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Analyzing Student Perceptions of Various Pedagogical Strategies in a First-Year Engineering Technology Classroom

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When teaching engineering technology, the instructor has a host of pedagogical techniques to consider when designing a course. How should the instructor deliver content? Which methods will make the course engaging and which will enable the students to learn the most? This exploratory study begins to look at this question within the context of the First-Year Engineering Technology (FYET) program at Purdue University Fort Wayne (PFW). PFW is unique from many universities in that it is historically a commuter campus that largely serves non-traditional students. It is within this context that our study looks at these different pedagogical strategies.

The course under investigation is *Introduction to Engineering Technology*, where students learn concepts, such as using Word, Excel, PowerPoint, Unit Conversions, Calculation, and Engineering Equations. Each of these concepts was practiced by solving and doing in-class activities (ICAs). The way the class was structured for the ICAs was varied with different iterations of readings, work time, review, and lecture. The work time in class to complete ICAs was also varied using different methods such as group study, answers on the board, and tutorials. Additionally, the pedagogical strategies used in the interventions ranged from a group work environment with a flipped classroom to productive failure where students tried solving problems before any instruction. Students were asked on a survey at the end of the semester to rank which way to solve the ICAs was their “favorite” and which way they felt helped them to understand the material the best. Additionally, they were asked how they received the course content for the ICAs. Only students over the age of 18 were considered and only students within Construction Management (CM), Mechanical Engineering Technology (MET), and Industrial Engineering Technology (IET) were considered as the course was designed for these specific majors.

The study looked at survey data collected at the end of the semester which asked students to evaluate and rank which of the pedagogical designs they liked best and which they learned the best with. The survey results of student perceptions were then analyzed to better understand the relationship between when students feel they learn best and when they most like the instructional methods. The results illustrated that students associate their enjoyment with learning. Additionally, the results showed that students preferred to be shown how to solve the activities and wanted the lecture content given with a chance to work after. The results of the study have implications for practices in engineering technology classrooms.

Introduction

First-year experiences are critical to students as they transition from their high school experiences into their undergraduate years. Many first-year classes may be the first formal introduction to the major that a student is interested in pursuing during their time at the university. Because of this, first-year experiences can be formative in building confidence in students that they can indeed succeed in their chosen major [1]. It is because of that programs must be vigilant in understanding how they structure their first-year experiences, especially when retention may already be a concern.

Purdue University Fort Wayne (PFW) is currently undergoing the process of designing a first-year experience for engineering technology students. Smaller regional campuses already struggle with student retention due to several different factors including economics as well as student commitments outside of the university [2]. Additionally, students may already be struggling with belonging given the higher percentage of first-generation college students represented at smaller regional campuses [3],[4]. Because of this, it is even more imperative that first-year experiences at regional campuses are designed in such a way as to promote student success in the classroom.

This exploratory study is the first step in understanding how first-year engineering technology classrooms at PFW can best be set up for student success by looking at students perceived experiences in the classroom, namely, what they learned and how they enjoyed aspects of the class in the form of in-class activities (ICAs). This has led to two primary questions for this initial exploratory study: (1) How did students' perception of understanding and enjoyment change based on different instructional strategies applied (flipped classroom, productive failure, etc.) to receive content in a first-year engineering technology class? (2) In what ways were students' perceptions of understanding and enjoyment related based on different instructional strategies applied to complete ICAs in a first-year engineering technology class?

Background

First-Year Engineering Technology

First-year engineering technology (FYET) programs have historically been understudied leading to a gap in the literature in understanding their unique experiences [5]. However, there have been some efforts within the literature to understand the unique experiences of students within a FYET program [5], [6], [7]. As a field, engineering technology (ET) generally has similar demographics to many STEM fields where it is majority white males with large gaps in participation by underrepresented groups [8]. The data also suggests that many ET majors originally started as engineering majors but decided to switch based on a handful of factors, mathematics being cited as one of the biggest [9]. Add onto this the challenges of retention and readiness already experienced by regional campuses [2],[10]; there is quite a need for integrated first-year experiences that support students who may be in the process of exploring their major as well as need support to persist to their second undergraduate year.

