Modeling Student Satisfaction and Implementation of the I-C-D Method to Improve the Industrial Engineering Undergraduate Course Experience

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Modeling Student Satisfaction and the Implementation of the ICD Method to Improve the Industrial Engineering Undergraduate Course Experience

Abstract

This paper discusses the results of a study performed at the Pennsylvania State University to identify and implement the significant factors of student satisfaction and motivation within the industrial engineering undergraduate classroom. Building on another study performed at the Pennsylvania State University, the three overarching factors influencing student satisfaction and motivation were found and further analyzed. This study defined the specific factors of Instructor Interaction and Feedback, Classroom Environment, and Modes of Instruction that were modeled to create a statistically significant model. By creating a model of significance, instructors will be able to have a concise and easy implementation plan to improve student satisfaction and motivation in the classroom, creating a better educational experience for both the students and the instructor. Once the factors that most significantly influence student motivation and satisfaction were identified, an implementation model was created and tested. The "Interact, Cultivate, and Deliver" method, also known as the "I-C-D" method, implements the eleven significant factors found across the three ordinal logistic regression models in a succinct manner for instructors. A pilot study of this method was implemented into an IE classroom and it was found that when the significant factors were implemented into the classroom, the satisfaction and motivation were significantly better than respective predicted values.

Disclaimer

The views expressed in this paper are those of the authors and do not necessarily reflect the official policy or position of the U.S. Air Force, the U.S. Department of Defense, or the U.S. Government.

Introduction

Previous studies at the Pennsylvania State University found the general driving factors of student satisfaction and motivation, which were used to move forward into quantitatively modeling student satisfaction and motivation. The models will show the significant factors with the categories of Instructor Interaction and Feedback, Classroom Environment, and Modes of Teaching for overall student satisfaction. The significant factors were then implemented into a test classroom to quantify the effect against predicted values of student motivation and satisfaction. Recommendations on how these factors can be easily implemented into industrial engineering classrooms will allow improvements in many classrooms outside of the Pennsylvania State University.

Student Learning Styles

In engineering classrooms, instructors often teach in a manner that is not aligned with the dominant learning styles of the student population.[1] Students should be challenged to think outside of their normal learning styles in order to best retain and use information in the future careers. Due to the disconnect of student learning styles and instructor teaching styles, students may become disinterested in the classroom and lack motivation to continue in the course or major.[1]

Many learning style models exist today, but only a select set of four have been used to study engineering education: the Myers-Briggs Type indicator, Kolb's Learning Style Model, the Hermann Brain Dominance Instrument, and finally the Feld-Silverman Learning Style model.[1,2,3] The most relevant learning style model to this research is the Felder-Silverman Learning Style model, which was based on aspects of the Myers-Brigg Type Indicator and Kolb's Learning style model. The model is based on five main questions that engineers are asked to answer regarding perception, sensing, processing, and understanding.[4] This model has its foundations in marrying modes of learning with modes of teaching styles. Through that connection, it will be easier for instructors to implement changes into the classroom to effectively teach students.

There are four main dichotomies used in this model: sensing and intuitive, visual and verbal, active and reflective learners, and sequential and global learners. Often, students fall on one side of each of the aforementioned categories. Sensing vs. intuitive learners refers to how the world is perceived.[5] Sensing involves interacting with surroundings using one of the five senses, whereas intuitive learners tend to mentally digest facts.[5] Sensing learners enjoy problem solving sessions and repetitive techniques while studying, whereas intuitive learners tend to perform best in surprising situations that test knowledge.[4,5] Visual and verbal learners relate to how students receive information through the senses. Visual learners retain information by studying pictures, graphs, or videos. These types of learners cannot learn in traditional lecture halls.[5] Auditory learners are able to process words and sounds into facts that can easily be recalled.[5] Active and reflective learning styles focus on the mental process of converting information into knowledge. Active experimentation involves physically doing something with the information at hand, whereas reflective learners take in the information and internalize it for recollection.[5] Labs and problem solving sessions are better for active learners, whereas reflective learners do not learn much in situations where there is little opportunity to reflect on information.[5] Finally, sequential learners tend to learn as the material is being presented in the classroom, whereas global learners tend to struggle seeing the larger picture while learning new material. [5,6] Understanding the types of learning styles that students can have can help professors better align their classrooms with the students so that the students are successful.

