound and Physics.

Response: “I chose this particular course to fulfill my general requirements because I saw music & sound. The physics part I am not sure what to expect. [I] never even took physics in high school.”

Thus we see that Sally has not really committed to a major, but recognizes the necessity of further education. She also recognizes that her attitude affects her own learning, but has not taken ownership of her own learning. Sally also holds a common student misconception that having a prior physics course will make a vast improvement in their performance in physics at the university level [17].

When asked to compare and contrast how a group of people works vs. a team of people, Sally provided a very thoughtful response. This included that groups may form at random and the members may not know one another very well, whereas teammates know each other better, are more prepared, and work toward a common goal. During the second class meeting, Sally provided another interesting glimpse of her thinking:

Prompt: Compare and contrast the meaning of the words, sound, music, and noise.

Response: “This is an interesting question, because I always looked at music as being noise, but I looked at it as is a pleasant noise; depending on the song of course! Music produces sound, or is the sound the music? I guess it depends on the way you look at it. “The hills are alive with the sound of music””. This indicates that Sally recognizes that there are different ways of knowing.

After solving a simple group problem, students journaled about when working with others to solve a problem is necessary, and whether this was one of those times. Sally’s feelings were: “I think it is necessary simply because more minds is [are] always better than one. Even though the problem may be fairly simple, it is always nice to know that you got the same answer as someone else did. If one day the problem is harder, someone in the group may be able to help someone else that may not understand how to solve it. I think this was one of those times just so you know you did the problem correctly.” This indicates that Sally recognizes the positive interdependency that members of a group or team share.

In week two of the class, when asked to describe what “well-balanced” means in the context of teams, Sally responded: “I think in the context of teams, that well-balanced is adding a little of everything to the group. Each individual in the team brings something different to the table. (This assuming that each team member will participate). Each person may look at situations in a different light making things more interesting.” Thus Sally understands the necessity of having team members with different skills, as well as the need for full participation by everyone.

In the third week of class, students were asked to describe how they feel about the class so far. Sally answered: “Honestly, I am a little nervous about this class, because I feel like I don’t have the same science background as others may [have] had. My mind doesn’t work in that “scientific way”. It will just take a little more from me to understand what exactly is going on and why. … I just have to get in the physics state of mind.” Here, Sally emulates what Smith and Anderson call a “Wonderer” [18]. A Wonderer rarely feels that they know what is going on in a science class, gets frustrated when they fail to make personal sense (construct their own knowledge) of the content, and are uncomfortable about making science claims or statements.

However, Sally demonstrates good teaming qualities by completing the statement “What I can do to help all of my team members be successful is…”, with: “If at any time I can help my team members with a problem, do it. Remind each other when deadlines are due. Keep everyone motivated to do well and keep up with what is being taught in the lecture. Also, obviously because we are part of a team we need to keep in mind that we are part of helping the other team members in being successful.”

After the first quiz during the fourth week of class, students made journal entries about their feelings concerning their performance. Sally’s response was: “I am not so sure how I did on this quiz. Sometimes I think I have the right idea but don’t know how to express it on paper or in “scientific words”. Most of the time, I don’t even know what I’m talking about…” These statements echo the “Wonderer” interpretation of Sally discussed above, and are consistent with her “very strongly disagree” response on an attitude survey we administered to the statement “Engineering/Science would be a highly interesting profession for me”. Sally, at this
point in the class (weeks four and five), does not feel that she can do science herself.

However, when asked if she feels that her team is well balanced, she is very positive: “I think that we are. We all bring different things to the group (ideas and attitudes). But, it is all good things, not bad. Different is good!” Additionally, when given the situation that there are two categories of potential team projects: 1. doing old things better, and 2. doing new things, she states: “I think that I would rather do new things now, because I will have the rest of my life to do old things better. So at this point in my life I would want to try new things. Why not?” Thus, although her personal self-confidence in the class is low, her willingness to try new things with her team is high.

About mid-way through the semester, Sally writes about the process of journaling:

“Journaling in this class has been helpful. I believe it is a good way for us to voice how we feel about this class, or any trouble we may be having, etc. It is a good way also for you [the instructor] to get to know your students on more than just an academic level. This also helps you to teach us based on what everyone writes…”

About three-fourths of the way through the term Sally is demonstrating the feeling of a safe learning environment that we desired:

“I think the most important aspect is the more laid back atmosphere that we are in. Not laid back in a bad way, but in a good way. I feel more comfortable asking a question or saying I don’t understand than I would in my other classes. I think that is important.”

Finally, during the last week of class, Sally provided the following:

Prompt: Describe what you have done in this class that you think will make a meaningful difference in your life.

Response: “I definitely learned that it is OK to ask questions when you are unsure of something. In the long run you are better off knowing than not knowing. I always thought my questions were stupid, but now my mentality is “that is how we learn”.”

Prompt: Look through your journal for a few minutes and think about the entries that you made. Describe how this makes you feel.

