Scenario-Based Learning Approach in Teaching Statics

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Abstract

This paper describes the initiatives currently underway at Cal Poly, Pomona to develop and implement a scenario-based learning approach to teach major concepts in statics. Statics is generally the first engineering course taken by most engineering students. The course is typically taught in lecture format, although several schools have been adopting a laboratory component. Statics is a prerequisite for many courses and materials covered in statics are crucial to just about every subsequent course that students will take. Yet, it is very common to see that students taking dynamics or mechanics of material lack basic skills such as drawing free body diagrams even though all of them completed statics and many of them even got good grades. Clearly, there has been little knowledge retention. We believe scenario-based learning approach offers an effective way of engaging learners and building competency mastery. This paper describes our experience in implementing scenario-based learning approach.

Introduction

The predominant delivery method to engineering education today is a didactic, passive approach using lectures and textbooks. In this method, students rigidly follow the material in the textbook chapter-by-chapter. Test and homework problems are modeled after the problems found in the textbooks offering little variation. Currently, the basic engineering subjects such as mechanics (statics, dynamics, etc.) are taught using popular textbooks. These textbooks are well written, cover enormous amount of material, and serve as excellent resource materials. Most of the problems in the textbooks are well defined, with parameters clearly indicated. However, researchers[1-5] assert that rather than didactic textbook problems, complex problem solving environments are critical for learning and the application of those skills. Didactic instructional approaches are less effective and engaging than methods involving more constructivist approaches. Furthermore, engineers must apply their knowledge in complex situations that extend far beyond the borders of the classroom.

Engineering in the real world is more than number crunching. It involves making decisions such as making the appropriate assumptions, model simplification, material/size selection, cost analysis, etc. As a result, with the current lecture approach, students may learn to solve problems and follow preset rules for a well-defined problem but lack the ability to transfer that learning into additional situations. In particular, they may fail to see the connection between solving a problem mathematically and real-world engineering application. Following the tenets of constructivism, *we believe learning can be engaging, meaningful, and persistent if the joy of*

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*discovery and learning context are incorporated into the instructional method. While covering material is very important, we feel "**uncovering,**" or constructing, a concept or skills is far more important. In this way, we intend to create active learning environments in which learning is both engaging and meaningful.*

Scenario-Based Learning

Scenario Based Learning[6-7] (SBL) is an effective approach that provides an excellent framework for active learning. Similar to case-based instruction, SBL utilizes an authentic context in which the problems are presented in certain sequence and choices offered that enable the learner to reach an outcome. Unlike case-based[8-9] instruction however, SBL generally adheres to a performance improvement imperative rather than the acquisition of knowledge and skills. Furthermore, SBL enables the system to present new scenarios and outcomes based on what a user selects. As with any constructivist approach, mistakes are an integral part of the learning process. In SBL mistakes inform the system which adapts thereby prompting the learner to make better choices in the future.

SBL is based on the understanding that in order for a learner to acquire and retain skills & knowledge, the learner must be placed in a scenario where his/her decisions affect, or alter subsequent events leading to new events, just like in real life. In real life, we are presented with choices everyday; some good, some bad, some ok, and some irrelevant. Choices we make improve, deteriorate our current situation, or, make no difference. In this way, SBL is a form of experiential learning.

In the SBL context, a scenario is a realistic situation where a sequence of events is presented and possible choices allow the learner to reach an outcome. Learning occurs when the user goes through the scenario and is guided to discover principles and develop critical competencies. Information and reference modules are presented in context when required or requested. Mistakes can be made and the resulting scenario will allow the user to make subsequent decisions. Learning still occurs if a user takes a wrong path all the way through. Thus learning becomes an experience and not blindly following a set of rules, or learning by rote. Fig. 1 shows an example of a SBL model showing how a scenario branches into various possibilities.

Our premises for using SBL area as follow:

- Reality is the ultimate and best learning experience.
- Learning must be fun and enjoyable like playing a favorite sport just as in real life.
- Learning must allow for mistakes. No one has ever learned anything without doing mistakes. However, the current teaching methodologies do not allow for any mistakes and look for one correct answer. This popular approach is too simplistic and doesn't reflect the reality. The better approach is to let the students make mistakes and learn from them.
- Real learning occurs when we can immerse ourselves in a situation in which we are forced to perform, get feedback from our environment, and given chances to correct or adjust our responses.

