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Introducing Hands-On Simulation Activities in Introduction to Engineering & Engineering Technology Class to Keep Students Engaged

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AC 2008-146: INTRODUCING HANDS-ON SIMULATION ACTIVITIES IN INTRODUCTION TO ENGINEERING & ENGINEERING TECHNOLOGY CLASS TO KEEP STUDENTS ENGAGED

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Introducing Hands-on Simulation Activities in the Introduction to Engineering and Engineering Technology Class to Keep Students Engaged

Abstract

Low enrollment and high attrition rates have often plagued Engineering and Engineering Technology programs. Part of this problem can be attributed to the lack of engaging hands-on activities during the first year of instruction. Most engineering and technology programs require students to take natural science, math and some general education courses during the first two years with minimal technical content. To maintain student's interest in the technical career path, it is important that students establish a link between the theoretical knowledge and its application to solve real life problems early in their learning experience. Simulation based activities have a proven record as instructional tool. Such activities have been used successfully in Lean Training programs in industry. Effectiveness of such activities as a pedagogical tool has been supported by research in the acquisition and retention of knowledge.

The Shipbuilding and Repair Career Day Events (SBRCD) project was funded by the National Shipbuilding research Program to increase awareness about shipbuilding and repair careers. Four simulation activities developed under the grant were incorporated into freshmen engineering course to encourage creative thinking and keep students engaged while providing information about shipbuilding and repair processes.

I. Introduction

The project team consisting of university faculty, industry personnel, school and community college teachers developed these four simulation activities learning experience related to shipbuilding and repair. These four activities have been designed as an integrated experience and each one builds upon the knowledge gained during the previous activity. First activity is related to shipyard operations which provide a big picture of how a shipyard operates. The second activity deals with cost estimation and construction of a ship. The third activity teaches about ship design and stability while the last one deals with the ship disaster investigation. These activities were used in an Introduction to Engineering class with very positive results. Student comments point to a very stimulating learning experience. The paper will discuss the design and development of these activities and its subsequent implementation within the classroom.

II. Freshman Engineering & Technology Courses

A two course freshman engineering and technology sequence was designed to help students transition into engineering and technology curriculum by providing general knowledge about career opportunities, professional certification and career paths while keeping them engaged with project based learning activities. ENGN-110 (2 credits) provides general information about career paths while ENGN-111 (3 credits) provides discipline specific activities from a variety of engineering and technology disciplines. The courses are team taught by a group of faculty from different departments and are managed by the Engineering Fundamental's division of the college. The courses were instituted to reverse the tide of increasing attrition and drop out from the college of engineering and technology.

The four simulation activities developed under the NSRP program were incorporated into ENGN-111 and are conducted in four sessions each lasting an hour and fifteen minutes. A fifth session is reserved for assessment.

III. Physical Simulation as a Teaching Tool

Physical simulations have a proven record as a teaching tool. Concepts often hard to grasp are made easy by the use of simulation exercises. The constructivism learning theory suggests that people learn better by actively participating in the process of learning. In order to involve students into the participatory learning process, the interaction among students, and between students and the instructor in a classroom setting becomes very critical. Effectiveness of simulation-based learning is well recognized. Edgar Dale's cone of learning as shown in Figure-1 supports the benefits of simulation based learning. According to the Encyclopedia of Educational Technology[1], "Simulation-based learning involves the placement of a student into a realistic scenario or situation. The student is then responsible for any changes that occur as a result of their decisions."

Educators have been designing, using, evaluating and writing about simulations for more than 45 years. However there are no generally accepted definitions of an education simulation or its many variations. Education simulations are sequential decision-making classroom events in which students fulfill assigned roles to manage discipline-specific tasks within an environment that models reality according to guidelines provided by the instructor. Education simulations typically place students in true-to-life roles, and although the simulation activities are "real world," modifications occur for learning purposes[1].

Another important use of simulations in education is to facilitate efforts at what has become known as "bridging the gap" between academics of profession and practice of that profession. Simulations are ideal for connecting factual knowledge, principles, and skills to their application within a profession. Simulations help students with an opportunity for decision making, and for evaluating the consequences of their decisions that no textbook or laboratory can.[2].

Simulations weave substance-specific information into real life problems in meaningful ways that students can understand. During simulations, students typically acquire broad discipline-specific knowledge that they are able to later transfer into a professional setting. Simulations also teach much more, including the process involved in the discipline, the organization involved, and the interactions with other discipline, people, and organizations.

