

Participation and Learning Relationships: A Service-Learning Case Study

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In a traditional classroom setting, students come in, find their seats, and begin to take notes from a lecture. Possibly, for variety, they complete a worksheet, or work on a textbook assignment. Each of these traditional classroom activities is intended to help students learn the course content and in turn help them achieve some desired course grade. In this scenario, grades become the primary motivator for students to learn, and it is grades which spur the students to participate in classroom activities and discussions.

Now imagine a different classroom—a classroom where students enter ready, motivated, and eager to master the days content not because of a fear of poor grades, but because of an internal desire to help others through participation in a class service project. In this classroom, the students understand that they *must* learn the appropriate skills found in the course content in order to better complete their service objectives, which are also—and not coincidentally—the course learning objectives. Here, students apply their newly learned skills towards the completion of a class service-learning project.

Background

Brewster and Fager (2000) discovered that as students reach the upper grades, student disengagement from classroom learning becomes more frequent and is more pronounced. Using token rewards, such as candy or parties, to encourage students to complete a required assignment in a timely manner is entirely unproductive. However, students whose motivations are

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intrinsically founded are more likely to succeed (Brewster and Fager, 2000).

Much research has been compiled on service-learning, its benefits, and its influence on intrinsic motivation (Giles and Eyler, 1994; Batchelder and Root, 1994; Osborne, Weadick, and Penticuff, in press). Dewey (1938) states that students tend to learn the course content associated with a service-oriented activity when they make a connection with its cause. Other literature on this subject also suggests that the benefits of engaging students in a service-learning activity can induce greater retention of course material because the students begin to see the relevance of their learning as it pertains to real life experiences and issues (Dewey, 1938; Kinsley and McPherson, 1989; Verducci and Pope, 2001).

Service-learning has been around for many years, although it has not always been defined and labeled as such. It was not until the mid 1980s that the term “service-learning” established its roots (Stanton, Giles, and Cruz, 1999). Service-learning is not the same as service. To label a learning activity service-learning, it must be associated with a learning goal or objective that pertains to the curriculum. (Chapin, 1998). As defined by the National and Community Service Trust Act of 1993, service-learning is a teaching strategy by which students learn and develop through active participation in a thoughtfully organized service.

Service-learning is closely associated with experiential learning, hands-on learning, or active learning (Dewey, 1938; Kolb, 1984). Listening to a lecture or a presentation is not necessarily active learning (Chickering and Gamson, 1987). Active learning refers to techniques in which students participate in actions that involve discovering, processing, and applying information (McKinney, 2005). Active learning stems from two basic concepts of learning styles: (1) that learning is by nature an active endeavor and (2) that different people learn in different ways (Meyers and Jones, 1993).

Project-based service-learning emphasizes learning opportunities that are interdisciplinary, student-centered, collaborative, and integrated with real-world issues and practices (Bradford, 2005). Teachers tend to agree that learning

environments that foster academic achievement through hands-on, authentic learning motivate students by engaging them in their own learning process (Brophy 1986).

Service-learning may also involve the “just-in-time” teaching approach, which disseminates information when the learner finds it most relevant and applicable and which takes advantage of that moment when student motivation to learn is at its peak. The “just-in-time” approach also results in overall higher retention rates because application of learned knowledge closely follows knowledge transfer (Berglund, 2004). According to Berglund, a “just-in-time” knowledge-transfer system should mirror the interaction of a student with a tutor by providing real-time assessments, dynamic feedback, and chunked and vetted knowledge.

Service-learning has been used as a method of teaching content in science education, civic education and history, business and marketing education, as well as other areas. However, a review of the literature found no service-learning studies that focused on student engagement or commitment to learning in a high school construction technology classroom setting. Likewise, while the many project opportunities for students make construction technology a natural setting for service-learning, there is an absence of research on how service-learning projects and/or activities promote the course content for construction technology. There is insufficient data available to determine if, in a construction technology classroom environment, a service-learning methodology is effective in engaging student learning.

This qualitative case study of a service-learning experience conducted among secondary students in a construction technology course addresses this lack of research. Data was informally collected during this case study to evaluate whether service-learning projects appear to help motivate and engage students in the learning process and whether students effectively learn the course curriculum and content objectives while participating in class service-learning projects. The study was conducted in an attempt to understand the relationship between students’ commitment to a service-learning project and their commitment to learn the associated course content.

