Learning Styles and Engineering Management

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Abstract

Learning styles have been discussed for years as an approach to enable engineering education to become more effective. However, even though many successful applications have been documented, there has been scant scientific evidence of its effectiveness. At the same time, there are many benefits in using asynchronous tools to complement in-campus classes as well as in distance education. However there is concern that these tools will not be as effective as traditional lectures.

This paper reports on a study[1] that was performed at the University of Missouri – Rolla, which successfully measured the impact of one of the learning styles to engineering students. It utilized a web site that contained three tutorial learning modules. These modules were designed for asynchronous application and with varying degrees of global and sequential content in their learning environments. Thirty-two graduate and undergraduate students participated in the study, which became a part of an established engineering course. The students were tested for their learning styles as well as their knowledge of the material before and after each of the Internet-based tutorial sessions. The results of the study showed that the student learning was no worse than in previous classes, which had covered the same material without the help of the asynchronous tutorials. This implies that educators can use more Web-based educational content in their classes with confidence that it can be effectively managed. In addition, it was found global learners learned better in a global environment and sequential students learned better in a sequential environment. This gives more choices to educators on how to reach their students and ways to improve learning effectiveness.

The Objective of the Study

With the explosive rate of change in technology, there is a great opportunity to improve methods in engineering education, and for educators to find ways to improve our instructional methods. In engineering management we struggle with the wide breadth of material that our students are expected to learn, and new material is continuously identified as key to their education. However we are constrained by market forces to limit the length of our degree programs. We, as educators, have several options: 1) reduce the depth of the material we cover, 2) eliminate some of our core material, 3) ignore some of the new material or 4) find methods to improve the learning the effectiveness of our students' learning. Other fields of engineering education as well as technical training programs face similar pressures to improve learning effectiveness. However, there are opportunities to make some of these needed improvements.

Asynchronous learning tools are among these new promising technologies that could make a significant improvement. Because asynchronous learning tools allow the user to use a learning environment that is different than for other students, it facilitates the design of learning modules that more closely meet the needs of the students. We are currently seeing numerous asynchronous learning applications in engineering management programs. Some of these applications support on-campus classes while others provide distance learning capabilities. Asynchronous learning offers the opportunity to provide different ways to reach the students to cover the same material.

Asynchronous learning modules also offer educators an opportunity for experimentation to identify and validate these improvements. We can measure the learning effectiveness of specific design parameters by developing learning modules that teach the same material but with controlled differences. These modules can then be assigned to specific students and the impact of the changes can be measured. The application of learning styles to course design offers an opportunity to improve learning effectiveness that can be tested in this way. The study here described, developed interactive, asynchronous learning modules in an Internet environment to apply learning styles concepts in different ways. These modules were utilized in an actual engineering class at UMR and the results were measured.

Learning Styles

Della-Dora and Blanchard[2] defines learning style as a "personally preferred way of dealing with information and experiences that crosses content areas"(p. 22). Keefe[3] states that learning style indicates how a student learns and likes to learn. Therefore, knowing how a student or employee likes to learn can assist the instructor or employer/trainer to develop more effective methods to instruct and communicate with these individuals.

Felder[4] categorizes a student's learning style in the following five dimensions

1) **Perception -** What type of information does the student preferentially perceive: sensory (external) – signs, sounds, physical sensations, or intuitive (internal) – possibilities, insights, hunches?
2) **Input -** Through which sensory channel is external information most effectively perceived: visual – pictures, diagrams, graphs, demonstrations, or auditory – words, sound? (where the other senses play a minimal role in educational environment).
3) **Organization -** With which organization of information is the student most comfortable: inductive – facts and observations are given, underlying principles are inferred, or deductive – principles are given consequences and applications are deduced?
4) **Processing -** How does the student prefer to process information: actively – though engagement in physical activity or discussion, or reflectively through introspection?
5) **Understanding -** How does the student progress toward understanding: sequentially – in continual steps, or globally – in large jumps holistically?

Felder and Solomon developed a Learning Styles Inventory (LSI) that based on the responses of a 44-question survey, categorizes individuals according to these five dimensions of learning styles.