Teaching Styles in the Classroom

Maximum retention and understanding of the subject matter can be obtained when the teaching styles of the professors match the learning styles of the students.[7] Often, students are taught the material and tested on the material with little to no application to the real-world career paths.[8] Inductive and deductive teaching styles are the two overarching categories of teaching styles in the classroom. Deductive learning styles are most often found in current engineering classrooms that follow the classic blackboard lecture and exam format.[10] Instructors begin by introducing the generalities of the topic, followed by mathematical proofs, practicing with homework, and then testing the material with an exam.[10]   Although this method is ubiquitous in classrooms, students often feel that there is no connection to the material and little retention.[10,12] Although this method is not favored by students, it is actually very effective in a clearly defined objectives and a path at achieving those objectives. Conversely, inductive teaching styles show the students the importance and application of the material, through specific and complex challenges.[8,10] Inductive teaching methods truly cover a large variety of instructional methods, from inquiry learning, problem-based learning, and project based learning. Often, these methods are deemed “student centered”, as the mastery of the concepts falls on the students to understand the importance of the material from the problems or projects.[11] Overall, inductive teaching styles have more student benefits than deductive teaching methods. Inductive teaching methods offer more combinations to reach the learning style needs of the classroom and engage students more actively in the subject matter.

Student Perceptions in the Classroom

Satisfaction, self-efficacy, motivation, and classroom environment are the main factors in a classroom that each student perceives differently, thereby affecting how the student receives the material. Understanding the interaction of these factors can allow professors and educators to have maximum impacts to improve student perception in the classroom.[13] Student satisfaction relates to the perception of the learning experience and value of the course. Satisfied students tend to persist through difficult classes and majors, as well as having better overall academic performance in their careers, when they are satisfied with their courses.[13] Students gain satisfaction in a variety of ways, from feeling a sense of achievement or receiving positive reinforcement for results. Forging student-teacher relationships within the classroom have also led to higher student satisfactions.[14] Often, students who are able to speak and interact comfortably with their instructors have had higher overall GPAs, degree attainment, honors distinction, and are more likely to pursue higher education.[14]

Self-efficacy refers to the personal reflection and judgement on the ability to complete a task.[15] Efficacy beliefs will influence the amount of effort students put into classes, how students face challenges, and the ability to cope with the rigor of academics.[16] Students need both the ability and motivation to learn the skills in the rigor of an engineering education, but they also need a strong belief in their capabilities.

Lastly, motivation is arguably the most important factor in the classroom, as it generates, directs, and sustains what actions students take to learn the material. Often, professors do not understand why the students are lacking motivation, as the course material and structure would be enough to motivate the instructors if the roles were reversed.[18] At the core of motivation are the subjective value of a goal within a course and the expectancies of achieving that goal.

Although each of the aforementioned perceptions are individually important, when improvements are made in satisfaction, self-efficacy, and motivation, the largest change in student perceptions of the classroom will take place.[18] When students are satisfied with their educational experiences and hold positive self-efficacy beliefs, student motivation and drive in the classroom often increases. These factors can be easily controlled and manipulated by the instructor. Students in positive and supportive classroom environments are able to learn, integrate, and recall new knowledge gained in the classroom.[18]

Engineering Education

Studying and improving engineering education has become a widespread research topic, challenging educators to rethink traditional classroom norms in order to retain and motivate students to stay within the engineering education track. Other studies have tried to quantify student satisfaction and motivation for different types of engineers. Quantitative modelling, using multiple regression models with predictors have been built in relation to first-year retention in programs at universities. One such study used predictor variables that related skills, pre-college characteristics, and social integrations in order to predict attrition rates from the Engineering College at the University of Michigan.[19] Research by Dr. J Fredericks Volkwein at the University of Albany and Alberto F. Cabrera at the Pennsylvania State University focused on the factors that most directly influence classroom vitality.[20] Further research was performed at Penn State University in order to study classroom environment and teacher practices on student satisfaction in a first-year engineering design course. Factors that were studied included the following: instructor interaction and feedback, collaborative learning, instructor climate, and peer climate within the classroom. Within this study, it was found that instructor interaction and feedback was the only variable studied that significantly impacted the student learning outcome ratings.[20]