Study Methods

Study Population

The study population was characteristic of similar high schools within the same general area and demographics. The city in which the high school is located has a population of approximately 14,000, and has shown a steady increase in population over the past few years. It is a rural northwestern United States city with a rich agricultural tradition. The socio-economic face of the city is at the lower end of the middle-class scale in average earnings per year, with an average yearly salary for an adult living and working in the area of roughly \$19,000 per year.

The study group consisted of students enrolled in a construction technology class in which the students participated in a service-learning project. Participants consisted of high school students, ages 14-18. While some of the students had elected to take the construction technology course, others were placed in the class by their counselors' direction. Consequently, the class contained both students who had chosen to take the course as well as those who were assigned to it. The course was offered as an elective to students, and students were permitted to take the course as many times as desired.

The population of the study group consisted of 22 males and 3 females. Of this sample, 7 students were on an individualized educational plan, 6 of the students were considered English language learners, 15 of the students were Caucasian, 9 were Hispanic, and one was Asian. This was reflective of the community's ethnic make up, the student population for the high school, and of those students who generally enroll in this type of class.

Methods

The case study took place during the beginning two weeks of the second trimester. The unit objectives for this period of time dealt with learning how to safely operate the laboratory machinery. Traditionally, the instructor taught the safe use of the equipment and machinery through lecture and demonstration, which was followed by a safety test to assess the students' level of understanding.

During the service-learning project, instead of the traditional demonstration/testing method, the instructor used the “just-in-time approach” with the study group. This meant that the students received instruction on the equipment and machinery when they found it necessary and relevant. Students were instructed on the procedures and rules for the use of each machine and/or tool as they needed it to complete their projects. In place of the traditional safety test, the instructor developed rubrics for assessing students’ knowledge of the unit objectives. Rubrics were established for the eight different laboratory machines. By evaluating the rubrics, students were categorized as unsatisfactory, satisfactory, or proficient in their ability to safely use each associated piece of machinery.

The researcher used these rubrics, along with observations, interviews, and student surveys, to assess (a) the students’ level of knowledge of how to safely use the construction technology machinery (b) the differences before and after the service-learning unit in the students’ perceived confidence in the use of the laboratory equipment, (c) the differences before and after the unit in the students’ perceptions of their knowledge of four content areas, and (d) the students’ motivation during the two-week unit and how their motivation affected their confidence levels. The data were collected mostly informally through the rubrics, pre- and post-surveys, interviews between instructor and student, peer evaluations, and instructor observations.

In this study, several methods were used to facilitate a learning atmosphere. The three main approaches were the non-directive approach, the “just-in-time” approach, and the interdisciplinary approach. The non-directive approach gave students the liberty to decide on the how they would spend their time in class, what projects (if any) they wanted to build, and when they would complete the project. By waiting for a student to ask how to use a particular lab tool, the instructor applied the “just-in-time” approach to teach the students how to use the lab machinery or equipment safely. Usually, this occurred at the time a student had need of a particular tool or piece of machinery. An interdisciplinary approach was incorporated because the instructor decided to invite the art class to help paint the toy blocks that the construction technology students were making.

The art class students painted numbers, letters, and symbols on the wooden blocks.

The instructor of the construction technology class also found ways to implement curriculum from other disciplines into the service-learning unit. For example, the construction technology students used math concepts when they needed to measure lengths and when plans for their projects required them to add and subtract fractions.

Instructor's Narrative of the Process

At the beginning of the second trimester, students were welcomed to class and presented with a choice of how to begin the first two weeks of the trimester. Typically, in the first two weeks of the course, students are shown how to safely operate the machinery in the laboratory. I talked to the students about the possibility of doing some kind of project for the community as a way of introducing the course content instead of the traditional method of demonstrating, memorizing, and then testing. This idea, to start off the trimester with a project instead of with the anticipated test and quizzes, was introduced on the first day of class and seemed to grab the attention of the students.

I presented the students with two different choices: They could choose to either begin class with the standard safety test, tool identification test, and demonstrations and lectures on how to run the equipment, or they could choose to begin the course with a service project, which would provide the motivation for the students to learn the curriculum. The students seemed willing and even eager to work on a project instead of the traditional alternative. At this point, I detected a rise in the excitement level in the classroom.

