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A mixed learning approach in mechatronics engineering

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ABSTRACT: This article presents a method for improving the current pedagogical strategy for sustainable education through creating a mixed learning scenario that integrates different learning styles such as *reading*, *hearing*, *speaking*, *trying* and *realising* into the learning process. The author took a mechatronics course offered at San José State University, San José, USA, as a working model in order to experiment the proposed teaching strategy for two semesters, with emphases on maximising students' learning by addressing all of the various learning styles. The effectiveness of this approach was assessed through student evaluation results and a student survey.

INTRODUCTION

Learning styles vary from person to person. For example, some people learn better by reading (verbal learners), while others learn better by conducting experiments (sensing learners). However, regardless of learning style preferences, studies have shown that, in general, people remember only about 10% of what they read, 20% of what they hear, but 90% of what they actually *try and realise* (see Figure 1) [1].

These results motivated the author to create a mixed learning approach for students that integrates *reading*, *hearing*, *seeing*, *speaking*, as well as *trying and realising*. On the other hand, the content in many courses is highly theoretical and it is not amenable to support such a complete learning experience [2]. Hands-on experience is the key to effective learning, especially in engineering and science disciplines [3-6]. However, most courses do not support this learning experience for students.

This article presents a mixed learning strategy in an undergraduate mechatronics course: *ME106/EE106 Fundamentals of Mechatronics Engineering*, which is a cross-disciplinary course offered by the Mechanical Engineering Department and cross-listed in the Electrical Engineering Department at San José State University, San José, USA. This course involves a great deal of theory and actual hands-on experience, and is therefore a good candidate to test the concept of the mixed learning approach. The mixed learning strategy enables students to gain a deeper understanding of the interactions between different elements of the course. Although the mechatronics course is used as a working model in this article, the proposed infrastructure is sufficiently general to serve as a paradigm for use in other courses or disciplines.

In this article, the author briefly introduces mechatronics education at San José State University (SJSU), before describing the mixed learning approach. A summary of the outcomes and feedback from students is also given.

Figure 1: Psychological investigation results [1].

MECHATRONICS EDUCATION AT SJSU

The mechatronics programme at SJSU is one of the earliest undergraduate mechatronics programmes in the USA [7][8]. In 1996, the National Science Foundation (NSF) of the USA granted SJSU about $500,000 to create a mechatronics programme and laboratories in the Mechanical and Aerospace Engineering Department. Currently, the mechatronics programme involves four laboratories: mechatronics, robotics, control and measurement, as well as 10 courses at both graduate and undergraduate levels.

ME106/EE106 is a required course with an annual enrolment of approximately 100 students. It is an introductory course that exposes students to analogue, digital, and semiconductor electronics, sensors and transducers, actuators, and micro-processors. The course consists of two components: lecture and laboratory. The lectures are intended to provide students with foundational concepts in mechatronics and familiarity with common elements of mechatronics systems. The laboratory experiments are designed to give students hands-on experience with components and measurement equipment used in the design of mechatronic products.

THE MIXED LEARNING APPROACH

The mixed learning approach has eight parts, elaborated on below.

Part I: Reading

The goal of this phase is to help students acquire the technical vocabulary necessary to engage in the study of the field of mechatronics. Rather than teach every term in the classroom, which is impossible due to the limit of class time, students learn some basic definitions by reading the introductory material posted on the course Web site and selecting *Tutorials* [9].

Part II: Lecture

The goal of this phase is to bring students from different backgrounds to the same level of understanding of the basic concepts.

Part III: Visual Aids

Videotapes, computer simulation, pictures, diagrams, graphics and demonstrations provide tools for visual learning to help students, especially visual learners, understand the various concepts and principles involved.

Part IV: Laboratory Experiments

The goal of this phase is to provide students with hands-on experience in a laboratory environment. Several experiments have been meticulously designed and arranged in parallel with the related lectures, such as digital/analog circuits, digital I/O, microcontroller, A/D and D/A converters, RC filters, PWM speed control, stepper motor control, etc. Students work (in teams of two or three) with real hardware, including sensors, actuators and digital I/O interface. Students also develop and test codes to control various devices. Students learn best when they enjoy the experience and see that the device being controlled actually works.

Part V: Student Presentations and Discussions

Auditory learning is achieved by words and sounds. This is accomplished in two steps, namely:

1. Students are required to give lectures on some subjects, such as electronics components, sensors and actuators. These are very broad topics and are appropriate for students to present. Students are assigned into groups and asked to study a specific component assigned in advance. On their appointed day, each group presents their topic in the class.
2. Students are required to discuss certain difficult concepts and phenomena in class. These discussions give the instructor valuable feedback on students' learning styles and thinking patterns. This approach also gives students an opportunity to improve their communication skills.

Part VI: Student-Designed Experiments

Students work in groups of three to develop a new laboratory experiment. They have to find laboratory development related information and figure out how to apply the theory learnt in the class in order to develop an actual experimental set-up. They are also required to write laboratory manuals, including laboratory objectives, laboratory procedures, hardware connection diagrams, questions and answers, as well as part fabrication, if necessary. This phase, together with student involved teaching, provides an active learning environment that changes the traditionally passive learning pattern – students are told what to do and how to do it.

Part VII: Group Project

In this stage, students work in teams and apply their acquired skills to design and build a fully functional mechatronics system, eg a fire-fighting robot, a smart cane, a Battlebot, etc, in order to win the term project competition. Through *trying and realising* various modules, including all sorts of mechanical parts, electronic components, analogue and digital circuit, sensors, actuators, and programming codes, they will implement a project and make it work. This learning approach matches the needs of students' creativity in project design with competition themes. Student projects, based on the author's opinion, worked best when they were aimed at winning a project contest.