This study analyzes only the "understanding" dimension. The "understanding" dimension classifies students as sequential or global utilizing the Felder-Solomon LSI. Table 1 displays the key characteristics that differentiate a sequential from a global learning style. These same characteristics were used to classify the learning modules as sequential or global.

TABLE 1 – Key Characteristics of Sequential and Global learners.

Sequential Learner	Global Learner
Left-brain	Right-brain
Words	Images
Numbers	Patterns
Parts	Wholes
Sequential	Simultaneous
Linear	Patterns
Detail	Whole-Picture
Verbal	Non-verbal
Punctual	Without sense of time
Organized	Creative, Intuitive and Spontaneous

Methodology

Three tutorial modules were developed for Internet application within an engineering class at the University of Missouri – Rolla in the fall of 1998. The learning modules were used to supplement the first three weeks of the lecture due to the variety of backgrounds of the students, and also to prepare the students to successfully complete the entire course. However, the professor still had an opportunity to lecture, in a more reduced format, to the students after they used each of the modules. The students were not only tested after each of the tutorial modules, but also after the lectures sessions that followed.

The first module (Balanced Module 1) was designed with a mixture of sequential and global characteristics and was used by all 32 students. This was the initial module and it prepared the students to utilize the other, differentiated modules. The second module was designed with two variations. Each of the variations covered the same material, but one was designed with a predominance of sequential characteristics (Sequential Module 2) and the other was designed to be global (Global Module 2). Half the global students and half the sequential students, Group A, were channeled to the sequential module, while the remaining students, Group B, used the global module. The third and final module was also designed with sequential and global variations with identical content. However, Group A utilized the information that was global in nature (Global Module 3), and Group B the information that was sequential in nature (Sequential Module 3), as shown on FIGURE 1. This switch enabled us to compare the impact of the global and sequential features to each group as well how global and sequential users simultaneously perform on identical information in their preferred or less preferred learning environment. In addition to the pre- and post-tests shown in the figure there were also tests before and after each module.

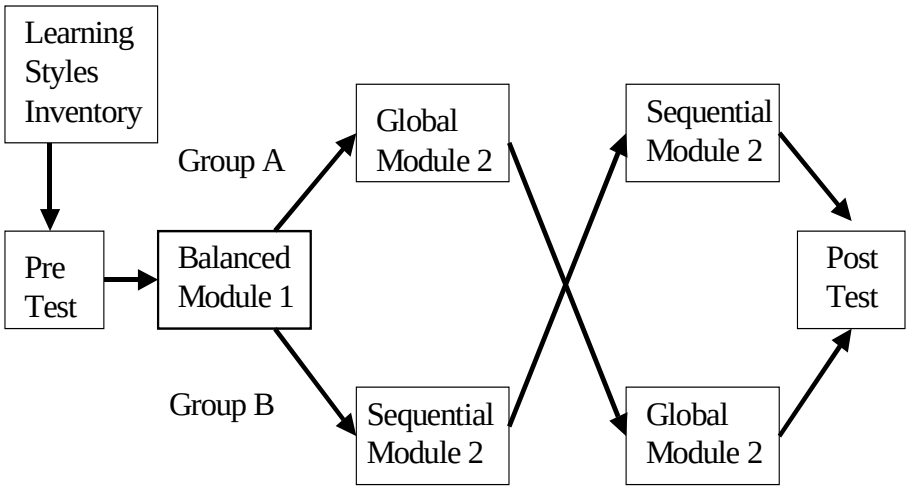

Figure 1 – Experimental Structure

Results

One way to compare the learning value of the synchronous tutorial modules is to compare the test results of the students who participated in this application with test results from previous years in which they were not utilized. The material covered did not change, nor the amount of time invested by the students. The exams were also equivalent. The major difference was that some of the lectures were replaced by Internet based tutorial modules that catered to particular learning style dimensions. The test results of the current students were not significantly better than in previous years, as an average less than one percent better. However, it shows that even in the first year these modules are applied, there was no detrimental impact of replacing some lectures by asynchronous learning modules. It should be noted that in this experiment, students were forced to learn in both global and sequential module environments, so the overall results have no advantage from the use of appropriate learning styles. It should also be noted that this was the first use of these modules and it should be expected that as more experience is gained with the modules, the learning impact should improve.

