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Impact of Project Based Learning in Introduction to Engineering/Technology Class

Alok K. Verma
Old Dominion University, averma@odu.edu

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AC 2011-876: IMPACT OF PROJECT BASED LEARNING IN INTRODUCTION TO ENGINEERING/ TECHNOLOGY CLASS

Alok K. Verma, Old Dominion University

Dr. Alok K. Verma is Ray Ferrari Professor and, Director of the Lean Institute at Old Dominion University. He also serves as the Director of the Automated Manufacturing Laboratory. Dr. Verma received his B.S. in Aeronautical Engineering from IIT Kanpur, MS in Engineering Mechanics and PhD in Mechanical Engineering from ODU. Prof. Verma is a licensed professional engineer in the state of Virginia, a certified manufacturing engineer and has certifications in Lean Manufacturing and Six Sigma. He has organized several international conferences as General Chair, including ICAM-2006 and ICAM-1999 and also serves as associate editor for three International Journals. He serves as the President of the International Society of Agile Manufacturing and as the chief editor of the International Journal of Agile Manufacturing. Dr. Verma's scholarly publications include more than 77 journal articles and papers in conference proceedings and over 50 technical reports. He is actively involved in applied research, and has served as a PI or Co-PI on several funded competitive grants exceeding $4.0 million. Dr. Verma has developed and delivered training program in Lean Enterprise & Design for Manufacturing for Northrop Grumman Newport News, STIHL and several other companies in U.S. He has developed simulation based training programs for shipbuilding and repair industry under a grant from the National Shipbuilding Research Program (NSRP). He is well known internationally and has been invited to deliver keynote addresses and invited papers at more than 12 national and international conferences on Lean/Agile manufacturing. Dr. Verma has received the Regional Alumni Award for Excellence for contribution to Lean Manufacturing research, the International Education Award at ODU and Ben Sparks Medal by ASME. He is active in ASME, ASEE, SME, IIE and SNAME. Dr. Verma continues to serve the Hampton Roads community in various leadership positions.

Impact of Project Based Learning in Introduction to Engineering /Technology Class

Abstract

Project based learning (PBL) has a proven record as a teaching tool. Concepts that are often hard to grasp are made easy by the use of project based activities. The constructivism learning theory suggests that people learn better by actively participating in the process of learning.

The Introduction to Engineering and Engineering Technology class has been modified to include project based learning kits to engage freshmen early on in the program. The goal is to demonstrate students the link between the scientific principles and their engineering applications. The course is team taught by faculty from various engineering and technology disciplines to provide students experience related to multiple fields to help them identify their career discipline. Students work in groups to build devices and test them.

Student evaluations indicate a marked increase in learning and comprehension of scientific principles and engineering concepts. The paper will discuss the design and development effort that have gone into creating the PBL kits that were developed related to Marine and Maritime industry. It will also discuss implementation within the course and results from pre and post surveys from students.

1. Research on Understanding and Learning

Ancient Chinese philosopher Confucius once said "I see and I forget, I hear and I remember, I do and I understand." We all know this instinctively, however, turn-of-the-century educationist Edgar Dale illustrated this with his Cone of Learning as illustrated in Figure 1. He made an observation that “After two weeks we remember only 10% of what we read, but we remember 90% of what we do!” Existing literature on understanding and learning also points to the fact that learning and retention are enhanced by activities involving actual work within a simulated work environment. Gardner [9] mentioned that “Understanding is a result of the learner reshaping and transforming information.” Savery and Duffy [10] concluded that “One’s knowledge is refined through negotiations with others and evaluation of individual understanding.”

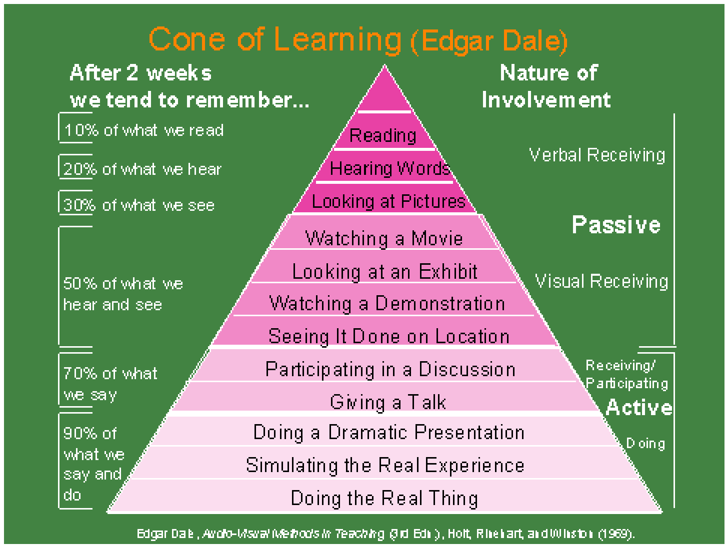

Figure-1, Cone of Learning by Edgar Dale

2. Various Learning Paradigms

Various learning paradigms have emerged in our quest for enhancing student learning and comprehension. Common terms used while describing these paradigms are: case studies, project based learning, interactive learning, active learning, e-learning, role playing, gaming, computer simulations etc. While some of these are synonymous, others are quite different. These paradigms can be broadly classified into three categories; Case Studies, Project Based Learning and Simulation Based Learning, as shown below in Figure 2.

