AC 2009-2061: INTENTIONAL LEARNING IN CORE ENGINEERING AND ENGINEERING TECHNOLOGY EDUCATION

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Intentional Learning in Core Engineering and Engineering Technology Education

Abstract

We report a Scholarship of Teaching and Learning (SoTL) case study on the intentional learning in the upper level core electrical engineering sequence in which the same instructor and the same group of students in two similar level technical courses, one with a more traditional instruction delivery and assessment and one with more elements of intentional learning, are compared. Besides regular course assessments and student feedback, we also conduct small group analyses and present results that compare the various aspects of the teaching and learning experience such as teaching effectiveness and student experience.

From the study, we can comfortably draw the conclusion that the students are more receptive to the teaching methods that incorporate intentional learning elements. Even with a deficiency in implementing such intentional learning methods as compared to the more traditional passive teaching that an instructor is more familiar with, student perception of learning still scored higher for the teaching method that implements more intentional learning elements. There is also an interesting correlation between students' classroom activeness to the final grades when more intentional learning elements are involved in teaching. Such correlation tends to disappear in the more traditional passive teaching.

Introduction

Intentional learning refers to cognitive processes in which the students take ownership of their own learning: the students set their own learning objectives, monitor their own progress toward their learning goals, pay attention to and look out for the conditions and environment in which they learn best, and actively make connections and add meaning to their learning.[1,2] It is well recognized that the most successful and accomplished learners are intentional learners and the benefit is life-long rather than short-lived during the college years. Intentional learning, however, does not come naturally for students. In addition, in many professional areas, especially in engineering and engineering technology education, intentional learning is foreign to instructors. Traditionally, engineering and engineering technology education is a passive process for the student, with the knowledge and skills "being taught" and "transferred" from generation to generation. Apprentices rarely have a global picture of their learning objectives and they passively rely on masters and teachers to monitor their progress. They tend to learn in the same learning settings and environment where generations before them always learned. They also depend on masters and teachers to make the connections and add meaning to their learning, and often the masters' connections are so lofty that only after many years of practice may the students make the link and understand the meaning. It is therefore a great challenge for engineering and engineering technology faculty to help their students to be more intentional learners, which will benefit them in their life-long professional careers. In this paper, we present a case study in the upper level core electrical engineering sequence where the same instructor and the same group of students in two similar level technical courses, one with more traditional instruction delivery and assessment[3-5] and one with more elements of intentional learning, are compared. Besides regular course assessments and student feedback, we also conduct small group analyses and present results that compare the various aspects of the teaching and learning experience such as teaching effectiveness and student experience.

Design of Experiment

During this study, as common to other Scholarship of Teaching and Learning (SoTL) projects, the students are the human subject of the study. Accordingly, we have applied for and secured the approval from the Human Subjects Institutional Review Board (IRB). During the IRB review process, we also secured the signed student informed consent statements close to the end of the semester. A sample informed consent statement is exhibited in Fig. 1.

Informed Consent Statement

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Project Title: Intentional learning in core engineering and engineering technology education

Purpose of Study:

You are invited to participate with no obligation in a research study which has as its main purpose to describe the similarities and differences between a more traditional lecture based content delivery method and a more intentional learning amenable delivery method of core engineering courses at a similar level in undergraduate. .

Description of Participation:

The students attending EE425 Foundations of Optical Engineering and EE 465 Foundations of Laser Electronics will be invited to participate the study. The two courses, although at a similar technical level, are inherently different in course contents. EE 425 serves a purpose of broad survey of modern optical engineering technologies with the review of fundamentals of wave optics. EE 465 is more focused on a single topic of lasers also with similar review of fundamental of wave optics. Accordingly EE 425 is more amenable to a group discussion, role playing (expert at different topics), and Jigsaw puzzle form of intentional learning tools. EE 465 is more involved in terms of design principles and the depth of the topic and is more suitable for a traditional lecture and paper exam type of teaching. The students are invited to participate in data collection such as SAI course evaluation and small group analysis. The questionnaires will take about 15 to 30 minutes to complete and will ask you questions regarding various aspect of the teaching and learning. These questionnaires will not be graded and data will be only available in summary form and no individual identity is accessible or revealed. We will have three small group analysis survey and one SAI survey during the semester.

