PROJECT-BASED LEARNING IN A FRESHMAN INDUSTRIAL TECHNOLOGY COURSE

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1. INTRODUCTION

A freshman-level course in industrial technology addresses topics related to all functional areas within manufacturing. It covers topics on management, planning, control, personnel, safety, wages, policy, and human factors necessary for effective management. The completion of the course requires a team project that integrates project-based learning (PBL). These projects deal with *entrepreneurship* and *product development*.

J. W. Thomas (2000) offered five criteria for a project that leads to PBL. The project should be central to the curriculum, focused on central concepts of the discipline, involve investigation by students, student driven (not pre-packaged), and realistic. Raucent (2004) has proposed a "pre-project" in the first year of an engineering curriculum. A "pre-project" is a project that is learning oriented, contextual to course topics, and developed by multidisciplinary faculty. Frank et al. (2003) concluded that in a PBL environment, students are exposed to several areas within their major field and therefore know more about the profession in the field. They also reported that teamwork during the PBL helps students deal with team conflict, task delegation to team members, and team decisions. PBL in the introductory industrial technology course strives to achieve similar goals by meeting the above-mentioned criteria. *This paper describes the need and justification for PBL-based learning in a freshman industrial technology course, the changes that were made in the course, project task descriptions, and the assessment of students' learning.*

2. NEED AND JUSTIFICATION OF PBL IN A FRESHMAN COURSE

The course (*Industrial Organization*) is open to all students in the College of Technology and serves between 180 and 300 students each semester. The course offers the students an opportunity to explore future career options within business and industry. Two changes were made to the course to address students' accountability for *subject matter* and *entrepreneurship*. The first change was in the approach to teaching the basic concepts of the topics covered in the text. Students are made to realize that the content stressed in the course is very relevant to

business and industry, and will be helpful during their career search. Therefore, students develop a sense of urgency to understand and learn the concepts.

The second change was requiring a *team-oriented entrepreneurial project* in the course. The project requires understanding of basic business and industrial concepts, along with industrial inquiry. It also requires the development of a product that could be marketable to consumers. The project addresses the following items: understanding group dynamics, developing an idea, preliminary images of the product, industrial materials, identifying consumers, geographic considerations, marketing techniques, manufacturing practices, working personnel, engineering economics/cost analysis, process analysis, and management structure.

3. PROJECT DESCRIPTION

The purpose of the project is to give students the opportunity to be entrepreneurs and apply their knowledge and skill to developing a consumer product. The project involves 12 tasks related to a consumer-driven product, covering items on entrepreneurship, teamwork, and all functional areas within the manufacturing industry.

3.1 Task #1 (Teamwork: Forming a Business Entity)

This task requires the team (five to seven members) to come up with a company name, a temporary leader, and a logo representing the image of the group. It is a simple task, but it allows an individual to step up to take charge and be a leader. It requires the group to think what is in a name that describes the makeup of the team and the relationship of the product being attempted. The last part of this task is to have a name that creates a visual image of the team. This requires thought and compromise as to the impression that a consumer would receive from the team's logo.

3.2 Task #2 (Teamwork: Brainstorming)

The team is now ready to brainstorm ideas of a product not currently on the market. As part of the class lecture, an in-class demonstration of formal brainstorming is presented. The team is now able to use the formal rules and hints for brainstorming to create ideas for their project. They use the rules of "make no evaluation", "quantity breeds quality", "freewheeling", and "hitchhiking." Students use the hints of "use the five senses", "think process", "think radical ideas", and "think of opposites." Participation is stressed throughout all the tasks because the students know that a peer evaluation is a part of their grade for the project.

3.3 Task #3 (Teamwork: Delegation of Tasks)

This task involves naming the product and the creation of preliminary drawings or sketches. At this point, the team realizes that individual talents need to be identified, since the group is comprised mostly of technology students, with other university majors involved. Identifying talents within the team and delegating authority and responsibility requires students to establish their workable division of labor to complete the rest of the project. The minimum requirement for a drawing is that the drawing adequately depicts the product to the consumer. The team conducts research on the types of industrial drawing that are necessary in making a product.

