121st ASEE Annual Conference & Exposition
Indianapolis, IN
June 15-18, 2014
Paper ID #9590

Designing Industrial Engineering Course Content and Delivery with an Understanding of the Learning Preferences and Factors Driving Satisfaction of Undergraduate Industrial Engineering Students

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Designing Industrial Engineering Course Content and Delivery with an Understanding of the Learning Preferences and Factors Driving Satisfaction of Undergraduate Industrial Engineering Students

Abstract

This paper discusses the results of a study aimed to understand the learning preferences, motivation, and satisfaction of junior and senior level industrial engineering students. While researching the literature on engineering education it became clear that little work exists that purely examines industrial engineering students, and virtually no work examines industrial engineering students' learning styles, motivation, and satisfaction collectively. This paper will carefully examine the learning styles of industrial engineering undergraduate students and will study the course and instructional practices that motivate them, and in turn, bring them satisfaction with their undergraduate education. Industrial engineering online education is a topic that has also received increased attention. Suggestions for designing industrial engineering course content and delivery both in class and on-line are made in an attempt to improve the industrial engineering education experience and help keep students in industrial engineering through improved instructional methods and course delivery structure.

Introduction

Studying and identifying the key factors that motivate Industrial Engineering students will allow instructors to tailor course delivery in a manner that increases student satisfaction with their education. The main goal of the research performed is to analyze the factors that motivate students in industrial engineering classes and how the classroom set-up affects their educational experience. An assessment targeting student satisfaction was created and administered to students to examine the classroom structure, instructional methods, and learning styles to determine the relationship between course content, delivery, and student satisfaction. The overarching research goal is for the Industrial Engineering undergraduate educational experience to be improved by making changes to instructional methods and classroom structure.

Student Learning Differences

Classroom instruction is challenging, because each student is a unique individual with differing strengths, difficulties, enthusiasm, and accountability. Hence, each student has his or her own specific way of learning[1]. Learning style models classify students based on where they fall on several different scales relating to how they acquire information and organize it. Multiple instruments exist to determine learning styles of students. One of the most well-known instruments is the Myers-Briggs Type Indicator, which is based on Jung's Theory of Psychological Types[1-3]. Another is Kolb's Experimental Learning Model which classifies students by the way they take in and process information[1-2]. Felder and Silverman created a model of students' learning styles that pulls components from both the Myers-Briggs Type Indicator and Kolb's Experimental Learning Model. Their hybrid model is centered on four different questions regarding perception, sensing, processing, and understanding[1-3]. Sensing learners, sensors, like information gathered from their senses such as visual images, sounds, and physical feelings. Sensors like facts and are inclined towards real-world applications. They are very detail-oriented and dislike abstract ideas; hence, they may struggle with science courses that have a heavy emphasis on theory[1-4]. Intuitive learners, also known as intuitors, are partial to information generated internally such as opinions, memories, and understandings. They enjoy theoretical and abstract ideas and are uninterested in specific details[1-4]. Most engineering teaching is more favorable to intuitive learners[1]. Sensors are very systematic, attentive, and methodical and make successful experimental scientists or plant engineers. Intuitors are extremely innovative and perceptive and make exceptional designers, theorists, and inventors[2,5]. Visual learners learn more effectively through graphic materials such as posters, charts, pictures, and displays[1-3]. Verbal learners learn best through auditory descriptions and written accounts[1-3]. Most engineering courses are taught in a predominantly verbal fashion, with writing on chalkboards and verbal explanations[2-3]. Active learners prefer to take in information "actively" through conversations and physical activities. Active learners are energized by others and often have trouble studying and working alone. They do best when learning with others and sharing ideas among team members[1-3]. Reflective learners like to contemplatively take in information and reflect on ideas[1,3]Reflective learners work best on their own or in pairs and often feel exhausted when they are working with others, especially partners they do not know well[3,10]. Sequential and global learners use entirely different processes of learning to understand concepts. Sequential learners grasp information in a series of logical steps. They like to learn information in a specific sequence and will only progress to the next step after they have mastered the previous one[1-3,6]. Global learners often struggle understanding information until they comprehend the "big picture." They often struggle with utilizing new material until they understand how it connects with material that they have already mastered[1-3,6].

Learning Styles Assessment Findings

In the first phase of this work, the NC State University Index of Learning Styles Questionnaire by Dr. Richard Felder[8] was administered to fifty-one junior and senior level industrial engineering students at Penn State University. A link to this specific questionnaire is provided in the bibliography. The goal of this assessment was to determine the breakdown of learning styles of the undergraduate industrial engineering junior and senior level students. Table 1 displays the raw results from the results of the Felder's Index of Learning Styles. Table 2 displays the overall results of the assessment. Figure 1 shows the learning style preferences of males and females separately using a spider graph. From Table 2 and Figure 1, of the 51 students that completed Felder's Index of Learning Styles Analysis, the majority of the industrial engineering students surveyed at Penn State University were Active, Sensing, Visual, and Sequential learners. Figure 1 shows a significant difference in learning styles does not exist between genders.