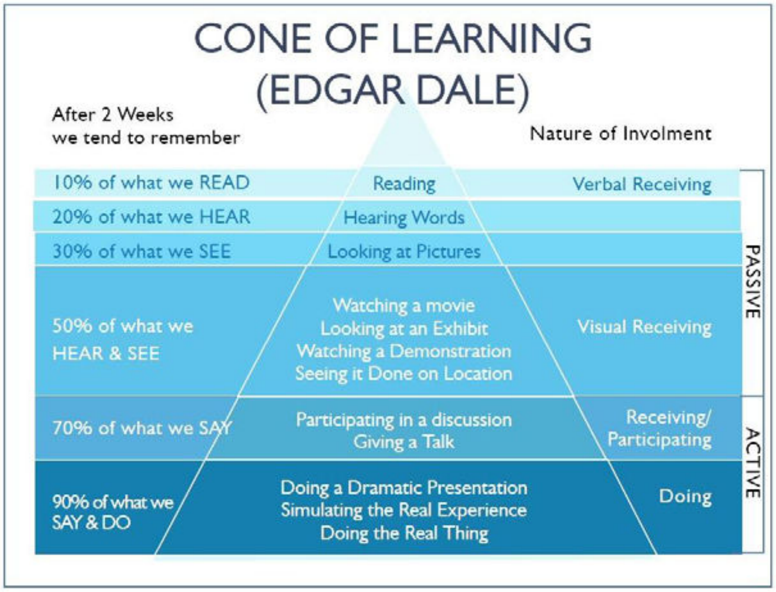

Figure-1, Cone of Learning by Edgar Dale

The entire structure of simulation is built around the concept of students participating in variety of roles within an environment, designed around the learning objectives of the course. During simulation, learning happens because the students are active and not passive in the process. They are able to experiment with various options and interact with fellow students. Increasing student's knowledge is an important goal of all education. Simulations are particularly adept at helping students acquire usable knowledge that is knowledge that can be transferred and applied to other situations. Simulations encourage purposeful use of knowledge to achieve clearly defined goals.

IV. Survey to Assess Student's Knowledge about Shipbuilding & Repair

A survey was designed to assess the impact of the simulation 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. A copy of the survey is attached in Appendix A.

V. Delivery Method

The course is instructor-led classroom training combined with in-class simulation exercises designed to invite class participation. This approach aids in the individualized instruction given to the participant. Instructional methods include facilitated discussion, hands-on simulation of production, 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. Students are encouraged to participate in the

Lean implementation projects. In addition a semester project on production simulation using ProModel software is also required.

VI. Ship Building and Repair Simulation Activities

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 Simulation** 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.
   Learning objectives for this simulation are:
   - Components of a ship
   - Operations within a shipyard
   - Methods of ship construction
   - Design calculations

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

c) **Ship Stability Simulation** 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.
   Learning objectives for this simulation 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.
   Learning objectives for this simulation are:
   - Basic ship terminology
   - Fundamentals of ship design and construction
   - Best practices followed in ship design, construction and shipping industry

   Figure 2 shows pictures of the four simulation kits used for these activities.

Figure-2, Shipbuilding and Repair Simulation Kits

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

VII. Implementation of the Simulation Activity

As mentioned above, these activities are conducted in groups of four or five students and done in a session lasting an hour and fifteen minutes. The students are given the kits and the teacher explains the contents of each kit. At this point students begin the activity by going through the manuals and the diagrams provided. Figure 3 shows students performing ship construction activity. Students use K’nex parts to construct submarine or clipper ship. Students first count part required to construct a given ship by examining the detailed drawings and pictures provided in the manuals. This activity tests students skills in their ability to combine multiview drawings to compose a three dimensional view of the object. 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.

Figure-3, Simulation Activity: Ship Construction Simulation

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.

VIII. Results

The shipbuilding and repair simulation activities have been well received by students. Comments at the end of the course reveal that student enjoy learning about ships, ship construction and concepts related to ship design and operation with the simulation exercise. Figure 4 shows the bar chart of student responses from the pre and post training evaluations. The x axis represents the pre and post attitudinal survey and the y axis shows the aggregate of student response averages from pre and post survey results. Figure 4 clearly indicates a marked increase in student's response about their knowledge of ship building. Student comments from course evaluations are also positive.

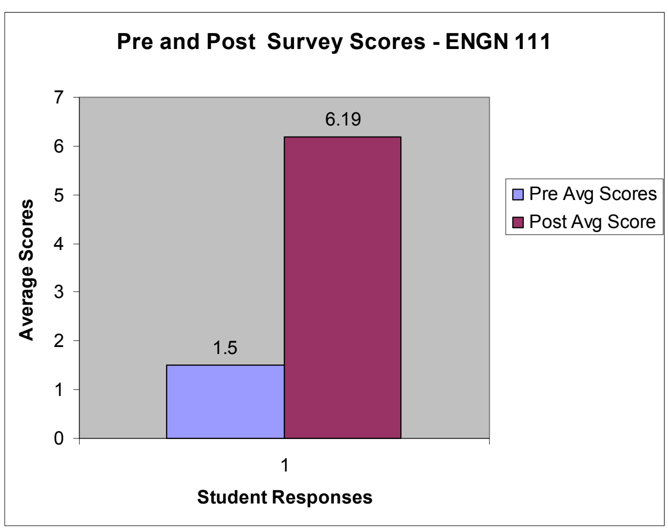

Figure-4, Plot of Student Responses

IX. Conclusions

A freshman introduction to engineering course has been redesigned to include four simulation activities related to shipbuilding. The study shows that, learning of ship design, construction and shipping concepts is made easier by incorporating physical simulations within the course material. Student learning is enhanced by incorporating these activities where students work in groups to accomplish a task. 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

Acknowledgements

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APPENDIX – A

ENGN-111
Post Simulation Quiz

Time 15 minu

Name______________________ **Pledged**_______________________

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

   a. T b. F (1 point)

2. Bow and stern are the names for _____________ and _____________ parts of th ship respectively. (1 point)

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

   a. T b. F (1 point)

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

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

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