A vote was held to assess the desires of the class. Each student submitted his/her anonymous vote as to how they wanted to begin the trimester. The votes were then tallied and the decision was unanimous in favor of the service project. One student asked, "How soon can we start?"

I told the class, "Let's start right now."

I heard comments in the class such as, "I can't believe we get to start on a project already" and "Hallelujah, no busy work."

The next step was to choose an appropriate service-learning project that would meet the objectives of the course. In the construction technology class, students are expected to learn how to safely operate machinery, such as the band saw, table saw, radial arm saw, drill press, planer, joiner, and hand tools. Course content also includes learning how to plan, construct, and finish a project while working in a cooperative group setting. I wanted the students to decide on a service-learning project that would incorporate all of these skills and techniques and one that would qualify as a relevant learning experience.

I had the students form groups of three to discuss some possible service projects to do. The groups of students were asked to come up with a list of ideas and/or options of how best they could meet the needs of others in their community while simultaneously accomplishing the class requirements. During this period of brainstorming the students came up with several creative ideas. Some of the ideas included tearing down an old hospital in town, building benches for the school, restoring parts of the rodeo grounds, and making gifts for Christmas.

The class was then presented with all of these different ideas. The students discussed collectively the pros and cons of each idea. The project ideas that did not meet the class objectives, we eliminated from the list. Some of the students felt overwhelmed with the possibility of taking on one of the larger projects. One student commented, "We'll never finish if we try to do something big, like tear down the old hospital."

In the end, the students choose to do a service project for the first graders of a local elementary school. The elementary school chosen was located in a lower socio-economic district and was within walking distance of the high school. This class of high school students felt that they could most benefit the first graders of this local elementary school by building a variety of small toys that would be ready to be delivered on the last day of school before the Christmas break. This allowed only two weeks for preparing, designing, manufacturing and assembling, finishing, and delivering the product.

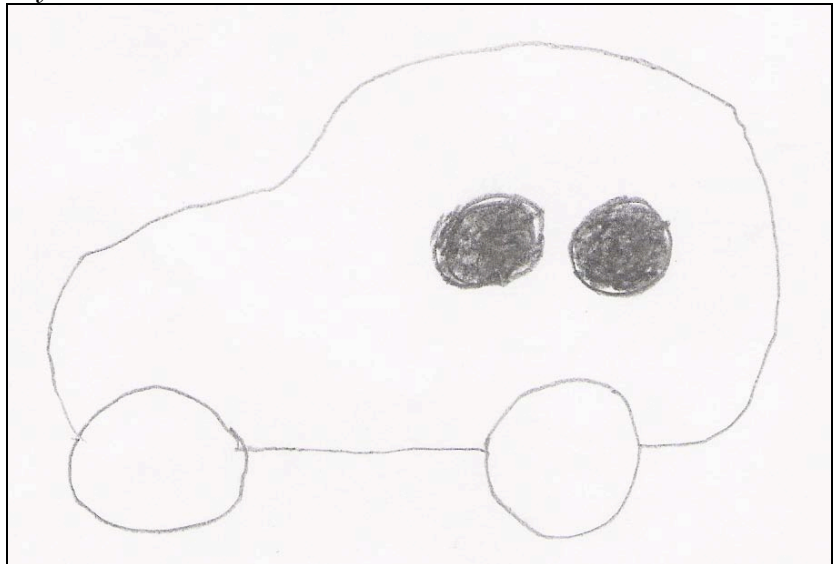
Once the project, the school, and age of the recipients were decided upon, I assigned each group the task of coming up with some possible wooden toy ideas. I asked each group to start

thinking about a practical toy design that we could make for the first graders. When the bell rang for lunch, students were still talking in their groups about what they could make for the elementary students. I was impressed by the class's willingness to serve. Two students stayed after the bell had rung to discuss some options for toy designs. After this first class, I felt that the students were excited and motivated to participate in this project. The next day, many students came to class with pictures of wooden toys that they had looked up on the internet at home. Some students even had some hand-sketched drawings of toy designs (see Figures 1 and 2). The amount of time the students spent out of class, working on ideas for the project, indicated that some of the students were already committed to the idea of the service-learning project.