The more interesting result was the difference in performance of students in the modules based on their sequential or global nature. Student learning was measured by comparing their scores in the pretest and post-test for each module. The sequential students performed 35% better in the sequential modules than in the global modules. The global students performed 15% better in the global modules than in the sequential modules. In this study half of the students were categorized by the LSI as global and half as sequential. Using rigorous statistical analysis, the null hypotheses that sequential learners learned better in global modules and that global learners learned better in sequential modules were rejected at the 0.05 level using a split-plot analysis. As a result we can conclude that the design of the learning environment with respect to learning styles does impact learning effectiveness.

At the conclusion of the session, the students were asked for their opinions regarding this Web-based application. In general they felt that it was an effective method that helped them learn. The feedback was particularly positive from the international students that participated.

Implications

These results provide opportunities and threats to educators. There are times when Web-based instruction or class enhancements are necessary due to the lack of resources to perform them in person or the communication capabilities provided by the Internet. The overall results of this study provide support that some of these tasks can be handled asynchronously without a detrimental impact to learning. At the same time it is a warning that distance education might bring more competition to our industry. Distance has provided universities protection from competition up to now, but these new technologies will reduce this barrier.

The improved performance based on learning styles point to an excellent opportunity to enable our students to learn more effectively. There are three basic strategies that we can use to enable course design with respect to learning styles to improve learning:

1. We can balance our sessions,
2. We can tailor the sessions to the specific class or students, or
3. We can provide interactive choices for the students to choose the learning environment that best fits their needs.

Balanced approach

Courses can be designed to balance the various learning styles so that all the students are satisfied at least some of the time. This has several advantages. It can be applied to a large range of students and does not need to be customized. It also forces students that are effective learners in specific learning styles to develop competencies in other learning styles. This is a valuable educational opportunity since it will make them better able to learn under a wider range of conditions. This approach clearly seems to be an improvement over traditional methods that ignore learning styles and is recommended by some experts[5].

Tailored approach

Courses can be tailored for individual students or group of students who have similar learning styles. This could apply to courses and training sessions that have a specific target market and user profile. A course developer would learn the profile of the course users and create the session to facilitate their learning by emphasizing their preferred learning styles. This addresses the need to make the learning experience more effective. Even if a few individuals are left out, and the modules are designed in ways that make it very ineffective for some, it might be an effective way to reach the many, and make effective use of scarce resources in an organization or society. The few that are not well served by these finely tuned educational tools can be handled with other methods on an exception basis. However their identification and customized approach can create problems.

Interactive approach

The third and final alternative is to provide for user choice so that they choose to learn in the environments that are appropriate for them. Asynchronous, interactive modules can react to explicit choices by the user, or to behavior assessed by the system to make the appropriate selection. This method makes the course design process more difficult to develop but it eliminates many of the problems of the first two approaches. The one-fits-all approach does not

take into account individual differences such as the ones identified in this study and miss an opportunity to improve effectiveness. Individuals will have different learning objectives at different times, and choices enable the user to pick environments that are more suitable for specific needs. Finally, the definition of a balanced session might be difficult to attain due to subjective bias by the designer. What is intended to be balanced, might be biased towards some specific learning styles. The customized course will also be easier to develop than the one with choice, but it will be difficult to precisely assess the users' learning styles and develop modules that fit their needs. By providing choices, the assessment risk is reduced. In addition, the choices made by prior students can indicate to the course designers ways to improve the course. Environments that are seldom selected might have problems that can be modified. Environments that are often selected can be used as template of successful design and support a process of continual improvement.

Summary

This article documents an experiment that shows that asynchronous Web-based learning modules can be at least as effective as live lectures, even when learning style enhancements are not used. In addition, the design of learning modules with respect to learning styles does affect the effectiveness of the session. This implies that learning styles should be considered in the design of learning modules in order to improve effectiveness of learning. Finally, viable strategies exist to help educators design effective learning modules that take into account learning styles.

Bibliography

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5. Felder recommends this method to improve our effectiveness.

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