Enjoyment in Learning

This study seeks to understand how enjoyment can be impacted in the FYET program. Enjoyment is defined in this study similar to other studies as feelings associated with fun when involved in a learning intervention [11]. Multiple studies within the literature have suggested that there is a relationship between a student enjoying what they are learning and the learning itself [12], [13]. While this is likely to be expected, when one is having fun as they are likely to be engaged, it does mean that enjoyment as a measure can potentially be leveraged in a first-year learning environment. Enjoyment can play a critical role in the experiences that students have in the classroom given that positive learning experiences can give rise to attributes such as confidence and self-efficacy, necessary components to better persistence [14]. This study aims to understand student enjoyment of learning interventions, and its perceived relationship with learning itself, to potentially leverage in future iterations of the course and curriculum.

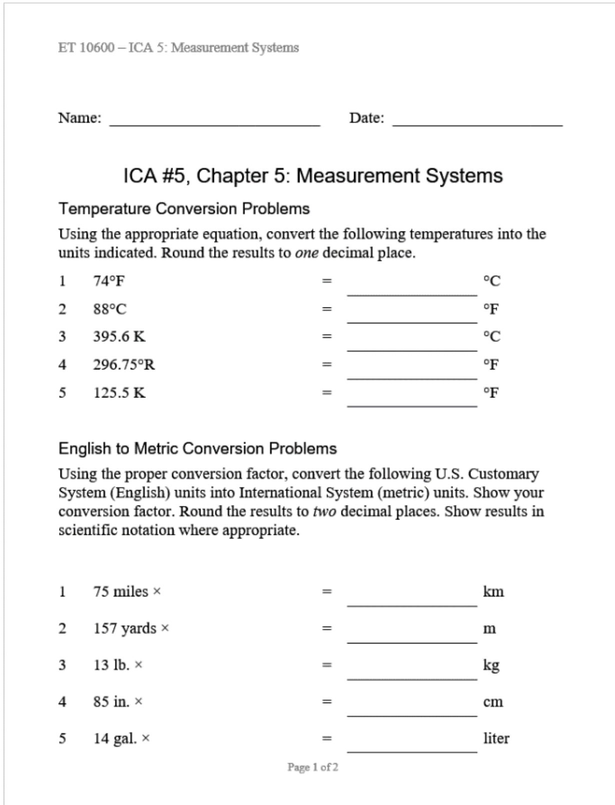
Methods

Course Information

An "Introduction to Engineering Technology" course has been undergoing development to become a FYET program [15]. The course traditionally was taught following *Introduction to Engineering Technology 8th Edition* [16] with information given as readings and lectures while practice was given as ICAs and homework. Additionally, there was a semester-long team project and first-year activities (FYA) to help with the transition to college. Most of the content focused on engineering technology fundamentals such as unit conversions, solving engineering equations, and how to use Microsoft Office 365 to solve problems. The course has no prerequisites, but it is preferred that students be college algebra-ready. A typical section size ranges from 25-30 students with three to five sections in the fall and one section in the spring.

The ICAs were set up to provide practice and examples that covered material such as calculations, engineering equations, how to calculate grades in Excel, unit conversions, and applying trig to solving engineering problems for example. Two examples of an ICA are given in Figure 1. In total, there were 21 ICAs given throughout the semester in the traditional design. In the new design, that is currently being worked on, this will need to be reduced to about 15.

The design of the course for the scope of this work had class time being consumed by lectures and ICAs while the project, homework, and FYAs all being completed outside of class. This placed a significant amount of unnecessary stress on new students who were already overwhelmed and overcommitted. This paper focuses on how the course was traditionally taught in a fall semester and narrows in on how content was delivered and how ICAs were completed to better implement ICAs in the course redesign. Multiple different strategies were implemented ranging from productive failure [17] to a flipped classroom approach. A survey was given at the end of the semester to understand students' perceptions. This is a precursor study to help with the course redesign.