I had set up a short visit with the elementary students for this second day of the project. I collected the toy designs from the students, asked them to get back into their groups, and to come up with some survey questions that they could ask the

Figure 1

Toy Car Sketch

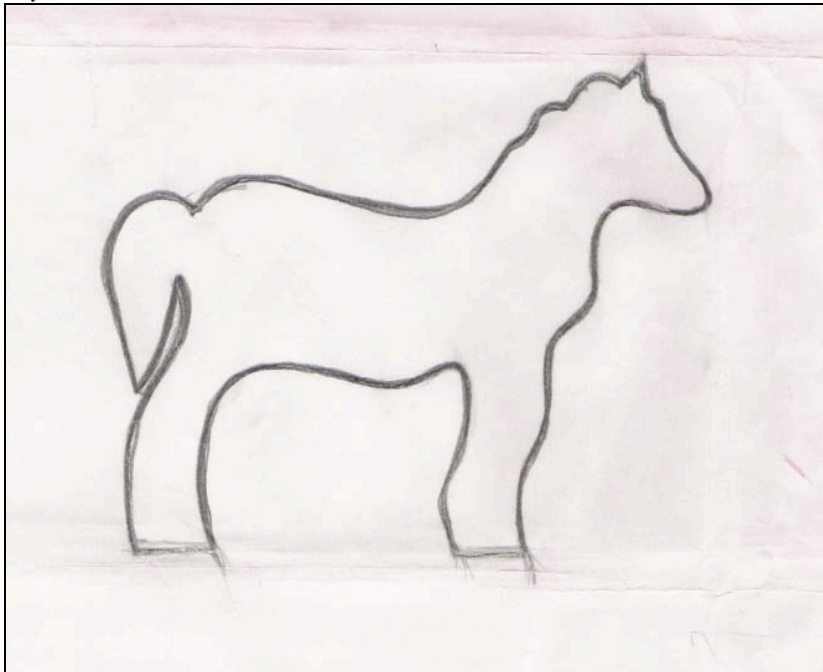


elementary students during the visit. This visit and survey had a two-fold purpose. The first and most obvious reason was for the high school students to get an understanding of what first-grade children would like for Christmas. The second reason was so that the high school students could make an emotional connection with the first graders—a connection which could help them see the relevance and importance of their service. To inspire this intrinsic attachment was one of my intended motives for the survey and a necessary part of any service-learning project.

Once the students wrote down the questions they were going to ask the younger children, we walked as a class to the elementary school. As the high school students strode toward the elementary school, one student said, “I wish we did this kind of stuff in every class.”

Figure 2

Toy Horse Sketch



Spirits were high with excitement as the high school students entered the elementary school. The first grade teachers had gathered all 90 of their children into one room where the high school students could meet and talk with them. This surprised me because I was under the impression that we were only going to meet with one class of 30 students. I felt a bit nervous at the thought of having 90 toys to make instead of 30. I noticed that the high school students were feeling some of my unease as well. I overheard one of the high school students say to his friend, "You go ahead and give them the interview, I'm just going to hang back here." I also caught some of the students glancing back and forth to one another as if they were saying "you go first."

Eventually, the high school students began their interviews. At this visit, the high school students worked in groups of three to survey and interview the first graders on their likes and dislikes. Gradually both the high school students and the first graders began to get to know one another.

As I observed the interview process, I noticed that three of the high school students were still at the door, not participating. When I tried to encourage them to get involved, one student said, "No way, I'll just wait here until we're done." The other two students just shook their heads as a way of expressing their unwillingness to take part.

When I asked the three students why they did not want to participate they all said, in turn, "I don't know." These three students might have been uncomfortable with the new situation and surroundings or may have not been interested in the project to begin with. I could not identify the reasons these students chose not to participate in the interview process of the project. (All three students did end up helping with the manufacturing of the toys and were present when the toys were delivered.)

On the walk back from the elementary school the attitudes of the students were subdued and reflective. Most of the students spent the time discussing the answers that the children had given them. Some talked about how many of the first graders wanted to get a simple toy doll or game. One student said, "I am surprised that they didn't ask for a bike or 'PlayStation,' like I would have done at their age. In the group of kids I talked to one wanted a Barbie Doll, two kids asked for a 'Bratz Doll,' and the

other one said she wanted a puzzle. I can't believe that's all they asked for."