Table 1: Detailed Results of Felder's learning styles assessment

Score Range	Dimension	Active	Refelective	Sensing	Intuitive
1 to 3	Fairly well balanced	33.33%	17.65%	19.61%	17.65%
5 to 7	Moderate	25.49%	9.80%	37.25%	1.96%
9 to 11	Very Strong	13.73%	0.00%	19.61%	3.92%
Score Range	**Dimension**	**Visual**	**Verbal**	**Sequential**	**Global**
1 to 3	Fairly well balanced	17.65%	15.69%	37.25%	21.57%
5 to 7	Moderate	25.49%	3.92%	25.49%	5.88%
9 to 11	Very Strong	37.25%	0.00%	7.84%	1.96%

Table 2: Summary Results of Felder's learning styles assessment

Active	Reflective	Sensing	Intuitive	Visual	Verbal	Sequential	Global
77.25 %	22.45%	76.47%	23.53%	80.39%	19.61%	70.58%	29.42%

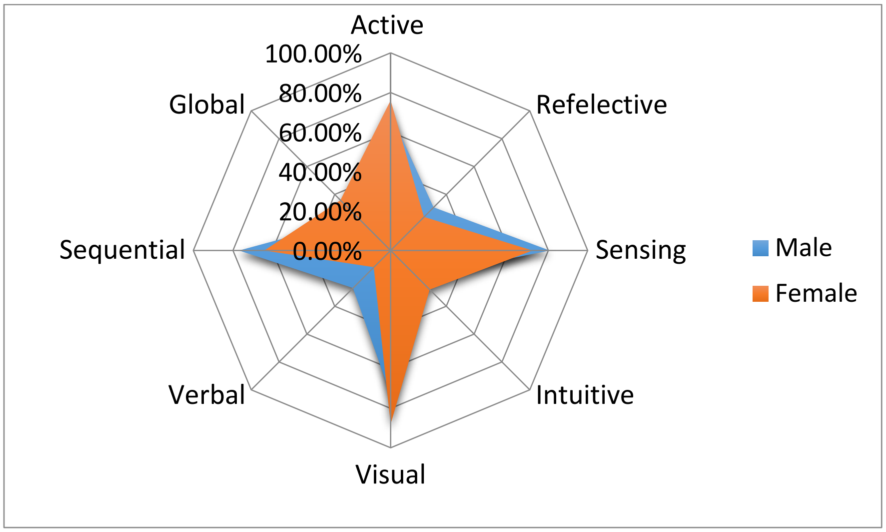

Figure 1: Spider graph displaying the results of the Felder learning styles assessment

Satisfaction Questionnaire Findings

In the second phase of this study, a self-designed questionnaire was created and administered to forty-one junior and senior level industrial engineering students at Penn State University during the Spring 2013 semester. The goal of this second assessment was to identify the factors that motivate students in industrial engineering to increase satisfaction with their industrial engineering education. After analyzing classroom practices that relate to student satisfaction, the researchers attempted to identify predictors for student satisfaction. Several other pedagogical methods and confounding factors were explored including modes of instruction, class attendance, and educational experiences in satisfying and unsatisfying classes.

Modes of Instruction

The questionnaire explored various modes of instruction used in a satisfying and an unsatisfying junior level industrial engineering class. The survey questions relevant to modes of instruction in satisfying and unsatisfying classes are shown in Table 3. The results of the responses to the questions shown in Table 3 are displayed visually in Figure 2. In an unsatisfying class, blackboard lecture was used more than in a satisfying class. However, in a satisfying class, there were more problem solving sessions, group activities, hands-on activities, and demonstrations.

Table 3: Student Survey Questions for Modes of Instruction.

Relevant Modes of Instruction Survey Questions
1. Of the junior level Industrial Engineering Classes listed on the previous page please select one that you found <u>extremely satisfying</u>: ______________________________ 2. What were the primary modes of instruction in this class? Please circle all that apply. A. Blackboard Lecture B. PowerPoint Lecture C. Problem solving sessions D. Hands-on activities E. Demonstrations F. Group activities G. Other: Please specify ____ 3. Of the junior level Industrial Engineering Classes listed on the previous page please select one that you found <u>extremely unsatisfying</u>: ______________________________ 4. What were the primary modes of instruction in this class? Please circle all that apply. A. Blackboard Lecture B. PowerPoint Lecture C. Problem solving sessions D. Hands-on activities E. Demonstrations F. Group activities G. Other: Please specify ____