Figure-2, Various Learning Paradigms

3. Project Based Learning as a Teaching Tool

Project Based Learning has proven record as a teaching tool. The constructivism learning theory suggests that people learn better by actively participating in the learning process. In order to involve students into the participatory learning process, the interaction among students, between students and the instructor in a classroom becomes very critical. Effectiveness of project-based learning is well recognized. Edgar Dale's cone of learning as shown in Figure-1 supports the benefits of project based learning.

Educators have been designing, using, evaluating and writing about Project Based Learning (PBL) for more than 20 years however, it has not found wide spread acceptance in classrooms. Project Based Learning is a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks[1]. Another important use of project based learning in education is to facilitate efforts at what has become known as "bridging the gap" between academics of profession and practice of that profession. PBL is ideal for connecting factual knowledge, principles, and skills to their application within a profession.

4. Incorporating PBL within the Intro to Engineering/Technology Course ENG-110/111

The Introduction to Engineering and Technology, ENG-110 and ENG-111 are 2 credit required classes for all freshmen within engineering and engineering technology programs. The classes are designed to engage freshmen in PBL activities in various disciplines to provide them with real life experiences. The goal is to provide students enough experiences about various disciplines so that they can make a judicious selection about their career path. The course is divided into five week modules taught by faculty members from different engineering disciplines. The author has focused one of these modules on marine and maritime topics.

5. Attitudinal Survey to Assess Impact of PBL

A survey was designed to assess the impact of the PBL activities on the student's knowledge about shipbuilding and repair. This survey contains questions about ships components, ship design and physics principles like buoyancy. Student responses are aggregated and average score is obtained on a scale of 1-10. Students are assessed using the same instrument after they have gone through the four simulation sessions. The difference in the score between the pre and post survey provides a measure of change in the knowledge base of the students. Figure -3 shows the attitudinal survey used to collect data.

6. Implementation of the Marine Kits in ENGN-111

The course is instructor-led classroom training combined with in-class hands-on activities designed to invite class participation. This approach aids in the individualized instruction given to the participant. Instructional methods include facilitated discussion, hands-on activity, and on-the-job practical applications. PowerPoint presentations are used to deliver the course, supplemented by a series of videotapes from Society of Manufacturing Engineers and Productivity Inc.

ENGN-111
Post Simulation Quiz

Time 15 minutes

Name______________________ **Pledged**_________________________

1. What is the use of bulkheads in the ships?

   ____
   (1 Point)

2. Starboard and Port are the names for _____________ and _____________ sides of the ship respectively. (1 point)

3. What are the different sources of power for the propulsion of ships?

   ____ (1Point)

4. Longitudinal bulkheads are used to reduce free surface effect in tanker ships.

   a. True b. False (1 Point)

5. Bow and Stern are the names for ___________ and ___________ parts of the ship respectively.

   a. True b. False (1 Point)

6. Draft of the ship depends on the density of water.

   a. True b. False (1 Point)

7. What is the "Bill of Materials"? What is its use? (1 point)

8. List four main operations used in shipbuilding. (1 point)

9. What is Archimedes' principle? Illustrate with a diagram. (5 points)

Figure-3 Attitudinal Survey

As mentioned above, these activities are conducted in groups of four or five students and done in a session lasting for about three hours for instructional Modules and two hours for Marine Kits. The teacher explains the activity with a power point presentation and then the students are given the kits. At this point students begin the activity by going through the manuals and instruction sheets provided with the kit. Figure 4 shows students performing shipyard operations activity. In this activity students build a scaled model of a container ship and then estimate the weight of an actual ship. They also perform design calculations like calculation of draft and kinetic energy of the ship.

Figure-4 Marine Kit-1 Activity: Shipyard Operations

Figure-5 Marine Kit-2 Activity: Ship Construction

Figuer-5 shows the Marine Kit-2 activity. In this activity students use K'nex parts to construct a clipper ship. Students first count parts required to construct a given ship by examining the detailed drawings and assembly instructions provided in the manuals. This activity tests student's skills for visualization and blue-print reading, project management, cost estimation and supply chain management. After identifying the parts needed to construct the ship, students prepare a bill of material and order the parts from the teacher who serves as the supplier. Groups are penalized for not having an accurate count of parts. If the group ordered fewer parts, then they can purchase the parts during assembly at double the price. If the group ordered too many parts, then they have to pay 20% restocking fee to return the parts. Each group's activity is assessed using a rubric containing performance criterions. The group that builds the ship with minimum cost, shortest amount of time, least number of defects and accurate calculations wins the competition.