Another high school student commented to me that he was surprised by what one girl asked for. He said, "She asked for a coat for Christmas." Even though he could not afford to buy her a coat, he seemed emotionally willing to help that student have a happy Christmas by surprising her with a toy. He told me, "I would love to go to the store and get her a coat if I had the money. But, the next best thing, I guess, would be to make sure she gets a toy from me."

Another student also told me that the first grade student he talked to wanted her "Dad to come back home for Christmas." I noticed how the high school students wanted to help these first graders have a great Christmas even though they understood that they couldn't give them all what they wanted. I realized that the high school students were emotionally concerned and connected to this service project as I heard their comments and felt their enthusiasm for serving the children they had just interviewed.

After we returned to our classroom, we discussed what we had learned. The students seemed to understand the significance of the project. As one student commented to the class as a whole, "We have got to get these toys done on time or we will disappoint a lot of kids." The students collectively seemed to understand the importance of serving the first grade students and recognized the impact they could have on the elementary students by making each child a toy for Christmas. Even though the first graders had been unaware of the reason for our visit, the high school students felt it necessary to give all of the first graders a toy. Initially, the high school students plan was to select one class to make toys for, but after the visit they wanted to help all 90 students, tripling the anticipated number of toys to build.

Now that the class had a general idea of what the first graders would like to get for Christmas, the designing phase of the process began. While some students were very creative in their toy designs, I felt that with the time constraints and with money being an issue, we had to focus our energies on building the toys from more simple designs. Ultimately, students decided

to design and manufacture toy blocks, trains, rabbits, unicorns, horses, and mini-catapults.

Next, the students manufactured the custom designed products. As the students began this process, I was concerned that we would not get finished with all of the toys by the time they were to be delivered. But, as I overheard the students encouraging their peers with words like “Make sure the bodies get cut out by tomorrow,” “Give me a hand with sanding these blocks,” and “We’re going to make the deadline,” I started to believe that the toys would be finished on time.

In manufacturing the toys, the students found they required specific skills and information to help them complete their projects. Students needed to learn how to safely operate the band saw, table saw, radial arm saw, sander, drill press, planer, surfacer, and various hand tools. Many of the students asked me to supervise them the first time they used each piece of machinery. I wanted the students to ask me for initial help so that I would be able to see if they were working with the equipment and machinery safely. Besides learning how to operate the laboratory tools and equipment, the students needed to know how to correctly use a tape measure and how to add and subtract fractions. The students required these skills in order to successfully accomplish their goals for the service-learning project. In addition, learning these skills fulfilled the unit objectives for that portion of the curriculum.

In the finishing stages of the manufacturing process, the students needed to learn how to correctly prepare the surfaces of the toys that were to receive a non-toxic finish or paint. The students also had to know how to apply the finish to the toys. The toys could be finished in a variety of ways, including polyurethane finish, Danish oil finish, acrylic paints, and water-lock finishes.

Students were assigned to different jobs as demand called for them. For example, when one group had cut out and routed all of the unicorns, horses, and rabbits, students from other groups who were caught up on their jobs, joined in to help with the sanding of those toys. Given the two-week time constraint and the 90 toys that needed to be completed, each student had many opportunities to contribute in many different ways to the project. All of the steps had to be accomplished by the deadline; otherwise

the first graders would not receive their Christmas gifts on time. This deadline motivated students to work diligently and not to procrastinate at any stage of the project.

As I talked with the students I could see how committed they were to working on the projects and getting the toys completed on time. One student expressed this commitment when she said, "The only reason why I came to school today is to work on this project." Another student commented, "This is the best class in school, because we actually do stuff instead of just sit there listening to boring teachers talk about themselves."

The end reward for their efforts came with the last step—delivering the toys to the first graders on their last day of school before the Christmas break. The high school students decided to dress up as elves—one student even dressed up as Santa—to present the gifts. The students were eager to deliver the toys. I was impressed with how hard the students had worked on their projects and how they dug in to meet the deadline that they had set for themselves.

At last, we piled up all the toys into one big cart and pushed them over to the elementary school. What a sight we must have been! A group of high school students dressed as elves and one Santa walking down one of the busier city streets pushing a cart full of wooden toys.