Students are encouraged to go beyond the basics and create a variety of detailed drawings. Animation imagery is a possibility, but is dependent upon the competencies within the group.

3.4 Task #4 (Research: Material Selection)

Those team members who have background in materials (usually Mechanical Engineering Technology majors) research different materials and inform the other team members about the advantages and disadvantages of each material. All members, however, are responsible for answering questions about the choice of materials during their group presentation at the semester's end. This requires members to have an awareness of different types of metals such as steel, cast iron, aluminium, or a special alloy researched for the product. In the search for materials, polymers are explored; and team members usually become aware of thermoplastics and thermosets, along with several types of plastic processing. Durability, weight, color, functionality, and cost are part of choosing the appropriate material for the product.

3.4 Task #5 (Research: Identifying the Target Customers)

Each team must consider and explain the most likely customer for their product. Such considerations include economic level, age, and type of activity associated with the customer clientele. The team also considers ethnicity, population concentration, and personal characteristics that influence buying habits.

3.5 Task #6 (Research: Location Selection for Manufacturing Plant)

The teams research an appropriate plant location for the production of their product. They consider land costs and availability, facility size for the operation, proximity to the buying market, access and transportation of raw materials to the plant, distribution factors, and Internet and global transactions. The use of the Internet enables students to look up locations, buildings, and the actual costs of acquiring the facilities.

3.6 Task #7 (Research: Market Analysis)

Each member of the team participates in this task. The team must create a marketing survey instrument. Team members survey 15 people "on the street" to obtain 75 to105 surveys. A typical survey would ask the following questions: 1) What do you think of this product? 2) Would you buy this product? 3) How much would you pay for this product? 4) What color do you like for this product? 5) What type of material would be best for this product? 6) How big should we make this product? 7) Would you recommend this product to your friends? The students are asked to report the results in graphical form.

3.7 Task #8 (Research: Manufacturing Concepts, Lean Manufacturing, Quality in Manufacturing)

The students research types of manufacturing and determine the best method for their product. This requires students to have a basic understanding of job shop, batch shop, assembly line, and continuous manufacturing techniques. The group may also insert information about just-in-time (JIT) and the advantages and disadvantages of using a "push-or-pull" manufacturing system. The students are required to give the rationale for their manufacturing choice. The team can enhance their project with further explanation of their expected use of Design for Manufacturing (DFM), Design for Assembly (DFA), and Design for Disassembly (DFD). This section of the

project may include quality control information such as the concepts of Quality Function Deployment (QFD), Pareto analysis, Ishakawa fishbone diagram, and X bar and R control charts.

3.9 Task #9 (Research: Human Resource Issues)

This task requires the team to analyze their workforce. The analysis requires critical thinking as to the number and type of workers needed to carry out the entire business activity. A job description and payroll cost are part of this activity. This requires the team to estimate the skill, educational, and special competency levels of individuals needed to plan, produce, and market the proposed product. Students apply their knowledge of human resources development related to finding, evaluating, selecting, training, motivating, promoting, and retaining the workforce.

3.8 Task #10 (Cost Analysis)

The cost analysis of materials and figures related to over-all production requires the team to research a variety of vendors and communicate with companies. The students estimate the amount of material required to produce one item, along with the estimated costs of machinery. This gives the team the option to buy, rent, or lease equipment needed to produce their product. The team is required to calculate payback on equipment and do break-even analysis.

3.9 Task #11 (Production Planning)

The team completes a production flow chart and indicate as many processes as possible. The students have several ways to approach this activity. They may wish to mention general phases of production such as concept development, product planning, product/process engineering, and pilot production/ramp-up. They are encouraged to give a conceptual explanation of concurrent engineering, manufacturing cells, group technology, and material handling. The team may wish to mention such manufacturing scheduling concepts as shortest operational time (SOT), first come first serve (FCFS), and earliest due date (EDD), along with the rationale for forward and backward production scheduling.