The proposed research is in concord with a normal course teaching and improving of teaching and learning. It does not pose any perceivable risk of psychic, legal, physical, or social harm. It also takes a low education outcome risk form that essentially different technical materials are presented in a more suitable approach as investigators see fit. The potential benefits include both better understanding and therefore better education outcome of the participating students as well as for the generations of engineering and engineering technology students at Western and at large as the investigators plan to share the result of the study to the general engineering and engineering technology education community.

Confidentiality:

Data collected by both SAI course evaluation and the small group analysis study are in summary form, no individual identity is accessible or revealed, the confidentiality of all subjects are maintained and all subjects are protected from the future potentially harmful use of the data collected. All data will be stored in the password protected university computers of the Principal Investigators.

Voluntary Participation:

Your participation is strictly voluntary. If you decide not to participate there will be no penalties or negative consequences. Your course grade or the way you are treated in this course will not be affected if you decide not to participate in this study. You may choose to withdraw from the study at any time and the Principal Investigator may choose to cancel your participation at any time. If you choose to withdraw, all data concerning you will be destroyed.

Do you have any questions? (Circle one) NO YES

If you circled YES, please contact the Principal Investigators, Dr. Bill Yang and/or Dr. Amy Martin at the above phone number or by email before signing this form. If you have questions or concerns regarding your rights as a research participant, you may also contact the chair of the WCU Institutional Review Board at 828-227-3177. Do not sign this form until these questions have been answered to your satisfaction.

YOU ARE MAKING A DECISION WHETHER OR NOT TO ALLOW THE PRINCIPAL INVESTIGATORS TO USE THE WORDS FROM YOUR QUESTIONNAIRES, INTERVIEWS, AND CLASS DEBATES FOR RESEARCH AND PRESENTATION PURPOSES ONLY. YOUR SIGNATURE BELOW ALSO INDICATES THAT YOU ARE OVER THE AGE OF 18.

I AGREE DO NOT AGREE (Circle one) to participate in this research study.

Participant's name (please print) ____________________ Date: __________________

Participant's Signature: ____

Fig. 1: Sample student informed Consent Statement

The IRB process is indeed very helpful as there are many subtleties involving the design of the study in SoTL projects. These issues are often foreign to professors and lecturers in engineering and engineering technology areas, who normally do not have training in their professional background in dealing with human subjects. Some of the subtleties are unique to SoTL projects. For example, when teaching effectiveness is being evaluated by comparing two different teaching methods, as in the study presented here, the design of the study should ensure that no group of students receives preferential treatment. As typically is the case in such SoTL projects, the new teaching method is evaluated against a control group in which the normal teaching method is applied. In such cases, the investigator should ensure that the new teaching method does not impair student learning. This task is usually more difficult than it appears to be since the effectiveness of the new teaching method is the very subject under the investigation. The investigators need to make sure that the potential benefit of the study significantly exceeds the risk of learning disadvantage. On the technical side, ideally such a study would deliver the same content to the same group of students with the same level of previous knowledge using different teaching methods, and would then compare the teaching effectiveness. This is however obviously impossible in practice. Most SoTL studies are conducted during the normal teaching and learning processes. The implication of such impairments imposed on SoTL studies has to be carefully addressed as in many cases it will limit the generality of the research results.