As we approached the elementary school the younger students were out at recess playing. When they saw "Santa," they began screaming and shouting out of excitement and surprise. It was fun to watch the faces of both the younger students who would be receiving the toys and the older students who built them. The high school students presented the toys to the first graders as they came up to sit on "Santa's" lap and tell him what they wanted for Christmas.

After all the construction technology students' effort to build the toys and deliver them to the younger students, it was a great reward for the high school students to see the children's enthusiasm and hear their words of appreciation. I overheard my students say, "This is the best class I've ever taken in high school;" "Look at how happy these kids are to get the toys we've made!" and "I hope we can do this again every year." I believe

Figure 3
Finished Toys



that this will be an experience that both the younger and older students will remember and reflect upon for a long time to come.

Findings

At the conclusion of the service learning project, the instructor considered the student interviews, personal

observations, the results of the pre-and post surveys, as well as other informal assessment measures in order to determine whether the students had mastered the unit objectives on the safe use of the lab machinery. The instructor also evaluated to what extent the students' confidence in the use of the machinery had increased during the two-week period and how much knowledge the students indicated they had gained in four content areas. In addition, the instructor sought to appraise the relationship between the students' motivation and commitment to the project and their stated confidence in their ability to use the machinery.

Student Mastery of Unit Objectives

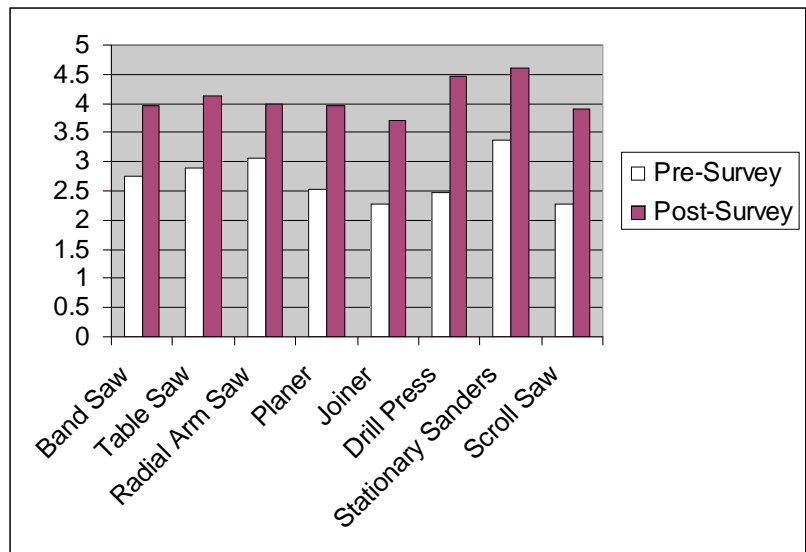
The instructor formally evaluated the students twice during the two-week service-learning experience by asking the students direct questions concerning the proper and safe processes and procedures for operating the laboratory equipment and machinery. From their responses, the instructor gauged whether or not the students understood how and when a piece of machinery should be used. In addition, the instructor informally assessed the students daily by observing them as they used the equipment to complete the building of their toys.

At the end of the service-learning project, it appeared from these evaluations that 19 out of the 25 students in the class (76%) had learned how to operate the laboratory equipment safely and had satisfactorily mastered the course unit objectives. This was on a par with the results in another construction technology class that the same instructor taught in the traditional lecture/testing format during this same two-week period.

Student Perceptions of Confidence

Two surveys, a pre-instruction survey and a post-instruction survey, were administered to the students in the service-learning class to assess their perceptions of their confidence in the use of the lab equipment. The survey asked the students to evaluate how confident they were in operating the following equipment: band saw, table saw, radial arm saw, planer, joiner, drill press, stationary sander, and scroll saw. The students ranked their responses on a five-point Likert scale with 1 representing "no experience and never been shown how" and 5