3.10 Task #12 (Business Plan Development and Oral and Written Presentations)

The last task is to develop a management personnel chart showing the structure of authority and responsibility. The members are also asked to create job descriptions and give an estimated salary for each manager. Each team is required to make a 20-minute formal presentation. The team must present their project in class, in a professional manner with appropriate technology, as if they were presenting to a group of investors.

4. ASSESSMENT OF STUDENTS LEARNING

The project based learning activity of entrepreneurship and product development has been conducted for two semesters. There were no assessments or evaluations conducted during the first semester; it was strictly an opportunity for a pilot run through the activity to work out major flaws in the delivery. During the second semester, two types of assessments were conducted, formative and subjective assessments. A series of statements were developed and evaluated by the students at the end of the second semester. Furthermore, students were interviewed by the instructor for subjective assessment of their learning.

The faculty have developed rapport with the freshman class to the point that the students understand that the course content is dynamic in nature. Students are encouraged to inform the instructor if the basic conceptual learning and practical application are understood. When discussing with the students regarding their understanding of the course content, the instructor focussed on the project. The instructor felt confident that the students were not afraid to let him know of their true thoughts.

4.1 Student Learning Assessment Statement and Scores on Likert Scale

There were three sections of the course, with a total of 161 students. Evaluations were provided by 150 students for each of the 14 statements, using a five-point Likert rating scale (Table 1).

Table 1: Assessment Questions and Scores on Likert Scale*

*Strongly Agree (SA)=5, Agree (A)=4, Undecided (U)=3, Disagree (D)=2, Strongly Disagree (SD)=1

	Statement	Score
1	I learned how to conduct industrial research on a topic needed for the development of documentation for the final project.	4.50
2	I learned how to work for a common goal.	4.46
3	I think that this type of project helped me be more valuable in the marketplace.	4.43
4	I learned how to prepare myself for presentation of the project.	4.22
5	I was introduced to a new field of study as a result of this project.	4.18
6	I learned how to be responsible to others and complete my part in the project.	4.14
7	I believe that this project required me to take basic information to the next level of understanding.	4.12
8	I acquired insight into a series of entrepreneurial procedures and considerations for creating a functional business plan.	4.03
9	I learned how to manage a group and the time it takes to complete the project.	4.02
10	I learned to position myself in the group at the desired level of participation.	3.99
11	I learned how to evaluate my fellow members on the basis of “effort” as an outcome of the final project.	3.82
12	I learned how to be assertive in a group situation.	3.80
13	I learned how to organize and assign work to be completed.	3.76
14	I learned to handle the dynamics of a group assignment.	3.70

4.2 Subjective Assessments

Along with the rating figures, a close working relationship between the instructor and each group yielded subjective assessment of how well the team and individuals performed each task. Interviewing the students about each statement provided detailed information on the strength of their rating. This information will be used to revise, add, or eliminate project components and determine appropriate statements for future evaluation.

4.2.1 Statement #1 (*I learned how to conduct industrial research on a topic needed for the development of documentation for the final project.)*

The students agreed (4.50) that they had to think about what resources were appropriate and how to access them for the completion of the project. Many students used the Internet; called vendors, businesses, and industries; and interviewed professors from other departments.

4.2.2 Statement #2 (I learned how to work for a common goal.)

The students agreed (4.46) that they learned something about working for a common goal. Students expressed that adjusting to different group personalities was more difficult than they first thought. Some students indicated that it was difficult on occasion to make compromises.

4.2.3 Statement #3 (I think that this type of project helped me be more valuable in the marketplace.)

The students agreed (4.43) that even in the early stages of their schooling; this project would make them more valuable in the marketplace. Students explained that if they learned in-depth knowledge about all of the concepts expressed in this course through other courses, they would feel confident in most job interviewing situations.

4.2.4 Statement #4 (I learned how to prepare myself for presentation of the project.)

The students agreed (4.22) that preparing and presenting the project was beneficial. Those who learned how to use computer animation and PowerPoint as presentation tools found them to be very useful.