ET 10600 – ICA 5: Measurement Systems

Name: ______________________ Date: __________________

ICA #5, Chapter 5: Measurement Systems

Temperature Conversion Problems

Using the appropriate equation, convert the following temperatures into the units indicated. Round the results to *one* decimal place.

1	74°F	=	____________	°C
2	88°C	=	____________	°F
3	395.6 K	=	____________	°C
4	296.75°R	=	____________	°F
5	125.5 K	=	____________	°F

English to Metric Conversion Problems

Using the proper conversion factor, convert the following U.S. Customary System (English) units into International System (metric) units. Show your conversion factor. Round the results to *two* decimal places. Show results in scientific notation where appropriate.

1	75 miles ×	=	____________	km
2	157 yards ×	=	____________	m
3	13 lb. ×	=	____________	kg
4	85 in. ×	=	____________	cm
5	14 gal. ×	=	____________	liter

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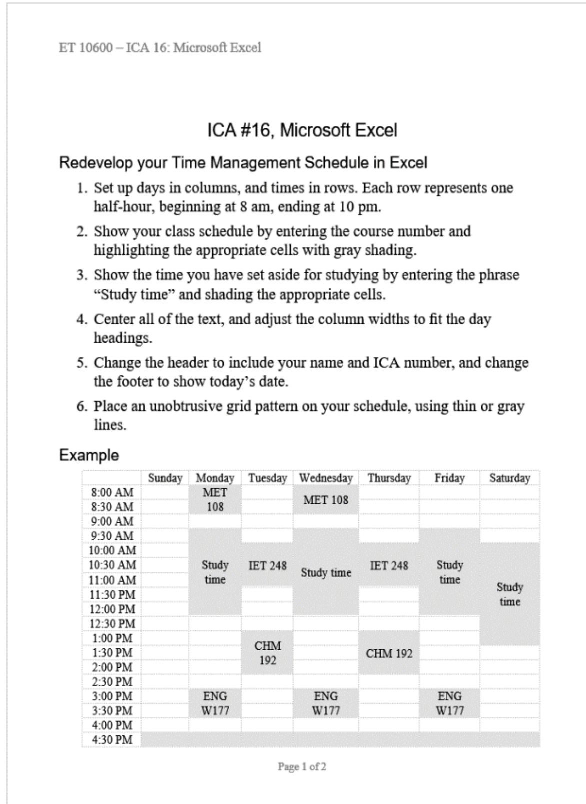
ET 10600 – ICA 16: Microsoft Excel

ICA #16, Microsoft Excel

Redevelop your Time Management Schedule in Excel

1. Set up days in columns, and times in rows. Each row represents one half-hour, beginning at 8 am, ending at 10 pm.
2. Show your class schedule by entering the course number and highlighting the appropriate cells with gray shading.
3. Show the time you have set aside for studying by entering the phrase "Study time" and shading the appropriate cells.
4. Center all of the text, and adjust the column widths to fit the day headings.
5. Change the header to include your name and ICA number, and change the footer to show today's date.
6. Place an unobtrusive grid pattern on your schedule, using thin or gray lines.

Example

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
8:00 AM		MET		MET 108			
8:30 AM		108					
9:00 AM							
9:30 AM							
10:00 AM							
10:30 AM		Study	IET 248	Study time	IET 248	Study	
11:00 AM		time				time	
11:30 PM							Study
12:00 PM							time
12:30 PM							
1:00 PM			CHM				
1:30 PM			192		CHM 192		
2:00 PM							
2:30 PM							
3:00 PM		ENG		ENG		ENG	
3:30 PM		W177		W177		W177	
4:00 PM							
4:30 PM							

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Figure 1: Two examples of an ICA given to students. The first was practicing how to do unit conversions and the second was using Excel to make a typical week to help promote time management.