Previous research was performed at the Pennsylvania State University under the same advisor's guidance to model student satisfaction and motivation in the industrial engineering classroom. This research that has been in progress since fall 2012 acted as a foundation for the research described later in this paper. Learning styles were first studied by using a population of industrial engineering students, randomly selected to participate. Utilizing these results, a screening experiment and survey were created in order to find the significant drivers of student satisfaction in a satisfying and unsatisfying course within their time as a student. These research results were then used as a foundation for the current engineering education study.

Research Methods

In the fall of 2012, a student survey was created by another researcher at the Pennsylvania State University in order to analyze the driving factors of student satisfaction in the classroom. The findings of this research were used as a screening survey to better understand industrial engineering students and how they learn best. In the fall of 2014, a new survey based on the findings of the initial research was created to allow accurate statistical modeling to occur.

The created questionnaire was administered to 107 junior-level industrial engineering students, at-will, at the Pennsylvania State University. As this was administered in an industrial engineering major track course, all 107 students were industrial engineers (this course does not always have only industrial engineering students, as it can be taken as an elective). The 107 students participated in the completion of the student satisfaction and motivation research questionnaire. The survey was created on the basis of three potentially significant areas of student satisfaction: instructor interaction and feedback, classroom environment, and modes of instruction. In previous phases of this research effort, the data was not able to be statistically modeled due to the paired nature of the data, since students were answering survey questions about a "satisfying" and "unsatisfying" class together. To alleviate this issue relating to being binary of “good” or “bad” courses, only one course was evaluated in each survey given to students. The course assigned to each student was randomly given for one of three courses that the students would have taken or have been currently enrolled in, named Class A, Class B, Class C. Each survey type had approximately 35 students in the sample set. Therefore, the 107 participating students were split into thirds to compare three courses. The questions and format among the class versions remained the same. Different courses within the curriculum were chosen to avoid a student ranking courses very high or very low in satisfaction, leading to a null model that shows little significance. All courses were chosen based on the following factors - being offered in the fall of 2014 and only having one instructor teaching the course. These factors needed to remain constant for the model to be free of bias for different teachings in different semesters. The survey was created with the help of statistical consultants and survey experts in order to create the most accurate survey for the study that could possibly be made. A sample of a set of questions included in the survey is included below for reference:

3. Overall, what is your level of satisfaction in regard to the **Instruction Interaction and Feedback** in the CLASS A Classroom?

Please note that each of the factors listed in question 2 would factor into the overall student satisfaction relating to the Instruction Interaction and Feedback in the CLASS A Classroom:

Extremely Unsatisfying	Unsatisfying	Neutral	Satisfying	Extremely Satisfying
1	2	3	4	5

4. Please rate the satisfaction that would be obtained from each statement to overall learning experience relating to **Classroom Environment** in the CLASS A classroom:

	Extremely Unsatisfying	Unsatisfying	Neutral	Satisfying	Extremely Satisfying
“Real World” applications of course material	1	2	3	4	5
The skills gained in this classroom will be applicable to future career	1	2	3	4	5

Grading procedures were clearly defined and consistently used	1	2	3	4	5
Presentations, assignments, and activities relate	1	2	3	4	5
Knowledge of current grade throughout the semester	1	2	3	4	5
Material on assignments and exams reflects material taught in course	1	2	3	4	5
Students are encouraged to be active participants in the classroom	1	2	3	4	5

Figure 1: Sample of Created Survey for Student Satisfaction

Likert item scales from 1-5 were used in this survey along an ordinal scale. For example, the rating of "1" in this survey would be deemed lower than a ranking of "5", using the natural ranking method known. A five-point Likert scale was used, allowing survey participants to rank questions from "very unsatisfying" to "extremely satisfying" with a neutral option residing in the middle. This was chosen to allow for regression modeling to be performed.[22] It was also assumed that the interval between the responses ("1"-"2", "4"-"5") are of the same width. If a student did not answer a survey question, it was assumed as a "1". This assumption rates the lack of a teaching style/learning style in the classroom to be of the same rating as "extremely unsatisfying". Survey participants were made aware of this assumption prior to answering the survey. The following table shows the specifics of the Likert scale used within this research:

Table 1. Likert-item Scale

Rating	***Satisfaction Level***
1	*"Extremely Unsatisfying"*
2	*"Unsatisfying"*
3	*"Neutral"*
4	*"Satisfying"*
5	*"Extremely Satisfying"*

Selection of Predictor and Explanatory Variables in Logistic Model

Each of the main three categories- Instructor Interaction and Feedback, Classroom Environment, and Modes of Instruction- were further divided into subcategories to better explain the models.

Instructor interaction and feedback was found to be the driving factor of student satisfaction in another study performed at the Pennsylvania State University. Instructor interaction has been found to be extremely important in students' academic careers.[18] If instructors can act as mentors to the students, while providing active feedback and routes to successful academic and professional careers, students are often more motivated.[18] Feedback on assignments and exams has been shown to be crucial to the student experience in the classroom as well. When feedback is given quickly, students are able to process the information and store the most accurate information for long term use.[18, 23] Detailed feedback can also lead to students gaining self-confidence and positive self-efficacy beliefs.[17,18] Approachability of the instructor is a significant factor for students as well, as students will only feel comfortable asking questions about course material or career paths when the teacher is approachable.[1,7] Professors should also show passion about the course material, as students tend to instantly be more interested in topics if the professor shows enthusiasm.[18] Another factor that was chosen was the relation and importance of the material to the student's' current or future career. Engineers often hold higher value and sense of social utility when they are knowledgeable of how course material is relevant to their futures. Lastly for this model, it is important to reach the learning styles of the majority of students in the classroom. Dr. Richard Felder suggests that professors should "teach around the cycle", ensuring that the learning needs of each type of student in the classroom is met at some point during the semester. [21]

Classroom environment is the marriage of student satisfaction, self-efficacy, and motivation. Students are able to thrive and retain information in classrooms that are positive and supportive. The climate or tone of the course is set and maintained by the instructor through interactions with students in the classroom and office hours. Other factors that affect classroom environment are student-student interactions and the range of perspectives on course material. Seven factors were chosen for this ordinal logistic regression model. Often, students gain more satisfaction when the course material is not only relevant in the "real-world" but also when the skills gained are applicable to the students' future career paths. Classroom environment can also be improved when grading procedures are clearly defined and consistently used throughout the course. This allows students to have attainable goals and realistic views on the assignments and exams. Relating to knowledge of grading procedures, students are often more satisfied if they are knowledgeable of grades throughout the course of the semester, acting as a continual benchmark of standings in the course and how to improve.[14] Presentations, activities, and assignments should also relate for a full picture of the course topic. In the same vein, material on assignments and exams should reflect material taught in the course. Although this seems like an obvious connection, educators often create assessments that are not reflective of course material.[24] Finally, students are encouraged to be active participants in the classroom.

Modes of instruction can also heavily influence the amount of information that a student retains, as well as overall satisfaction and motivation. It has been found that blackboard lectures are very popular in engineering classrooms, which can be unsatisfying for active learners. On the other hand, interactive PowerPoint lectures where problem breaks are taken can often be very helpful to students.[10] Problem solving sessions, either integrated into the course or as a standalone activity, are cooperative learning techniques that enhance learning experiences. Hands-on activities and demonstrations were also chosen for the survey to see the potential impact of student satisfaction within the ordinal logistic regression model.

Model Notation and Variables

The following notation is used for this research and statistical model when referencing the four ordinal logistic regression models. The predictor values or independent values are matched in Tables 2-5 with the classroom description. The responses variables of instructor interaction and feedback, classroom environment, modes of instruction, and overall satisfaction are modeled by "x", "t", "z", and "y" respectively. These predictor variables were chosen through previous research at the Pennsylvania State University and research around the world on engineering education affecting student satisfaction and motivation.