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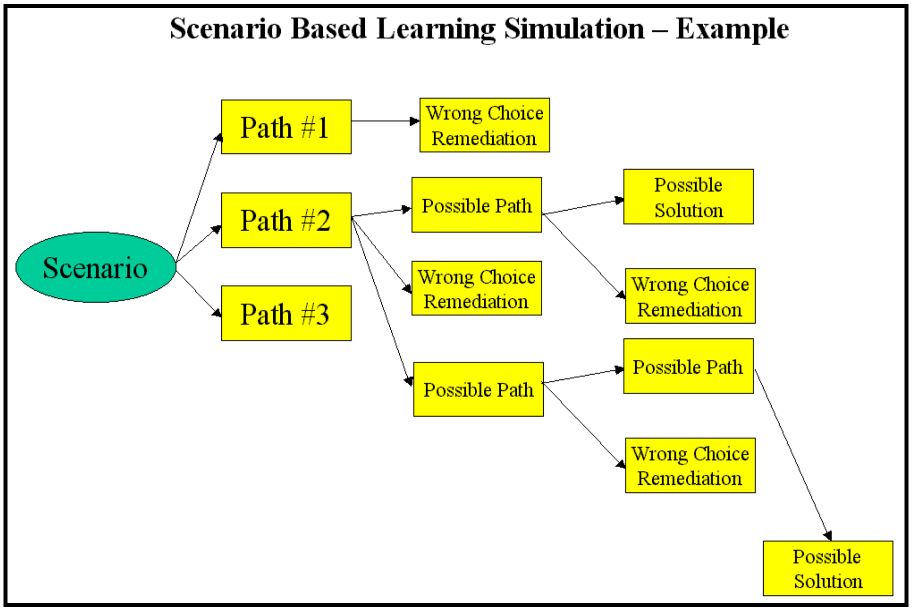

Figure 1 – An Example of SBL Model

Scenario-based learning has similarities with project-based learning[10], but has some important differences. The closest approach to scenario-based learning is the story-centered curriculum championed by Robert Shank[2-3] from Carnegie Mellon University (CMU) and Kieran Egan[11-12]. CMU West is applying this concept to the development of a six-unit network security course. Egan's approach is adopted in various forms at elementary and high school level. Thus the concept of SBL is not new. However, its application has been very limited and mostly applied to business courses to analyze *what if* scenarios. However, SBL has not been adopted or applied systematically to teach basic engineering courses.

A number of research studies point to the efficacy of using such an approach. Below, results from a National Training Laboratory study support the effectiveness of "learning by doing" and "teaching one-to-one." Results of this study (Refer Fig. 2) show that knowledge retention is superior when such methods are used compared to more common methods of instruction, such as lecture, including use of audio/video, demonstration, or even discussion groups.

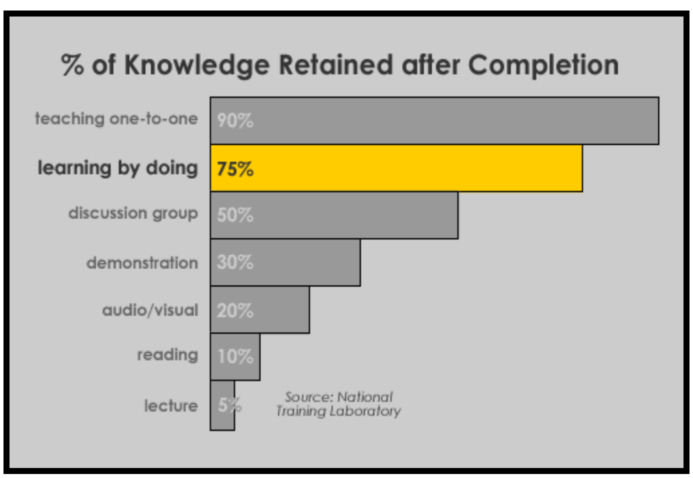

Figure 2 – Knowledge Retention Study

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Example – Introducing Vectors

Which would you rather do?	
Option 1 (Traditional)	**Option 2**
Here! Read the definitions and solve the problem at the back of the book. Definition 1: A vector is a physical quantity that has a direction and magnitude.	In this interactive story, you will play the character role *Bob.* You are at a rest area and it is getting dark. Your car is low on gas. The rest areas have a very detailed street map of the area. Task: Your task is to draw ways to various gas stations showing the distances and find the nearest gas station. Scenario Continued:

Option 1 is a traditional "lecture-test" format. Option 2 doesn't even talk about vectors but presents a scenario. In option 2, most students will draw straight-line segments showing the distances to various gas stations from where they are, or they may write down something like 3 blocks north, 2 blocks east etc. Obviously they have used vectors in their own way. What is needed now is to introduce some notation (such as showing the arrow to indicate the direction) and naming convention to assure consistency. At this point, the mystery of vectors is gone and it becomes easy for them to see vector as something they know intuitively and use it in everyday life. This example doesn't cover all aspects of vector algebra but it has succeeded in *uncovering the concept, vector*. Once a concept is uncovered, it is a lot easier for educators to introduce some "real" math as a matter of necessity and consistency, and students are more willing and open. Although this example is not a fully developed SBL model, this simplistic approach does indicate that introducing vectors in this way is better than giving a definition.