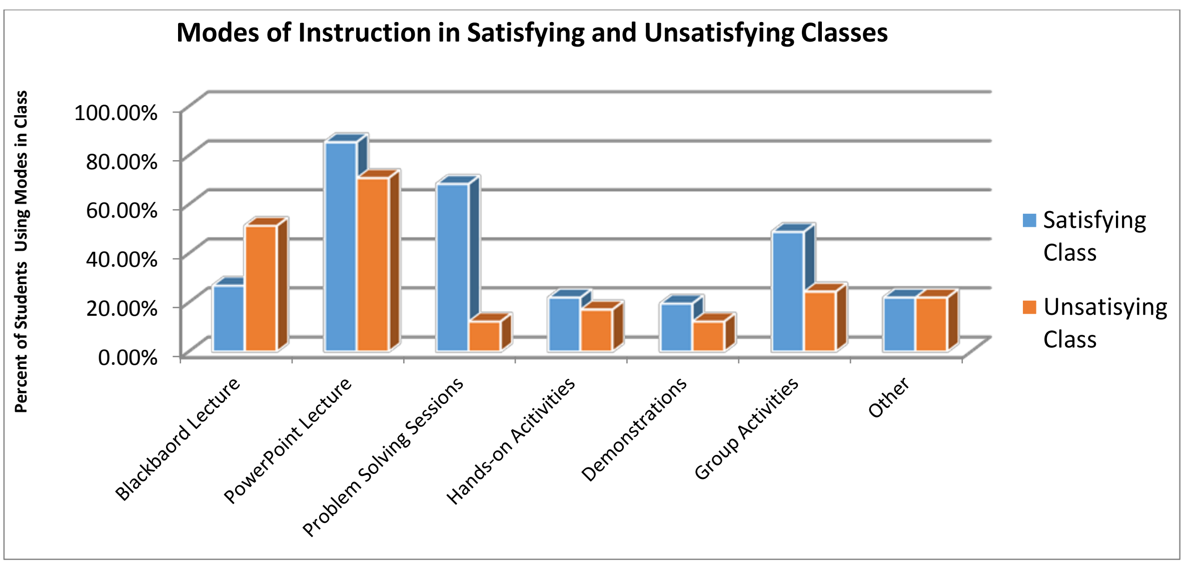

Figure 2: Modes of instruction used in a satisfying and unsatisfying class.

Class Attendance

The questionnaire included a section that inquired about class attendance in satisfying and unsatisfying classes. The questionnaire asked the students if attendance was incorporated into the course grade in a satisfying and unsatisfying class and if attending class helped the student to understand the class material. The survey questions relevant to modes of instruction in satisfying and unsatisfying classes are shown in Table 4. In a satisfying class, attendance was included in grading more frequently (70% of the time), and in an unsatisfying class, attendance was not included in grading as frequently (30% of the time). Virtually all students in a satisfying class stated that attending class helped understanding of class material. More than half of students in an unsatisfying class stated that attending class did not help understanding of class material.

Table 4: Student Survey Questions for Class Attendance.

Relevant Class Attendance Survey Questions
1. Of the junior level Industrial Engineering Classes listed on the previous page please select one that you found extremely satisfying: ________________________
2. Was class attendance included as part of your grade for this class? A. Yes B. No
3. Did attending the class help your understanding of the class material? A. Yes B. No
4. Of the junior level Industrial Engineering Classes listed on the previous page please select one that you found extremely unsatisfying: ________________________
5. Was class attendance included as part of your grade for this class? A. Yes B. No
6. Did attending the class help your understanding of the class material? A. Yes B. No

Classroom Climate and Structure

The questionnaire included a section encompassing many statements about classroom climate and structure. This section of the questionnaire can be found in Table 5.

Table 5: Student Survey Questions for Classroom Climate and Structure.

Relevant Classroom Climate and Structure Survey Questions										
1. Of the junior level Industrial Engineering Classes listed on the previous page please select one that you found extremely satisfying: ________________________										
2. Please rate your agreement with the following statements regarding the class selected in question 1 on a scale of 1 (I do not agree at all)- 10 (I agree completely).										
A. The class topics interested me.	1	2	3	4	5	6	7	8	9	10
B. The class focused material on "real-world" applications.	1	2	3	4	5	6	7	8	9	10
C. The skills I learned will be applicable to my future career.	1	2	3	4	5	6	7	8	9	10
D. The course material was understandable.	1	2	3	4	5	6	7	8	9	10
E. Grading procedures were clear.	1	2	3	4	5	6	7	8	9	10
F. I received timely and productive feedback on my work.	1	2	3	4	5	6	7	8	9	10
G. I knew my grade throughout the semester.	1	2	3	4	5	6	7	8	9	10
H. It was clear what was needed to prepare for assessments.	1	2	3	4	5	6	7	8	9	10
I. Material on assessments reflected material taught in class.	1	2	3	4	5	6	7	8	9	10
J. My professor was approachable.	1	2	3	4	5	6	7	8	9	10
K. My professor offered to help me if needed.	1	2	3	4	5	6	7	8	9	10
L. My professor was passionate about the class material.	1	2	3	4	5	6	7	8	9	10
M. My professor stressed the importance of class material.	1	2	3	4	5	6	7	8	9	10
N. My professor was fair.	1	2	3	4	5	6	7	8	9	10
O. The way the material was taught met my learning preferences.	1	2	3	4	5	6	7	8	9	10
3. Of the junior level Industrial Engineering Classes listed on the previous page please select one that you found extremely unsatisfying: ________________________										
4. Question (2) is repeated here for an extremely unsatisfying class.										