Table 2. Instructor Interaction and Feedback Model –Predictor Variables

Model 1: **Instruction Interaction and Feedback (x)**	
Predictor	***Predictor Description***
a_1	*"The instructor gives detailed feedback"*
a_2	*"The instructor gives frequent feedback"*
a_3	*"My instructor was approachable"*
a_4	*"My instructor was available to help with course material"*
a_5	*"My instructor was passionate about course material"*
a_6	*"My instructor stressed the importance of course material"*
a_7	*"The instructor relates class topics to student interested to increase motivation and value in course"*
a_8	*"The instructor incorporates different modes of learning styles"*

Table 3. Classroom Environment Model – Predictor Variables

Model 2: **Classroom Environment (t)**	
Predictor	***Predictor Description***
b_1	*"Real World Applications of course material"*
b_2	*"Skills gained applicable to future career"*
b_3	*"Grading procedures were clearly defined and consistently used"*
b_4	*"Presentations, assignments, and activities relate"*
b_5	*"Knowledge of current grade throughout semester"*
b_6	*"Material on assignments and exam reflects material taught in course"*
b_7	*"Students are encouraged to be active participants in classroom"*

Table 4. Modes of Instruction Model- Predictor Variables

***Model 3:* Modes of Instruction (z)**	
Predictor	***Predictor Description***
c_1	*Blackboard lectures*
c_2	*PowerPoint lectures*
c_3	*Problem-solving sessions*
c_4	*Hands-on activities*
c_5	*Demonstrations*
c_6	*Group-work*

Table 5. Overall Satisfaction Model- Predictor Variables

***Model 4:* Overall Satisfaction in the Classroom (y)**	
Predictor	***Predictor Description***
x	*Instructor Interaction and Feedback*
t	*Classroom Environment*
z	*Modes of Instruction*

Ordinal Logistic Regression as a Modeling Technique

Ordinal logistic regression models are a specific extension of multiple regression models, which use many predictor variables that have an effect on the dependent variable. These models are used to explain an ordinal dependent variable given one or more independent variable(s).[25] Specifically, this model was chosen because the dependent variable must be ordinal in nature in order to use this model; therefore, the 5-point Likert scale for student satisfaction satisfied this condition. The independent variables that feed into this model must be either ordinal, categorical or continuous in nature. The results of this type of regression can often be used to help predict future states and implement changes into a system that will have the most significant effect.[25] It was also verified through goodness of fit tests that the data set was a good fit for the ordinal logistic regression model. Only statistically significant variables will be included in each of the final models. Finally, it is still widely debated in academia whether ordinal scales should be treated as continuous or categorical for the dependent variable. Likert-items scales have an underlying continuous variables denoting a student's level of satisfaction. For this reason, it was decided that the underlying distribution would be continuous when running the ordinal logistic regression model in the statistical package, SPSS.[26, 27,28]

Ordinal Logistic Regression Results

Variables within each model that had p-values less than the significance level of 0.10 were chosen as "significantly" impacting the statistical model. The research was also able to predict response probability for future uses of this model. Overall, the results align fairly well with previous research in other areas and the learning styles of this industrial engineering student population. For the "Overall Satisfaction" model (with independent variables of Instructor interaction and feedback, classroom environment, and modes of instruction) were all found to be statistically significant to student satisfaction. This was expected and verified through this model, as these overarching categories have been found in previous research, both within this research group at the Pennsylvania State University and other universities, to be significant. The following tables shows all of the variables and the model to which they were aligned, along with the p-value and significance distinction.

Table 6: Parameters and significance levels

Model	Parameter	p-value	Significance of variable
Instructor Interaction and Feedback (x)	*"The instructor gives detailed feedback"*	0.001	Yes
	"The instructor gives frequent feedback"	0.409	-
	"My instructor was approachable"	0.000	Yes
	"My instructor was available to help with course material"	0.478	-
	"My instructor was passionate about course material"	0.128	-
	"My instructor stressed the importance of course material"	0.085	Yes
	"The instructor relates class topics to student interested to increase motivation and value in course"	0.099	Yes
	"The instructor incorporates different modes of learning styles"	0.139	-
Classroom Environment (y)	*"Real World Applications of course material"*	0.096	Yes
	"Skills gained applicable to future career"	0.069	Yes
	"Grading procedures were clearly defined and consistently used"	0.138	-
	"Presentations, assignments, and activities relate"	0.046	Yes
	"Knowledge of current grade throughout semester"	0.523	-
	"Material on assignments and exam reflects material taught in course"	0.502	-
	"Students are encouraged to be active participants in classroom"	0.000	Yes
Modes of Instruction (z)	*Blackboard lectures*	0.562	-
	PowerPoint lectures	0.000	Yes
	Problem-solving sessions	0.000	Yes
	Hands-on activities	0.592	-
	Demonstrations	0.302	-
	Group-work	0.002	Yes