Part VIII: Interaction with Industry

Interaction with industry is accomplished in two ways, namely:

1. Engineers from industry, with first-hand experience in mechatronics, are invited to give lectures in topics such as motor selection, circuit design, sensor usage, etc.
2. Students visit local companies, identify industry needs and convert real-world problems into appropriate student projects. One of the advantages of this kind of interaction is that students become familiar with various industry needs early in their careers and have an opportunity to adjust their career goals. The companies involved usually get workable solutions for their problems.

A key ingredient in making this mixed approach work is to make it a fun and enjoyable experience. Stimulating students' interests in the subject matter has proven an essential element in effective teaching and learning. Table 1 illustrates how the mixed learning approach enhances student learning by offering opportunities for students to experience all the learning steps of Figure 1. Figure 2 is a simple concept map of the mixed learning approach.

OUTCOMES AND STUDENT FEEDBACK

The mixed learning scenario was found to improve student learning and satisfaction with the course. For example, in spring 2001 (before the mixed approach was used), the average grade in the final examination was 67.87; in fall 2001 and spring 2002 (after mixed approach was used), the average grade went up to 79.91 and 81.01 respectively.

Figure 3 shows the Student Opinion of Teaching Effectiveness (SOTE) scores for the ME106/EE106 course before (spring 2001) and after (fall 2001 and spring 2002) the mixed approach was applied. It is clear that these scores improved considerably after using the mixed learning strategy.

Furthermore, one-to-one student interviews identified several additional benefits of this approach:

- It exposes students to real-world problems and the needs of industry and helps them set to appropriate career goals while still in school.
- It provides workable solutions to real-world problems of local industry.
- It improves the University's laboratory experience by involving students in laboratory development.
- Most importantly, it makes students learn how to *think* and *learn.*

CONCLUSIONS

Integrating different learning approaches into an undergraduate mechatronics class (ME106/EE106) has achieved encouraging results at San José State University. In particular, in the two semesters where it was used, the mixed learning strategy enabled students to gain a deeper understanding of the interactions between the different elements of the course, increased their interest in engineering, triggered their active attitude towards learning and further inspired their creativity.

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Table 1: The mixed learning scenario and effectiveness in student learning.

Learning Style	Try and Realise	Speak	See	Hear	Read	Fun
Reading			●		●	●
Lecture			●	●		●
Visual Aids			●	●		●
Laboratory Experiments	●		●			●
Student Presentations/Discussion		●		●	●	●
Student-Designed Experiments	●	●	●	●	●	●
Group Project	●	●	●	●	●	●
Interaction with Industry	●		●	●		●

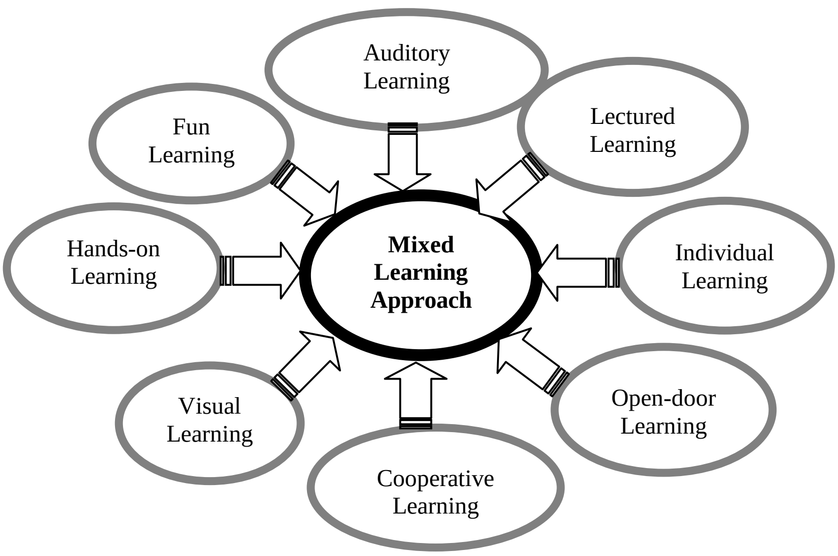
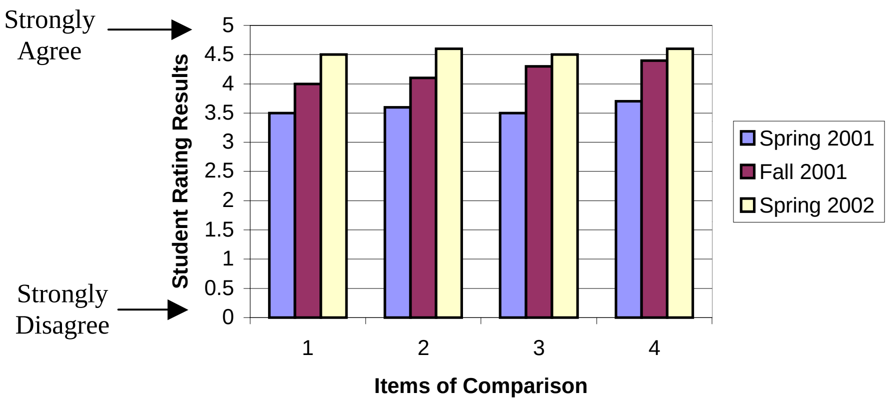


Figure 2: Integrating different learning styles to create the mixed learning scenario.



The number on the horizontal axis denotes:

1. Helped me learn the material.
2. Increased my understanding of the subject.
3. Probability that I would recommend it to another student.
4. Overall effectiveness.

Figure 3: Comparison of Student Opinion on Teaching Effectiveness (SOTE) scores.

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