The Wilcoxon signed-rank test was used to analyze the paired, ordinal data from the classroom climate and structure questions for satisfying and unsatisfying classes shown in Table 5. At the five-percent significance level ($\alpha= 0.05$) it was found that the data provided adequate evidence that the median of responses in a satisfying class (Question 2 A-O) were significantly larger than the median of responses in an unsatisfying class (Questions 4 A-O). In fact, the p-values for each of these tests were found to be 0.000. This indicated that statistically significant differences existed between these classroom climate and structure characteristics in satisfying and unsatisfying industrial engineering classes.

Overall Learning Experience and Quality of Instruction

The questionnaire included a section examining students' overall learning experience on a scale of 0, poor learning experience, to 7, excellent learning experience in a satisfying and unsatisfying class. Additionally, the questionnnaire also asked students to rate the overall quality of his or her instructor on a scale of 0, poor instructor, to 7, excellent instructor in a satisfying and unsatisfying class. The survey questions relevant to overall learning experience and quality of instruction are shown in Table 6 and displayed visually in Figure 3. Clearly, in a satisfying class students felt they had a positive learning experience. In an unsatisfying class students only randomly felt they had a positive learning experience. Figure 4 visually shows that in a satisfying class students rated his or her instructor as a 6 or 7, excellent instructor, more than ninety-percent of the time. Conversely, less than five-percent of students stated that his or her instructor was excellent in an unsatisfying class. In fact, more than fifty-percent of students rated his or her instructor as as a 0, 1, or 2 in an unsatisfying class.

Table 6: Student Survey Questions for Overall Learning Experience and Quality of Instruction.

Relevant Learning Experience and Quality of Instruction Survey Questions
1. Of the junior level Industrial Engineering Classes listed on the previous page please select one that you found extremely satisfying: _________________________
2. Please rate your overall learning experience with this class on a scale of 0-7. 0 (Poor learning experience)- 7 (Excellent learning experience) 0 1 2 3 4 5 6 7
3. Please rate the overall quality of your instructor for this class on a scale of 0-7. 0 (Poor Instructor)- 7 (Excellent instructor) 0 1 2 3 4 5 6 7
4. Of the junior level Industrial Engineering Classes listed on the previous page please select one that you found extremely un satisfying: _________________________
5. Please rate your overall learning experience with this class on a scale of 0-7. 0 (Poor learning experience)- 7 (Excellent learning experience) 0 1 2 3 4 5 6 7
6. Please rate the overall quality of your instructor for this class on a scale of 0-7. 0 (Poor Instructor)- 7 (Excellent instructor) 0 1 2 3 4 5 6 7

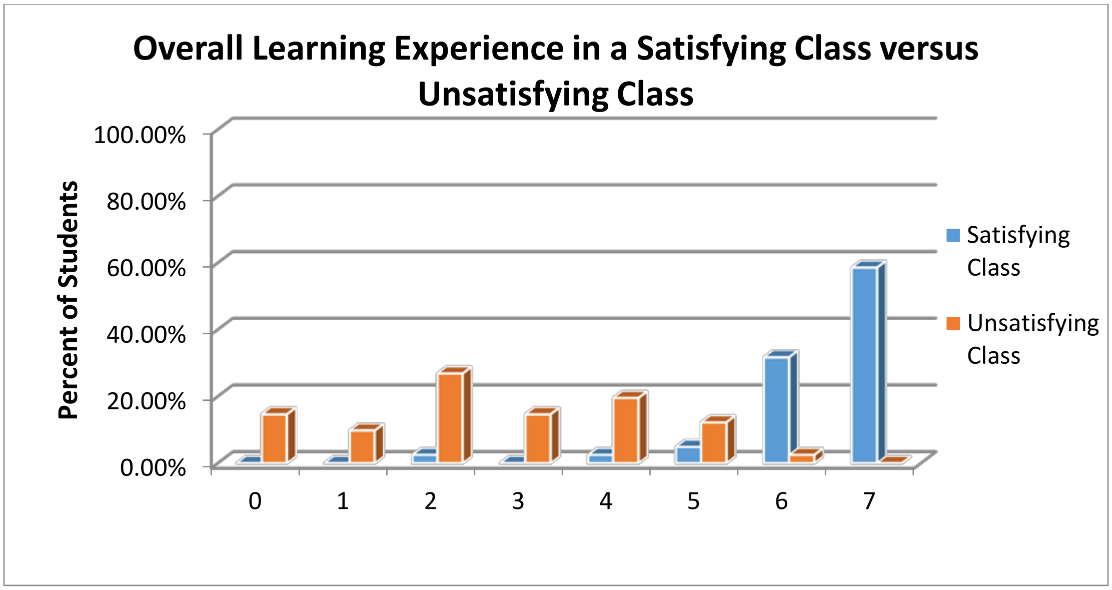

Figure 3: Overall Learning experience in a Satisfying and Unsatisfying class.