Within the "Instructor Interaction and Feedback" model, the following were significant factors in increasing student satisfaction: detailed feedback, approachability of instructor, the relayed importance of the material from the instructor, and finally the relation of topics to student interest to increase value in the course. Detailed feedback was found to have the highest impact on satisfaction within the instructor interaction and feedback model. This conclusion aligns well with other research that shows that feedback can act as a motivator for students as attainable goals are set from frequent feedback.[17,18]

For the "Classroom Environment" model, real-world applications, relation to future careers, the relation of presentations, assignments, and activities relate, and finally students should be active participants in the classroom. Felder and Silverman have also researched applying course theories to real-world applications to be the most effective, such as case-studies and field-trips to sites.[4, 18] When students can see the application to their future career paths, students often have increased satisfaction and can handle industry workload much easier.[28] Alumni speakers are also very important for student perception on how course and curriculum materials can be used and influence industry career paths. The most significant factor within this model was the active participation of students in the classroom, with the lowest p-value among the model factors. Students who feel comfortable to participate in the classroom environment are often more satisfied and absorb the material. [8,10]

For the Modes of Instruction model, interactive PowerPoint lectures, problem-solving sessions, and group-work were all found to be statistically significant to overall satisfaction ratings in the industrial engineering classroom. Students have noted in previous research that PowerPoint lectures with intentional blanks or problems scattered throughout allow students to better retain and use information.[21] Problem-solving sessions allow students to engage with one another while working through the concept and are well suited for the student population of active, sensing, visual, and sequential learners within this population.[5,6,21] Finally, group-work can often incorporate a variety of learning styles and allow students to determine the course taken to complete the task.[9]

I-C-D Teaching Model for Implementation into the Classroom

For instructors to increase student satisfaction, the eleven significant factors found through this model must be implemented into the classroom. These eleven factors fed into the overall student satisfaction model. Earlier parts of this paper have discussed how instructors can implement these techniques in a specific way, through outlining previous research and the justification of why the factors were chosen (see '*Selection of Predictor and Explanatory variables in Logistic Model'* and '*Research Results').* The I-C-D Method is a specific and easy technique for instructors to use. To increase overall student satisfaction, instructors should "Interact, Cultivate, and Deliver". This technique leads to increase motivated, higher satisfaction levels, and increased perseverance in self-learning. Instructors should also remember to be a figurative "coach" to the students, thereby giving students the sense that the professor is on their metaphorical academic "team". The following figure summarizes the eleven significant factors that are easily implemented into the classroom:

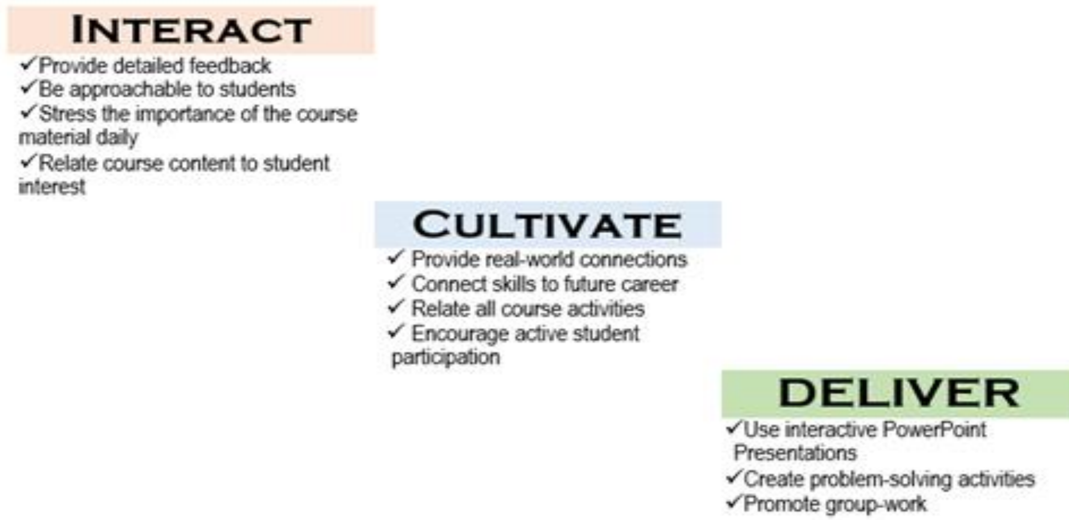

Figure 2: I-C-D Method for Implementation

Test Implementation in Classroom

At the Pennsylvania State University, there is an existing end-of-course survey that gathers student feedback on the material, course structure, and instructor. The question relating to the overall quality of the course was used to compare student satisfaction rates between a classroom that did not have the I-C-D method implemented and another class that did have the method implemented. The pre-existing survey method uses a Likert-scale from “1”-”7” which cannot directly be mapped to the scale used within this research, because this research uses a Likert scale from “1”-“5”. Although the scales do not match, it is assumed that the implementation of this technique will raise student satisfaction above the “Average Rating” of “4” on the class survey Likert-scale. By providing a path to increase satisfaction of students while increasing ratings of the instructors, both parties can benefit from the findings of this research. The instructors will gain students with increased motivation, satisfaction, and learning retention while also increasing their ratings.

Using SPSS, the predicted probabilities for ratings of “Satisfied” of “4” and “Extremely Satisfied” of “5” were found using the ordinal logistic regression model created, if the significant factors were implemented into the classroom. The implementation of these significant factors would raise the student satisfaction levels above an “average” of “3”. Instructor interaction and feedback, classroom environment, modes of instruction, and overall student satisfaction were found to have a 50% or higher probability of being rated as “Satisfied” or “Extremely Satisfied”.

The factors that were found to be significant through this ordinal logistic regression model were then implemented into an industrial engineering curriculum classroom. The course was an introductory course in engineering economics in the Industrial Engineering curriculum. The instructor ensured that any quiz or exam was given back within a week of being administered, following the recommendation that frequent and detailed feedback is most effective for students. The instructor also ensured from the first day of class and through reminders that he was available after class and in office hours for any questions or concerns. This allowed students to feel that if they were struggling with a concept, the teacher was approachable and willing to help, leading to higher academic success rates and satisfaction. During each course period, the professor attempted to relate the material to relevant real-world applications that could peak the student interest. In this course, cost justification and return on investment concepts could not only be used in their current lives but also in their future careers. The time value of money, as well as interest rates, and topics such as 401K, Roth IRA, and mortgages are incorporated into this course so that the students have a firm understanding of these financial concepts in relation to engineering economy, both within and outside of their careers. Within this course, all materials were connected throughout the course, such as presentations, assignments, and in-class activities. The instructor implemented interactive PowerPoint lectures with problems that are similar in structure to problems found on quizzes or exams. This relation allowed students a baseline of what to expect when preparing for assessments or projects. The instructor also gave insight into how the students could succeed on an exam or assignment to increase student motivation and spark student interest towards reaching success in the classroom. The instructor also ensured that a variety of teaching styles were used in order to reach all of the learning styles within the student population. Active learning was met through interactive PowerPoints using an inductive teaching style, allowing students to be more engaged and retain information for further use. Problem solving sessions were incorporated as stand-alone events to prepare for exams and as mini-breakout sessions during class lectures. These sessions helped to reach the sensing, sequential, and active learners who enjoy seeing the concepts applied to a situation. Within this course, students were assigned to groups in order to complete a case-study based on information provided by a large corporation. This project allowed the students to be exposed to team-building skills as well as a real-life engineering economy issue. This case study also acted as cooperative, group-learning as well as case-based learning.