Figure 4
Students' Perceptions of Confidence in Use of Machinery



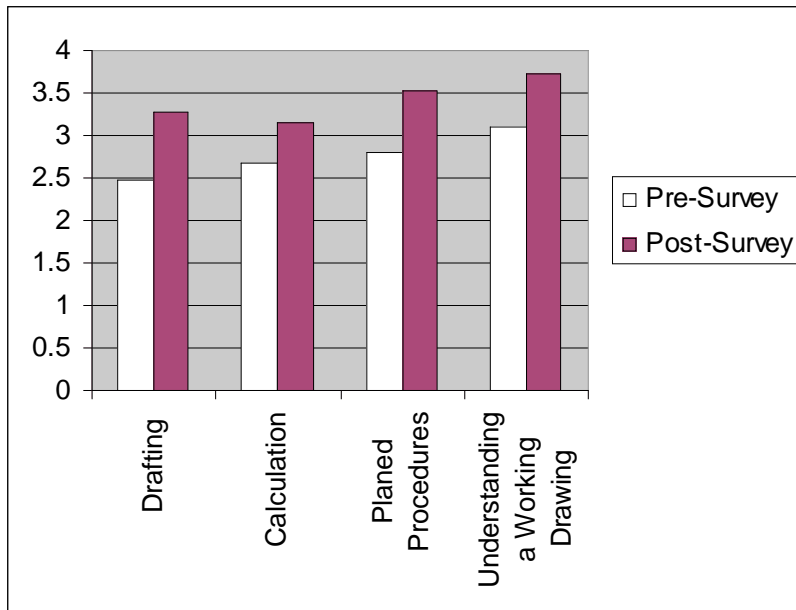
representing “very confident, no help needed and feel very safe in the process.”

At the conclusion of the service-learning project, differences in the pre- and post-surveys were analyzed. The compilation of the survey data showed that after the service-learning project, the class’s average confidence level had increased in the use of all eight of the laboratory machines. In verification of the students’ own perceptions of increased confidence, the instructor observed an increase in student aptitude and skill level for each of the eight different pieces of equipment or machinery.

Student Perceptions of Knowledge of Content

Additional questions on the pre- and post-surveys asked the students to indicate their perceptions of their knowledge in four content areas: drafting skill, calculating the cost of materials, the process of writing out a plan of procedures, and reading and understanding a working drawing. As shown in Figure 5, in this

Figure 5
Students' Perceptions of Content Area Knowledge



portion of the survey, while the students indicated an overall gain in their content area knowledge from pre- to post-survey, the increase was less overall compared to the increase in their confidence in the use of the laboratory machinery.

One reason for the students' lack of a sense of increased content knowledge could be due to the small amount of time the students spent in active participation concerning these four concepts. Although, the class had opportunity to practice working out a plan of procedure for the service-learning project, the instructor only briefly explained to the class as a whole the other three concepts of drafting a project, calculation of materials, and understanding a working drawing. It may be that not enough time was allowed to sufficiently practice and apply these concepts fully during the time frame of the service-learning project.

Student Motivation and Commitment

To determine the motivation and commitment of the students towards the service-learning project, the instructor observed and talked with the students as they participated in each stage of the project. The determining factors were classroom participation, amount of out-of-class time spent working on the project, students perceived attitudes and feelings towards the project, and student comments concerning the project. A high-level of participation and a willingness to spend extra time outside of the regular class period devoted to the project was labeled commitment as defined by Kanter (1968).

Students were labeled “on task” when they were observed participating throughout an entire class period on their toy-building projects. Through daily observations, the instructor found that 23 out of the 25 students in the class were actively engaged in the entire process of the service-learning project. This calculates to 92% of the class that were on task during this two-week time frame. This percentage of participating students was significantly higher than in the other similar but traditionally taught class. In the class taught by traditional teaching methods, the instructor noted that only 12 of the 22 students stayed on task through the same two-week period. This calculates to approximately 54% of the students consistently participating in class activities on a daily basis, significantly lower than that of the service-learning project class.

Effects of Motivation on Confidence and Content Knowledge

While the students in the service-learning class showed an overall higher level of motivation than did the students in the traditionally taught construction technology class, there was, nevertheless, considerable variation in the levels of commitment of the 25 students enrolled in the service-learning class. From observations and discussions with the students, the instructor judged 13 of the students to be highly committed and 6 to be moderately committed. Four were deemed to have low commitment and 2 to have no commitment to the project.