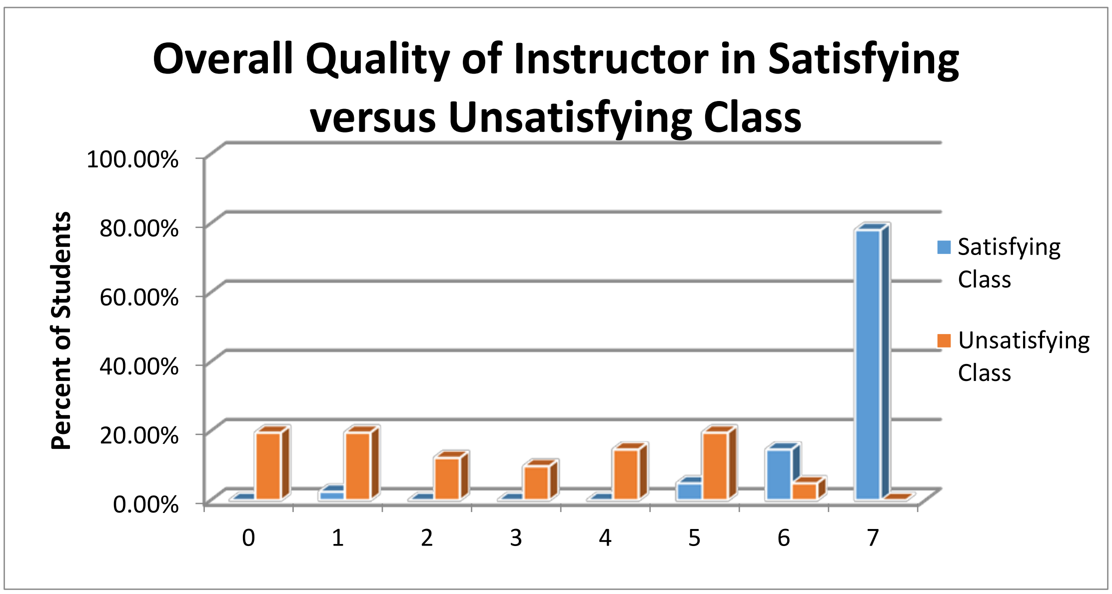

Figure 4: Overall Quality of Instructor in a Satisfying and Unsatisfying class.

On-Line Learning Experience

The questionnaire also explored online industrial engineering education. There has been an increased emphasis at Penn State University to increase junior and senior level industrial engineering on-line course offerings. The survey questions relating to online Industrial Engineering courses are shown in Table 7.

Table 7: Student Survey Questions for On-Line Industrial Engineering Education.

Relevant On-Line Industrial Engineering Education Survey Questions
1. Have you ever taken an Industrial Engineering course online? A. Yes B. No 2. Would you prefer to take an Industrial Engineering class in the online format or traditional in class format? A. Online format B. Traditional in-class format

The results show that approximately 40% of the students surveyed stated they had in fact taken an online Industrial Engineering course from Penn State University. An overwhelming majority of students, approximately 90%, chose the traditional in-class as the preferred class format.

Student Comments

Finally, the student questionnaire asked the students to give qualitative feedback on ways to improve classes and undergraduate Industrial Engineering instruction. After the responses were received from the students, the quotes were analyzed by the research team. It was apparent to the research team that a number of common themes emerged from the qualitative comments collected from the questionnaires. Approachability of Educators, Priorities of Educators, Enthusiasm of Educators, Assessment Practices, Grading Procedures, Use of “Real World” Examples, Modes of Teaching, and Active Learning Activities in Class were the main factors noted by the students to improve undergraduate Industrial Engineering classes and instruction.

Discussion

Learning Styles Assessment

The results of the learning styles study showed the majority of junior and senior industrial engineering students at Penn State University were Active, Sensing, Visual, and Sequential learners. Over 77% of the students surveyed were active learners while 76% assessed were identified as being sensing learners. Over 80% of the students assessed were visual learners while 70% were deemed as being sequential learners. As part of this study, Penn State’s industrial engineering student learning styles were compared to learning styles of Industrial Engineers and STEM Majors at other major universities or institutions.

Comparison of Learning Styles

Among other studies, learning styles research has been performed in Science, Technology, and Engineering Majors in Denmark at Aalborg University, by Anette Kolmos and Jette Egulund Holgaard[11] and at North Carolina State University by Richard M. Felder et al.[1]. The work performed at Aalborg University was focused on Learning Styles of Science and Engineering students in Problem and Project based education[11]. The First Year program was studied at Aalborg University in Architecture and Design and Civil Engineering, Computer Science, Computer Engineering, Electronics, Physics, Geography, Global Business Development, Industry, Informatics, Chemistry & Bio-technology, and Software and Health Technology[11]. Of the 493 students who completed the Felder-Soloman Index of Learning Styles survey, the majority of students were Active, Visual and Sensory learners, while sequential and global learners were relatively even[11]. This has shown that the learning styles or preferences of industrial engineering students at Penn State University are not significantly different from other STEM/Engineering majors at other institutions. The Aalborg University research study and this research study both shed light on the need to motivate engineering instructors to incorporate modes of instruction into their course delivery that incorporate all learning styles.