Hyatt Skywalk Tragedy

The following is a scenario-based assignment.

Scenario (News article from Kansas City Star[13])

Hyatt was a popular Kansas City nightspot, especially on Fridays, when an orchestra played for 1940s-era tea dance contests. At 7:05 p.m. on July 17, 1981, two 120-foot-long walkways tore loose from their suspension rods, dumping 65 tons of concrete, metal, glass, and dance spectators onto hundreds of people below. Dozens of victims pinned, dying beneath the debris. Bodies cut in half. Broken necks, broken backs, severed limbs and shattered lives. That tragic night, 111 persons died, including 18 pairs of husbands and wives. Of the 200 injured, three died weeks or months later, pushing the death toll to 114.

Twenty years later, the Hyatt skywalk tragedy remains the nation's worst structural failure disaster. It triggered multimillion-dollar lawsuits, taught engineering schools a terrible lesson about design flaws and marked a beginning point nationally for treating the psychological scars of rescue workers. Boarded up during repairs, the Hyatt reopened 75 days later -- but without skywalks and without a plaque or other memorial marking what had happened. Today, those who

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witnessed that horrific night say it changed their lives forever. They can never forget it. And neither will Kansas City.

Your Task

Jack Gillum, who was in-charge of the $50 million Hyatt Project said in an interview that *any first-year engineering student could figure it out.*

Your task as an engineering student is to investigate this incident and follow through the scenarios presented. Your assignment requires review of several concepts.

Students start with this scenario and go thorough an interactive session of choosing appropriate responses and finding out the results of responses. Based on options chosen, students will be directed through a *guided discovery process* during which they would perform several tasks including:

- Finding the building code and checking if Hyatt Skywalk met the building codes
- Analyzing the drawings
- Estimating the load on skywalk and the suspension rods
- Drawing free body diagrams of original and modified design

Furthermore, students are led through scenarios and outcomes that deal with popular notions such as the cause of disaster was vibration induced by the dancers and/or the design change that doubled the load on the box beams. At every step of the decision making process, students can access any reference material.

Integrating Concepts

With the SBL approach, a well-designed scenario will integrate several concepts simultaneously. One of the experiences that have been developed includes collecting/estimating real data to respond to a need. An example of this experience involves visiting a construction site (such Habitat For Humanity[14]), where students would estimate the wind load on a structure (roof truss). With this example, estimating wind load (deals with calculating the *distributed forces*), applying these forces on the truss appropriately (*equivalent forces)* and performing *truss analysis,* cover three different topics traditionally taught in different chapters. This approach makes it possible to more closely approximate the complexity of an authentic environment. As a result, students will be better prepared to apply this information in realistic settings.

Current Topics

Our current development efforts include developing complete SBL modules to teach include:

- Vectors, Equilibrium of bodies, Free Body Diagrams
- Structural analysis
- Frames and machines
- Centroids and CG and Distributed loads

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- Friction (Belts, Wedge)

Evaluation

Evaluation process that is currently under development at Cal Poly is based on:

- Usability: Students respond to a survey at the conclusion of their experience. Additionally, focus groups are planned that would provide formative data on the usability of the SBL modules during the development stage.
- Engagement: The degree of engagement will be assessed through instructor observations and journals. Students will also complete affective survey information at the conclusion of the program.
- Learning Outcomes: In order to assess learning outcomes, students will first be divided into experimental and control groups. They will then be asked to complete a conceptual map representing their understanding of specific statics concepts. At the conclusion of the course, this procedure will be repeated in order to document growth and development of conceptual understanding. Additional information and content tests will be used to support this data.
- Overall Effectiveness: Small Group Instructional Diagnosis[15-16] (SGID), an independent diagnostic study will be conducted to evaluate the effectiveness of using SBL approach with the help of Faculty Center for Professional Development at Cal Poly, Pomona.

Summary

SBL is a very effective pedagogical approach. Our initial efforts in applying SBL approach have clearly demonstrated increased learner interest in the subject and improved knowledge retention. Efforts are currently underway to develop and implement SBL approach to teach all major concepts.

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