In our study, we try to compare the teaching and learning effectiveness of two different teaching methods in the core engineering and engineering technology curriculum. The control group will use the traditional content delivery method where the teacher specifies the learning objectives and the evaluation methods. The content is delivered mostly in the traditional lecture form assisted by available multimedia tools such as PowerPoint presentations. The new teaching method under evaluation is designed according to intentional learning principles and utilizes several intentional learning tools such as a "jigsaw puzzle" type of group discussion and role playing. The students are also given the opportunity to define their learning objectives and choose the evaluation methods. In both control and study cases, the same teacher teaches the same group of students during the same semester. The students come to the two classes involved in the study and with the same prior knowledge. The subject areas of the two courses involved are also similar. The students attending Course A and Course B (control) were invited to participate the study. The two courses are at a similar technical level and of the same general topic area of modern optics and optoelectronics. However, they have different focuses and are inherently different in course content. Course A serves a purpose of broad survey of modern optical engineering technologies with the review of fundamentals of wave optics. Course B is more focused on a single topic. It is arguable that Course A is more amenable to a group discussion, role playing (expert at different topics), and "jigsaw puzzle" forms of intentional learning tools. Course B is more involved in terms of design principles and the depth of the topic and is arguably more suitable for a traditional lecture and paper exam type of teaching. The design of the study is in concordance with a normal course. It does not pose any perceivable risk of psychic, legal, physical, or social harm, which is a pre-requisite to obtain IRB approval. The study also poses a low educational outcome risk in that essentially different technical materials are presented in a more suitable approach as the investigators see most fit. The potential benefits actually include both better understanding and better learning outcomes for the participating students as well as benefits to the general engineering and engineering technology education community at large. While such design minimizes the risk of learning deficiency due to the proposed study, it should be noted that the implication on the comparison results also needs to be taken into consideration.

The data points we collected for this study include the traditional ones such as test and exam scores and course discussion participation. The students are also invited to participate in data collection of the standard student assessment of instruction (SAI) course evaluation as a routine university wide survey as well as targeted small group analysis (SGA) sessions. Sample questions of the assessment tool of SAI are exhibited in Fig. 2.

Student Assessment of Instruction: Standard Course Form

Organization and Clarity

My instructor is well prepared for class meetings.
My instructor explains the subject matter clearly.
My instructor clearly communicates course goals and objectives.
My instructor answers questions appropriately.

Enthusiasm and Intellectual Stimulation

My instructor is enthusiastic about teaching this course.
My instructor presents the subject in an interesting manner.
My instructor stimulates my thinking.
My instructor motivates me to do my best work.

Rapport and Respect

My instructor helps students sufficiently with course-related issues.
My instructor is regularly available for consultation.
My instructor is impartial in dealing with students.
My instructor respects opinions different from his or her own.

Feedback and Accessibility

Assessment methods accurately assess what I have learned in this course.
Grades are assigned fairly.
The basis for assigning grades is clearly explained.
The instructor provides feedback on my progress in the course on a regular basis.

Student Perceptions of Learning

My instructor advances my knowledge of course content.
My instructor promotes my understanding of important conceptual themes.
My instructor enhances my capacity to communicate effectively about the course subject matter.
My instructor encourages me to value new viewpoints related to the course.

Fig. 2. SAI questionnaire, standard course form used for both courses in the study.

The SAI contains both the standardized response on a scale from 1 to 4 displayed in Fig. 2 as well as open ended questions. Each course in the study gets its own survey with the same questionnaire. The other assessment tool, the SGA analysis, runs two common sessions for both courses in the study, one at the beginning of the semester and one at the end of the semester. Questions are targeted to evaluate teaching effectiveness and the student perception of the teaching. Sample questions include "What aspects of this course and/or the instruction are helping you learn?" "What aspects of this course and/or the instruction would you recommend be changed to improve your learning?", and for the follow-up session, "What aspects of this course and/or the instruction have been changed to improve your learning?" and "Are there aspects of this course and/or the instruction that are impacting your learning in a negative way?"

Data Analysis and Assessment Results

Table I summarizes the final grades categorized by the course participation level assigned by the instructor according to the activeness of each student in asking questions, feedback, and leading the discussions, etc. It is noted that while in Course B all students are more involved in classroom discussion by requirement, it was the roughly the same group of students who are more active than the other in both courses.

Table I: Final grades and group average points categorized by activeness of the students

Level of student activeness	% of students	Course A		Course B (Control)	
		Min. & Max. Grade	Group Average Point	Min. & Max. Grade	Group Average Point
most active	27	B+, A	3.55	A-, A	3.89
active	18	B, A	3.50	B, A	3.5
less active	27	B, A-	3.33	B, A	3.67
inactive	27	B, B+	3.11	B+, A	3.67

It should be noted that the above data should be used carefully as many other factors can also play into the final grades. For example, it may not make too much sense to compare the absolute values of the quality points across two courses. In fact, on average, the instructor believes there is no significant difference between the levels that the students achieved with respect to the course objectives. Also, the assessment of student activeness level is more subjective than objective. Nonetheless, the data seems to suggest that in the course involving more intentional learning elements, there is a positive correlation between the student activeness in the classroom and the final grades. In the more traditional passively delivered course with less intentional learning elements, however, the student activeness in the classroom is not necessarily correlated with the final grades. However, the most active group stands out in both courses while the less active groups did significantly better in Course B than Course A.