In Richard Felder's work, learning styles of many different Universities, such as Iowa State Materials Engineering, Michigan Technology Environmental Engineering, and Tulane University first and second year engineering students, as well as many other universities were analyzed in order to survey learning style preferences[1]. For example, 129 undergraduate Materials engineering students at Iowa State University completed the ILS, forty-four item assessments that showed 63% of students were active learners, 67% of students are sensing learners, 85% of students were visual learners, and 58% were sequential learners[1]. In spite of these findings, engineering undergraduate courses are generally taught toward intuitive learners, learning toward theory and mathematical proofs over practical, "real-world" applications, and experimentation. Although the majority of students surveyed at Iowa State were visual learners (85%), engineering instruction is very verbal, focusing on written explanations and mathematical formulas[1]. These findings match largely with the results of the current study performed on industrial engineering students at Penn State University.

In addition to the studies mentioned, Industrial Engineering student learning styles were also solely analyzed at the University of Sao Paulo, which showed that 66% of undergraduate engineering students were Active Learners, 70% of students were sensing learners, 73% were visual learners, and finally 50% of students were sequential learners. Table 8 shows Iowa State Materials Engineers, University of Sao Paulo Industrial Engineers, and finally Industrial Engineers at Penn State University. The Learning styles results in Table 8 show that industrial engineering students at Penn State University are not significantly different from Iowa State Materials Engineers and University of Sao Paulo Industrial Engineers.

Table 8: Learning styles of Industrial Engineers at Penn State University compared to Materials Engineers at Iowa State University and other Industrial Engineers at University of Sao Paulo.

School	**Major**	**%Active**	**%Sensing**	**%Visual**	**%Sequential**	**Source**
Iowa State University	Materials Engineer	63	67	85	58	[1]
University of Sao Paulo	Industrial Engineering	66	70	73	50	[1]
Penn State University	Industrial Engineers	77.25	76.47	80.39	70.58	-

Incorporating Learning Styles Results into Industrial Engineering Course Delivery

The results in Table 2 and Table 8 show that dominant learning preferences among STEM majors are Active, Sensing, and Visual learners. Felder suggests that instructors should design a "balanced teaching approach", so that the majority of learning styles can be reached in the classroom[1]. The knowledge of student learning styles will provide motivation to the instructor to adapt the course to the needs of the students[1]. When an educator's teaching style and students' learning styles match, students gain a better understanding of the course material[1-3]. Students remember the course material for a longer amount of time and retain a deeper understanding of the material. These students have a more positive course outlook than students whose learning styles did not align with the educator's teaching style[3]. Teachers often instinctively prefer to teach in the same way they prefer to learn or the way they were taught [3]. A typical college lecture favors intuitive, verbal, reflective, and sequential learning styles[1-3]. Sensing, visual, active, and global learners rarely experience compatible learning styles in typical science courses[3].

Accommodating a variety of students' learning styles through varied teaching methods can help reduce many of these issues. Although teaching to Felder's sixteen different learning styles may seem daunting, using a variety of teaching techniques in the classroom will allow all students to be accommodated. A specific learning style could not be met in the classroom and then the students will have to learn to adjust to other learning styles[3,7]. Educators are urged to help students become proficient with all learning styles to prepare for the professional world[7].

Felder and colleagues suggest several classroom techniques to help reach all learning styles. Students' learning styles should be discussed with students. Students can understand the ways they learn best, which can help them become more successful in the classroom and industry. Students who are struggling academically can benefit from studying their learning style preference, showing the students' that academic challenges are not completely due to personal failures, and they can modify their approach to classes to succeed in the classroom[2-3].

To gear classroom material toward both sensing and intuitive learners, educators can divide classroom material between real-world facts and theoretical concepts. When studying theoretical concepts, educators should be sure to show numerical examples to help sensors understand abstract concepts. Teaching topics that can help improve presentations reach both visual and verbal learners include showing charts, graphs and sketches after verbally explaining information[2-3]. For active and reflective learners, time is required to allow students to think about the concepts and also allow time for students to take part in class actively. Active activities such as assigning group-problem solving sessions or having group homework assignments are very effective for active learners[2-3]. Sequential learners learn best when material is introduced in a step-wise fashion. However, connections must be made for global learners by discussing the relation of current material to older material, material in other classes, and other connections to everyday life[2-3]. Global learners are also supported when educators accept creative solutions to problems, even if they are incorrect[2]. This encourages the innovative nature of global learners and supports their unique abilities to solve problems.

Modes of Instruction, Overall Learning Experience, Attendance, and Course Instruction

Several observations about the primary modes of instruction used in a satisfying class and unsatisfying class were made from the study performed. In an unsatisfying class, blackboard lecture is used much more often than in a satisfying class. Felder and colleagues found that most college classes are taught by writing on blackboards and explaining concepts verbally[2-3]. As noted in the beginning of this chapter, the results of his Learning Styles Assessment showed that industrial engineering students at Penn State University were overwhelmingly Active learners.