After implementing the I-C-D method in the engineering economy classroom, the end of course university survey was used to perform impact analysis. Specifically, it was analyzed to determine how many students were above the “satisfied” rating on the 7-point Likert-item scale. The selected questions used for analysis related to the overall quality of the course and the overall quality of the instructor. The percentage of “6” or “7” responses for the question “Rate the overall quality of this course” was 98.61%. The percentage of “6” or “7” responses for the question “Rate the overall quality of the instructor” was also 98.61% on the instructor report of scores. These scores reflect that implementing the eleven significant factors within the “Instructor Interaction and Feedback”, “Classroom Environment”, and “Modes of Instruction” have a positive and significant effect on the ratings of student satisfaction when compared to ratings prior to the implementation. If an instructor chooses to implement the eleven significant factors summarized by the I-C-D model in their classroom, he/she should notice a similar increase in student satisfaction and potentially ratings, if a survey of satisfaction is given. This implementation should also affect the student’s motivation to learn the material. It should be noted that the course the I-C-D model was implemented into one of the courses originally selected for the survey that the model was built on. Therefore, the course was used in the initial survey data and then as impact analysis after the I-C-D teaching method was implemented. Direct analysis to a course that did not have the I-C-D method implementation incorporated is in the scope of future work for this research area.

Conclusions and Recommendations

A need for quantifying student satisfaction in engineering classrooms was found within engineering education, research was performed at the Pennsylvania State University in order to statistically model satisfaction of students. Within the three statistical models of "Instructor Interaction and Feedback", "Classroom Environment", and "Modes of instruction", a total of twenty-one factors were tested for potential impact on student satisfaction. Through this research and the use of an ordinal logistic regression model, eleven significant factors were identified and the I-C-D Method was created.

The findings of this research further solidify that it is not the concept, course text, or subject that motivates and satisfies students in the classroom. To really have an impact on student satisfaction, instructors must make adjustments to how the course is delivered, the environment of the class, and student-teacher interactions. The following factors were found to be significant within the three models that then feed into overall student satisfaction:

- Detailed feedback should be provided to students on exams, activities, and assignments. By providing feedback, instructors are providing a pathway of success for students.
- Instructors should create a classroom environment that allows for students to easily approach instructors and teaching assistants for help. The environment set by the instructor is the connection point of student motivation, satisfaction, and self-efficacy.
- Course material importance and application to future academic and career paths should be heavily stressed. This will motivate students to learn and retain the material, instead of simply finishing the course.
- Topics within the course should relate to student interest as much as possible in order to increase motivation. Students are more interested in course content when it is connected to previously held knowledge.
- A clear connection between the course material and real-world applications should be established when possible. This will prepare students for their future career paths.
- All presentations, assignments, and activities within the course should relate. Students better retain information when it is reinforced through multiple channels in the course.
- Instructors should encourage active student participation in the classroom. This will increase the student's' positive self-efficacy beliefs within this course and moving through the curriculum content.
- Instructors should use interactive PowerPoint lectures that allow students to be engaged in the material during the lecture. This hybrid of a lecture style will reach many types of learners in the student population.
- Group-work should be incorporated into the course to increase student success within academia and industry.

The “Interact, Cultivate, Deliver” method summarizes these eleven significant factors in a short and easy way for implementation. The I-C-D method should also be further tested on other classrooms and compared to results to further validate the model under similar conditions. A control group was not used in this first phase of the research, specifically it was not used in the creation of this predictive model and the initial testing into a classroom. Therefore, in the future, a control group should be used and compared to a classroom within I-C-D implemented. The same instructors and course policies should be analyzed at the Pennsylvania State University before testing in other university classrooms. It should also be noted that a comparison between a course where this method is implemented and a course where it is not implemented within the same semester should be analyzed.

For future research within this field, other engineering majors could be analyzed in a similar manner to better understand and compare engineering students from different majors. Another model could also be created off of known surveys that are used at the end of courses across the university. This would allow professors to predict their overall student satisfaction and course rating from the survey and be able to implement changes into the classroom in order to increase this satisfaction. Students that are increasingly satisfied and motivated to learn will retain more information for future use and be more likely to give back to their university post-graduation.

Disclaimer

The views expressed in this paper are those of the authors and do not necessarily reflect the official policy or position of the U.S. Air Force, the U.S. Department of Defense, or the U.S. Government.

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