4.2.5 Statement #5 (I was introduced to a new field of study as a result of this project.)

There was agreement (4.18) among the students that the project introduced them to new fields of study. Some students did not like certain aspects of manufacturing, while others expressed a strong interest in areas of manufacturing because of their new awareness. Some non-technology students indicated that they want to pursue a major in industrial technology.

4.2.6 Statement #6 (*I learned how to be responsible to others and complete my part in the project.*)

Students agreed (4.14) that being responsible to others in the group and completing individual parts of the project was important for the team grade. They feared the peer evaluation more than the concept of being responsible.

4.2.7 Statement #7 (I believe that this project required me to take basic information to the next level of understanding.)
The students indicated (4.12) that the industrial research they had to perform gave them a deeper understanding of the general concepts discussed in the text. Students thought that doing such research constituted taking information to the next level.

4.2.8 Statement #8 (I acquired insight into a series of entrepreneurial procedures and consider-actions for creating a functional business plan.)
Although the students were not sure if they fully understood a business plan, they agreed (4.03) that insight was gained as to what it took to be an entrepreneur. They thought that the amount of detail in developing the project and its documentation was good preparation for developing a business plan.

4.2.9 Statement #9 (I learned how to manage a group and the time it takes to complete the project.)
The students agreed (4.02) that they learned how to manage a group and the time it took to complete the project. Students indicated that the logistics of assembling the project during the semester took longer than expected. The students found it very difficult, at this point in their education, to be able to manage others.

4.2.10 Statement #10 (I learned to position myself in the group at the desired level of participation.)
On the issue of positioning themselves in the group to the desired level of participation, students were undecided (3.99). They did not understand what was meant by positioning. They were not able to identify the component in the project that gave them this knowledge.

4.2.11 Statement #11 (*I learned how to evaluate my fellow members on the basis of "effort" as an outcome of the final project.)*
Not all students (3.82) knew how to evaluate fellow group members. For this evaluation scheme, students did not understand what constituted "effort" on the part of a member. Students were confused between evaluating the effort of getting the information and the usefulness of information gathered.

4.2.12 Statement #12 (I learned how to be assertive in a group situation.)
The students were undecided (3.80) on how to be assertive. Students expressed having a hard time negotiating and discussing different ideas without taking a defensive posture. They seemed to have difficulty with open group communications. Several indicated that they did not express an idea because they were not sure of how it would be accepted.

4.2.13 Statement #13 (I learned how to organize and assign work to be completed.)
The students were undecided (3.76) about how to organize and assign work. Students indicated that identifying what should be organized was a problem. The students indicated that they often-times did not have the opportunity to be part of assigning work and therefore did not learn.

4.2.14 Statement #14 (*I learned to handle the dynamics of a group assignment.*)

Students expressed that working in a group was difficult (3.70) and that they did not know how to develop a team attitude. They expressed that many times the work fell on just a few members of the team.

The value 3.70 was interpreted as meaning that the students were not be able to perform the task very well. The value was the lowest, and the subsequent interview with the students led to this conclusion. In interviews students indicated that they had little or no experience in team building.

5. SUMMARY AND CONCLUSIONS

The students felt that they did learn about industrial research/inquiry, common goals, and as a result, being more valuable in the market place. Additional information on computer-based research should be given to the teams for those unfamiliar with conducting industrial inquiry. Supplementary information on presenting, time management, taking knowledge to the application level, and creating a business plan should be either discussed in class or given to the teams. It seemed obvious that freshman students are not aware of leadership concepts at this point in their education. It is recommended that information be provided on how, what, and why people position themselves in a group situation. Work measurement and its application should be covered either in class or as a team, and a clearer explanation of peer evaluation should be presented. A better explanation of being assertive needs to be discussed. The student needs to know there are many ways of being assertive without being overbearing.

It is recommended that the concept of organizing and assigning work be focused on each team member to organize and assign his or her own work. This statement was misinterpreted as organizing and assigning work to other team members. The final recommendation would be to provide a guest speaker for a short lesson on the mechanics of developing effective teams.

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