Hence, it is understandable that most students felt unsatisfied with a blackboard lecture as the primary mode of instruction in the classroom. While blackboard lectures do allow students to listen, see, and write at the same time, blackboard lectures still do not offer Active learners the extent of physical, hands-on experience they need to fully understand new concepts. Conversely, in a satisfying class, there are more problem solving sessions, group activities, hands-on activities, and demonstrations. These activities best meet the needs of Active learners who prefer to take in information "actively" through physical activities. Experience helps these learners best understand new concepts, and they are energized by working with others[1-3]. Problem solving sessions, group activities, hands-on activities, and demonstrations allow Active learners the most hands-on interaction and collaboration, and this helps them to learn most effectively. The results showed that students enjoy attending class if the instructor is putting forth effort to deliver a satisfying class. In a satisfying class, attendance was included in grading more frequently, and in an unsatisfying class, attendance was not included in grading as frequently. Virtually all students in a satisfying class stated that attending class helped understanding of class material.

The results of this study shows that the effort put forth by the instructor in delivering the course is of utmost importance to delivering positive learning experiences and overall student satisfaction. Litzinger and colleagues discussed the importance of effective learning experiences. Effective learning experiences help students understand important concepts and contribute to a positive learning experience[9]. Deliberate practice, practice with the intent of developing a specific ability, contributes to effective learning experiences[9-10]. The medium from which students receive deliberate practice is course design and instructor teaching[9].

Student Comments and Classroom Climate and Structure

The results of the questionnaire show that instructors can do seemingly "small things" in their course delivery that can significantly improve student satisfaction in the course. The eight common themes that students openly expressed to improve course delivery and improve their satisfaction with their industrial engineering educational experience were: Approachability of Educators, Priorities of Educators, Enthusiasm of Educators, Assessment Practices, Grading Procedures, Use of "Real World" Examples, Modes of Teaching, and Active Learning Activities in Class. Instructors can increase student motivation and satisfaction with their education by continuing to work on addressing these areas of course delivery. Looking at the sample of student comments, it is obvious that doing the "little things" such as providing more real life connections to material being taught in class and giving students clear and timely feedback can help to improve student satisfaction. For all fifteen of the course climate and structure questions, students agreed with each of the statements more in a satisfying class.

Questions A through D: Class Topics, Real-World Applications, Future Careers

Felder and Silverman, Ambrose, et. al, and Litzinger et. al state that by relating a task to students' interests students will place more value on a task[2,9-10]. Allowing students to work on a topic that has meaning or relevance to them will help them become increasingly more motivated and allow them to further their interests[10]. Additionally, research shows that students who do not see the value in a goal will act in a rejecting or evading manner[2,10]. Hence, educators must help students find an interest in class topics. Felder and Silverman, and Ambrose et. al state that providing tasks that focus on real-world events increases student motivation and allows students to understand the actual applications of theory learned in class. Educators should implement activities focusing on "real-world" applications in the classroom. Case studies, discussions on relevant current events, and field trips are all activities that can be used to stress "real-world" applications[2,10]. More emphasis needs to be placed on learning activities that help students solve problems that could be encountered in future careers. Research performed by Sheppard, et. al (2009) at several United States engineering institutions discovered that current engineering curricula are over-emphasizing analytic skills and not putting enough emphasis on professional skills, design, and experimentation[9,12]. Model eliciting activities, problem-based learning, and cooperative learning are several strategies that help students engage in real-life situations that will be relevant to their future careers[9, 13-15]. Finally, educators must set class activities at an appropriate level that is challenging, but achievable for students[1, 9-10]. Instructors should use "scaffolding" techniques, gradually removing help as students begin to learn the information[9-10].

Questions E though I: Grading Procedures, Feedback, and Assessments

Ambrose et. al state that it is critical for educators to clearly state to students what they value and reward[10]. Hence, educators should strive to be very upfront and clear about his or her grading policies. Ambrose et. al and Litzinger et. al stress the importance of timely feedback regarding student understanding of theoretical concepts, professional abilities, basic skills, and the assimilation of their knowledge and abilities[9-10]. Litzinger and colleagues explain the importance of providing feedback and returning assignments to students. This helps students to understand what they can do to enhance their learning and also increase their grade[9]. Assessments should reflect students' comprehension of class material. Assessments and student comprehension are need to be supported by each other to allow students to clearly understand how to prepare assessments[1,10]. Educators should create assessments that measure students' thought processes and level comprehension of class material[1, 9-10].

Questions J through N: Instructor Approachability, Passion, and Fairness

A large-scale study by Austin (1993) discovered that the interaction between faculty and students was one of the most predictive factors of beneficial change in students' academic advancement, personal growth, and satisfaction[14,16]. Another study by Atman et. al, "Enabling engineering student successes," found that senior students' behavioral motivation, psychological motivation, motivation from a mentor, and motivation to do social good were related to how often students interacted with instructors and how satisfied students were with instructors[14]. Clearly, student and instructor interaction is a crucial element in student motivation, satisfaction, and success. Hence, instructors must take the time to create a supportive, welcoming environment in their collegiate classrooms and offices. Bandura states that for students to be successful in class, he or she must hold efficacy expectancies, or confidence that he or she can reach a desired result[17]. Therefore, educators must convey how they will be able to help students, as this will increase students' confidence in succeeding in the class. Educators should offer review sessions, additional office hours, and supplementary material, especially when the material may be more difficult. Educators need to effectively communicate their excitement and interest in their class material. A passionate professor can make students curious about the material and motivate them to study the material more[9-10]. Litzinger et. al state that instructors should focus on stimulating interest in their subject area for all students regardless of their varying backgrounds and abilities[9]. Educators should stress the importance of how course material will be relevant in the future. Similarly, if students understand how current class material is vital for their understanding in future classes, they may value the class more[2, 9]. Hence, tying course material to future academic and career plans will show students the importance of the course.