Response: “I think that reading all of these entries is kinda funny to me. Some of the earlier entries I was talking about how I didn’t think I was going to do well in this class, etc. Now it is the last day of class and I feel that I did pretty OK for not being a real “scientific person”. Hopefully my grade reflects this!”

We interpret these last remarks as an indication that Sally has gained self-confidence in science because of her experience in this course, and that she has engaged in “quality learning” as discussed by Brass, et al. [19]. Focusing here on the teeming aspects, Sally’s final reflection on the team project includes: “…Besides what we learned through the experiment, I learned how to work with different types of people to produce a common goal. I thought that our team worked exceptionally well together throughout the semester. It was a good balance. No one let anybody down in the group as far as producing the work they needed to do or being lazy. Everyone contributed in a productive manner. I think that the team project was a good way to break up the class time spent together as well as the work that needed to be done outside of the class. It was not a class you had to take notes throughout the entire time. I definitely feel that the team project was a good way to integrate working with people and learning physics…”

SUMMARY DISCUSSION

The concepts of “reflection in action” and of a “reflective practitioner” were developed by Schön [20]. We find content analyses of free-form journal entries and end-of-term reflection statements very revealing. We feel that self-reflection statements indicate that students analyze information and put it into the context of their own learning in a constructivist way. For the teeming part of the course, in addition to learning the physics and engineering-design aspects necessary for their specific project, students also engaged in workforce training scenarios. For example, students become directly involved in considering costs and safety. They also learn to access resources needed to complete their projects, including sources of information and technical support. Finally, the project compels them to practice teeming and give a professional technical presentation. All of these skills are required in today’s workforce, and this part of our course has a positive impact on students.

For end-of-term anonymous surveys, students assign a letter grade (A, B, C, D, or F) by hand to statements about the course, where A is excellent/strongly agree and F is terrible/strongly disagree. We score the responses as A and A+ = 4.0, A- = 3.7, B+=3.4, B=3, B-=2.7, C=2, D=1 and F=0. The averaged results concerning teeming are presented in Table I.

Note that these data are consistent with our previous findings in Honors Physics for engineering majors [3,4]. This justifies our position that teeming can be taught to and used to teach all students. In addition, it argues that the content learning and affective impact of team projects should be experienced by every student during university coursework. It is obvious from the first entry in Table I and our reading of all the teams’ binders and students’ journals that some students did not participate fully in the teeming. This is always a problem with team assignments, and a fact of life that students need to learn to cope with. The fact that the second entry

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scored lower than we had hoped probably has to do with the course being developed “on the fly” as the term progressed. Next year the course will be more structured and we will have more time to spend helping the students learn to organize.

We feel that the student responses in Table I demonstrate that our efforts at organizing the teams with different majors, genders and class ranks were successful (entry 3), and that the students learned to take on a challenge, to communicate, and to work with others in ways they did not anticipate (entries 4 – 7). Most importantly, entry 8 shows that we were able to incorporate multidisciplinary efforts into this project that allowed for student creativity and ownership (entry 9). The student responses to entries 8 and 9 are very important. Getting students actively involved in doing science is key to recruiting them into and retaining them in the field. If we can do this in our general education courses, we should be able to make an impact not only in the number of science majors, but in the number of non-science majors that have a true sense of what science is. The broad impact and the fact that we are extending engineering team concepts to all students are what make this work worthy of dissemination to the educational community.

ACKNOWLEDGMENT

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TABLE I.
AVERAGE RESULTS OF SURVEYS (49 RESPONDENTS)

<table>
<thead>
<tr>
<th>Entry</th>
<th>Item Description</th>
<th>Score</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>The teams were well balanced by the motivation and dedication of the team members.</td>
<td>2.80</td>
</tr>
<tr>
<td>2</td>
<td>The teamwork parts of this course helped me learn to organize.</td>
<td>2.89</td>
</tr>
<tr>
<td>3</td>
<td>The teams were well balanced by the skills and areas of interest of the team members.</td>
<td>3.10</td>
</tr>
<tr>
<td>4</td>
<td>The team project part of this course was a worthwhile challenge.</td>
<td>3.12</td>
</tr>
<tr>
<td>5</td>
<td>The teamwork part of this course helped me learn to communicate with others.</td>
<td>3.15</td>
</tr>
<tr>
<td>6</td>
<td>The teamwork part of this course helped me learn things I never expected in a course like this.</td>
<td>3.15</td>
</tr>
<tr>
<td>7</td>
<td>The teamwork part of this course helped me learn to work with others.</td>
<td>3.19</td>
</tr>
<tr>
<td>8</td>
<td>The team project part of this course incorporated different areas of science and engineering.</td>
<td>3.37</td>
</tr>
<tr>
<td>9</td>
<td>The team project part of this course allowed for student ownership and creativity.</td>
<td>3.49</td>
</tr>
<tr>
<td>10</td>
<td>The support and guidance we received for the team projects was appropriate.</td>
<td>3.65</td>
</tr>
</tbody>
</table>

REFERENCES