Table II: Summary SAI results for both courses.

SAI assessment area	Course A	Course B (Control)
S1: Organization and Clarity	3.0	3.2
S2: Enthusiasm and Intellectual Stimulation	3.0	3.1
S3: Rapport and Respect	3.7	3.7
S4: Feedback and Accessibility	3.3	3.3
S5: Student Perceptions of Learning	3.2	3.1

Table II presents a summary of the SAI results for both courses. Due to the standardized nature of the SAI questionnaire, the scores are indeed very comparable across both courses and the results are consistent. In assessment areas unrelated to the delivery method, namely S3 and S4, the instructor received the same scores. On the other hand, for those assessment areas closely related to the content delivery method, the instructor scored higher in Course B (Control) on both S1, Organization and Clarity, and S2, Enthusiasm and Intellectual Stimulation, whereas the student perceptions of learning (S5) is actually higher for Course A than the control. This seems to suggest that, even with a deficiency in implementing such intentional learning methods as compared to the more traditional passive teaching that an instructor is more familiar with, the student perception of learning is still better for Course A than the control. The SAI questionnaire also incorporates two open-ended questions, Q1: Describe the best aspects of this course and Q2: Describe changes that could be made to improve the course. The response rate to each of these questions can be considered a rough gauge of the strength and weakness of the teaching. In this respect, Course A has a 64% response rate to Q1 and a 82% response rate to Q2. In comparison, Course B, the control, has only a 45% response rate to Q1 and a closer 54% response rate to Q2. The data reflects the uneasiness that the students had on the teaching of Course A. In comparison to the responses to the control Course B, the data seems to suggest that while the students do like the new teaching method, there are at the same time also many places that can be improved.

Combining both numerical assessment data and the open-ended question response, the SAI data seems to suggest that the students indeed feel they are learning better in a more intentional learning environment.

In addition to SAI, we also conducted two sessions of SGA that are more specifically targeted on the student learning experiences. In both responses, the students largely embrace the new teaching method in Course A with less than 10% of students expressing more willingness toward the teaching method of Course B. One student noted that Course A "is more interactive between students and [the instructor] and that "in [Course B (Control)] I think we need to get away from having powerpoints all the time." Another student commented, with regards to Course A, that "the class is more involved now. I can tell that the instructor is trying to get the class more involved and participating more, and this really helps in learning the material." Overall, students noted that in Course A, they were being required to take more responsibility for learning the material, which was aiding in their learning and retention of the materal.

Conclusion and Discussion

In terms of content delivery, the instructor was able to deliver more technical content in Course B (Control) than in Course A. This is largely due to the decreased student discussion involved in Course B, which then naturally included more lecturing time. While there were concerns from the students that the content delivery pace may be too fast in Course B and the students largely feel more comfortable with the content delivery pace in Course A, it seems to the instructor that there are no significant impairments to the level of students' understanding and absorption of the material in Course B as compared to Course A. While from the previous discussion of the acquired data we can probably conclude that the students feel better and have better perceptions of learning in terms of teaching and learning efficiency, the more conventional delivery method in Course B seems to exceed that of the new teaching method implementing more intentional learning tools in terms of teaching efficiency. It should be noted, however, that this result can be biased due to the possibility that the instructor is more efficient applying traditional teaching method than the new teaching method involving more intentional learning elements.

In summary, we can comfortably draw the conclusion that the students are more receptive to the teaching methods that incorporate intentional learning elements. Even with a deficiency in implementing such intentional learning methods as compared to the more traditional passive teaching that an instructor is more familiar with, the student perception of learning still scored higher for the teaching method that implements more intentional learning elements. There is also an interesting correlation between students' classroom activeness to the final grades when more intentional learning elements are involved in teaching. Such correlation tends to disappear in the more traditional passive teaching.

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