Question O: Learning Styles and Preferences

Research by Felder and colleagues shows the importance of meeting student learning preferences. When student learning preferences match the instructor's teaching methods, students understand the material more thoroughly[1-3]. Many class and instructor components above contribute to creating a satisfying classroom. As Ambrose and colleagues state, for a student to reach the highest motivation, a student must value his or her goals, believe in his or her capability for success, and feel that his or her environment is supportive. Positivity must be achieved in all three areas to have motivated behavior[10]. Educators can help students value the course and subject matter, support students' ability to do well in their courses, and create environments that are supportive and helpful to students through the use of these techniques. Motivated students strive to get the most from their education by truly embracing new concepts and using them to further their knowledge[10].

On-Line Engineering Education

The results showed that approximately ninety-percent of students chose the traditional in-class format as his or her preferred undergraduate class format versus an online undergraduate class format. Most students are Active learners, and they learn best through interactive classroom activities and working with others[1-3]. In an online class, students work independently and rarely, if ever, have group activities. Additionally, online classes do not offer the opportunities that a traditional class does for demonstrations, problem solving sessions, and hands-on activities. These activities are crucial for Active learners, which would be lacking in an online format.

Researchers at the Teachers College of Columbia University have found that the percentage of students failing or withdrawing from a class is considerably higher in an online class setting versus a traditional class setting[18]. Online classes do not provide the variety of tools needed or the strength of support that students need to succeed in classes online[19]. Therefore, industrial engineering undergraduate students from this institution have a strong preference for the traditional in-class format of courses. The in-class format allows them to work actively with modes of instruction that are better aligned with their preferred modes of instruction. Additionally, literature has shown that online classes burden learners with many additional challenges that traditional learners do not face, such as the need to be technologically proficient, extremely self-directed, and self-motivated. Also in online classes, the lack of instructor denies students the opportunity to hear when assignments are due, receive advice on better manage their time for course success, and finally speak with students for overall assistance[19]. In an online classroom setting, students need to have the opportunity to interact with other students and the professor in a classroom lecture, through web-cam chats or live chat rooms.

Conclusions and Recommendations

This study has identified the predictors to undergraduate student motivation and satisfaction with their industrial engineering experience. Several suggestions that can be implemented by educators in undergraduate industrial engineering/STEM programs to increase student satisfaction were made in an attempt to help instructors increase student motivation and satisfaction with their industrial engineering coursework. Specifically, this study has helped to identify the instructional methods that are best to increase industrial engineering student motivation and satisfaction with the delivery of their industrial engineering courses.

Learning Styles in the classroom are very important for student understanding of course material. The breakdown of learning styles among junior and senior level industrial engineering students at Penn State University was found to be similar to industrial engineering and STEM majors at other institutions. Industrial engineering instructors should aim to meet student learning styles by using teaching methods to specifically target Active, Sensing, and Visual learners, whose needs are not normally met in the collegiate classroom. Using blended modes of teaching can be effective in addressing the student learning style differences that exist in the classroom. Students in an unsatisfying class often experience modes of instruction that do not complement their preferred mode of learning or their dominant learning styles. The incorporation of more problem solving sessions, group activities, hands-on activities, and demonstrations in classes give active learners the interaction and collaboration with others that allows for the most efficient and effective learning. Additional teaching method suggestions include incorporating real-world facts and numerical examples into these active and problem based learning experiences to teach abstract concepts, and using graphs and charts to visually display information.

Student motivation is a significant predictor of student satisfaction. Student motivation can be reinforced by targeting student interest in class topics, showing passion for the course material, offering to help students, and by creating a supportive classroom environment. Educators should also relate class topics to student interest and “real world” applications to increase motivation and students’ value on a task. Instructors must make grading procedures clear, make assessments straight-forward, give assignments back to students quickly with helpful feedback, and use “real-world” examples in class to help students clearly understand class material. Instructors need to be enthusiastic about course material, while creating an environment that encourages and allows students to approach the instructor with any questions they may have. Students are more inclined to attend their classes if instructors are putting forth an honest effort to deliver a course in a manner that motivates and satisfies the learning needs of the students. More than half of students that identified a class as being an unsatisfying class specified that attending the class did not help his or her understanding of class material. This study showed that industrial engineering students from Penn State University have a strong preference for the traditional in-class format of courses over on-line courses. When delivering an on-line engineering course, instructors must be actively involved with course delivery and be readily accessible to their students.

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