7. Marine Kits - Activities Related to Shipbuilding and Repair

The four simulation activities are related to operation of a shipyard, ship construction, ship stability and best practices in the shipping operations.

a) Shipyard Operation Activity simulates operations within a shipyard. Plasma cutting, bending and welding shops are simulated. Students use card stock paper to build a container ship. This simulation demonstrates modular construction of a ship.
Topics covered in this Marine Kit are:
   - Components of a ship
   - Operations within a shipyard
   - Methods of ship construction
   - Design calculations

b) Ship Construction Activity simulates construction of a clipper ship and a submarine. This simulation also covers calculations related to bill of material, sales tax and labor cost.
Topics covered in this Marine Kit are:
   - Basic ship terminology
   - Fundamentals of ship construction
   - Processes involved in cost estimation and part acquisition

c) Ship Stability Activity involves the understanding of center of gravity, center of buoyancy, and Archimedes Principle. This simulation uses foam hull shape to conduct experiment to identify center of buoyancy and observe the effect of salinity on buoyancy.
Topics covered in this Marine Kit are:
   - Finding the Center of Buoyancy
   - Applying Archimedes principle to find weight and volume of displaces water
   - Observing the effect of salinity on the draft.

d) Ship Disaster Investigation simulation involves ship disaster case studies. Students play the roles of Ship Disaster Investigation Agency (SDIA) agents analyzing the ship disaster. They identify possible causes behind the disaster. In this open ended problem based simulation students learn fundamentals of ship design, basic terminology used in the shipbuilding and shipping industry and the correct practices followed in ship design, construction and shipping industry.

Topics covered in this Marine Kit are:

- Basic ship terminology
- Fundamentals of ship design and construction
- Best practices followed in ship design, construction and shipping industry

Figure 6 shows the contents of the four Marine Kits.

Fig. 6 Marine Kits 1-4

Students perform each activity in groups of four - five. Students are provided with handouts and manuals which include instructions to carry out hands-on activity. The kit comes with a teacher's manual and model solutions for the simulations. Among the four activities, shipyard operation and ship construction simulations are more structured while ship stability and ship disaster investigation are open ended activities where students are given clues and they are encouraged to find solutions.

8. Results

Results from the attitudinal survey are shown in Table 1 and plotted in Figure 7 as bar chart of student responses from the pre and post training evaluations. The x axis represents the scale 1-5 on which respondents evaluated questions on the attitudinal survey, 1 being strongly agree and 5 being strongly disagree. Figure 7 clearly indicates that the post training response curve is skewed to the right. The results are presented for two semesters. Before the PBL training, mean of student responses was 1.5 for fall 2007 and 2.4 for spring 2010 semester. After participating in the PBL activities this mean moved up to 6.9 and 6.64 for the two semesters. This indicates that the class room training utilizing PBL had a positive impact on the learning and retention of the participants.

	Pre Score Avg.	Post Score Avg.
Fall 2007	1.5	6.9
Spring 2010	2.4	6.64

Table -1 Survey Results

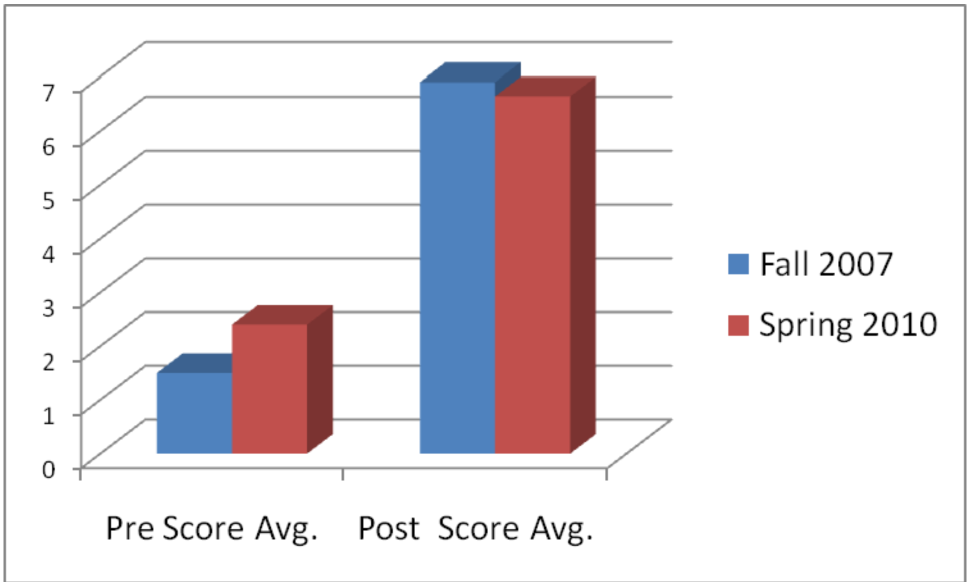

Figure - 7 Plots of Student Responses

9. Conclusions

Freshmen experience in engineering and technology programs was enhanced by including PBL experiences for students in the introduction to engineering courses. The five week module focused on PBL activities involving ship design, construction, ship operations and ship stability. Student learning is enhanced by incorporating these activities where students work in groups to accomplish problem solving. Open ended problems provide opportunities for group discussion and creative thinking. Student's comments from curse evaluations indicate that students find these learning experiences very enjoyable. Results indicate marked increase in student scoring between pre and post survey results.

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