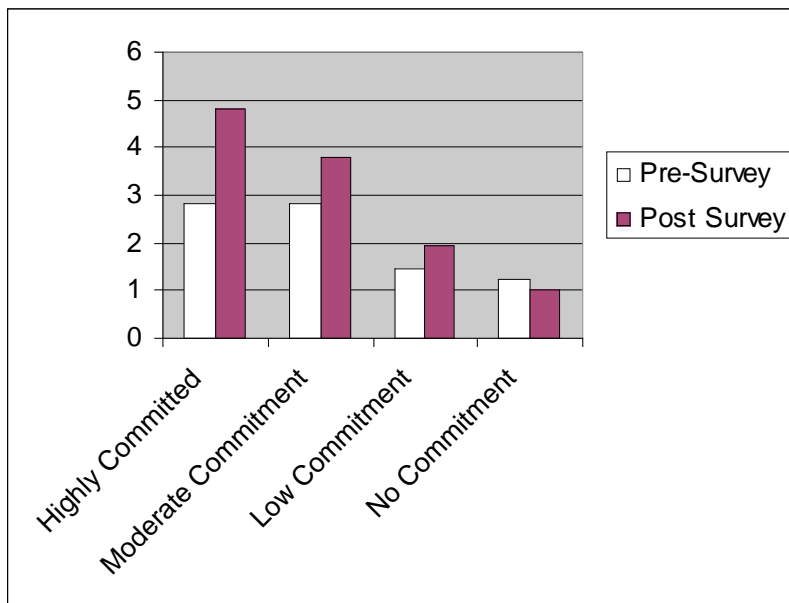
The instructor then compared the survey data for the groups of students at each of the four commitment levels to determine whether or not there appeared to be a relationship

between the students' commitment to the project and an increase in the students' perceptions of confidence on the use of the laboratory machinery and/or the students' perceptions of a gain in content knowledge. The results of the comparison showed that those students who were most motivated and committed were also those whose perceived confidence and perceived knowledge of content made the greatest increases. (See Figure 6).

At the beginning of the project, the students who were later deemed highly committed to the service-learning project rated themselves with an average of 2.8 in perceived confidence and content knowledge. This same group's average increased to 4.76 at the end of the two-week project. This translates into a change from "some experience, but need to be shown how with instructors assistance" to "confident, with little assistance needed" in the use of the basic lab machinery. Increases are also noted for the group of students who were labeled as moderately committed as well as those who were judged to have

Figure 6

Pre-and Post-Survey Results Compared by Commitment Levels



low commitment, although the increases for these two groups are not as great as that of the highly motivated students. The two students in the group showing no-commitment to the service-learning project actually scored lower from the pre- to post-survey on their own evaluation of what they learned. Overall, as the levels of commitment decrease from high to no commitment, not only do the students' perceptions of confidence and learning decrease, but their gains from pre- to post-survey decrease as well.

In summary, out of a classroom of 25 students, 23 showed some level of commitment to the service-learning project, and 19 of these demonstrated to the instructor both their ability to use the machinery safely and their mastery of the course content at or above a satisfactory level. In other words, 82.6% of the students who were labeled "committed" to the service-learning project also achieved a satisfactory rating in the use of the machinery and the application of content skills in this two-week time frame.

Conclusions

This study suggests that service-learning projects or activities motivate the majority of students to participate in class. In addition, it appears that service-learning projects can serve as a tool for engaging some students who would not normally respond to traditional methods of teaching the curriculum for a construction technology course.

The study indicated that learning occurs through the process of service-learning projects or activities. The instructor noted that the students in the study group gained as much, if not more, information and skills pertaining to the safe operation of machinery as other students learned through more traditional teaching methods of demonstrations and lectures. It appears that a service element provides a strong factor in motivating students to learn course content. The students in this study wanted to learn how to use the machinery so that they could complete the project in time to deliver the toys to the first graders at the elementary school.

There seems to be a connection between a student's level of commitment to a service-learning project and how well he or she learns, understands, and applies the concepts of the course

curriculum. In this case study, the students' commitment to the service-learning project had a definite effect on their perceptions of their ability to use the laboratory machinery and on their perceptions of the amount they had learned during the project. As commitment increased so did a student's belief that he or she had mastered the course content. The students' perceptions were verified by the instructor's observations.

The conclusions of this study are based on one instructor's observations and personal evaluations. The implications of the study derive from these observations as well as experiences in previous years of teaching similar classes. Admittedly, this study was structured on an informal experimental basis. Therefore, the findings and conclusions derived from the study are applicable to this individual case study and are not necessarily valid for a more general student population. It is suggested that more definitive, quantitative studies be carried out with other populations and samples to further explore and investigate this study's conclusions.

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