Implemented Strategies

Multiple different methods to complete the ICAs were implemented based on the ICA content, convenience, and time allotted. The methods are described in Table 1. Additionally, the class structure and how students received information varied throughout the semester. It was done at random most days or students were allowed to choose by conducting an informal survey. The class consisted of a lecture and time to work on the ICA by one of the methods from Table 1, and then the ICA was reviewed to ensure everyone had the answers before they left. The variations are described in Table 2.

Data Collection and Analysis

Students' perceptions were collected through a survey that was given at the end of the semester. Students were given ten points for completing the survey which was worth 1% of their grade. The survey was anonymous, and students received a code at the end of the survey to post into a quiz within the learning management software to receive credit. All results were not reviewed until after final grades were posted. The survey did not require students to answer each question and there was an option to state "I Prefer Not to Answer" as well. The survey questions are given in Table 3.

Table 1: Strategies implemented to complete ICAs.

Strategy	Description	Thought for Why Implemented
Self-Study with Instructor Circulating	Students were expected to work on the ICA by themselves during class and work at their own pace. The instructor would circulate the classroom to help students stay on course and provide help.	Allows for a segmented approach that can account for diversity in the students' academic backgrounds. Students learn how to learn on their own.
Group Study with Instructor Circulating	Same approach as the self-study, but students were allowed to work in teams of three to five. Teams were made for the project, but students could choose who to work with in class.	Promotes team building and relationships along with additional support while the instructor is with other students.
Full-Tutorial	Instructor completes entire ICA step by step as class follows along.	Everyone is guaranteed to complete the activity in class and has the correct process with answers for the entire ICA to refer back to.
Partial-Tutorial	The instructor completes part of the ICA step by step and then students can work as a team or individually to complete the remaining.	Students have a foundation and examples to refer to as they then practice on their own.
Class Study-Volunteer Answer on Board	Each part of the ICA was given to one student to complete. The student then puts the solution on the whiteboard for others to learn from. Problems were assigned by students volunteering.	This method allows for many problems to be completed in a short amount of time.
Class Study-Required Answer on Board	Each part of the ICA was given to one student to complete. The students then put the solution on the whiteboard for others to learn from. Problems were assigned at random to students.	This method allows for many problems to be completed in a short amount of time while guaranteeing that everyone participated.

Table 2: Class structure variations

Structure	Thoughts for Why Implemented
ICA, Review	No lecture was given, and students were given a reading before class. It was desired to understand if students would complete a reading alone or if a recorded lecture would be needed in a flipped approach.
ICA, Lecture, ICA Review	The idea of productive failure was evaluated. In this iteration, students were given a second chance after receiving the material to complete the ICA.
Lecture, ICA, Review	This was to evaluate what was considered the traditional way of completing the ICA.
ICA, Lecture, Review	A modified version of productive failure. Students attempt and fail, but then were given the content needed and answers. The second chance was left off due to limited time when lectures were longer.

Table 3: Survey Questions

Question	Question Type
Is this your first semester at PFW?	Multiple Choice
Is this your first semester at a college?	Multiple Choice
What is the highest level of math that you have completed, are currently taking, or have received credit for?	Multiple Choice
Are you a first-generation college student?	Multiple Choice
How many hours a week do you spend working at a job?	Multiple Choice
Please Rank in order which was your favorite way to complete in class activities/labs? 1 is your favorite.	Ranking
Please Rank in order which way helped you understand the information the best from the in-class activities/labs? 1 is the way that provides the best understanding.	Ranking
Please Rank in order which was your favorite way to complete in class activities/labs? 1 is your favorite (Structure)	Ranking
Please Rank in order which way helped you understand the information the best from the in-class activities/labs? 1 is the way that provides the best understanding. (Structure	Ranking
Do you have any recommendations on how the in-class activity structure can be improved or other ideas/feedback in regard to the ICA's? (Type "I prefer not to answer if you wish not to answer")	Open-ended
Please Rank from 1(didn't help at all) to 100(best learning tool ever) how beneficial the following learning tools were for you in regard to your success in the course and understanding of course content. Put 0 for I prefer not to answer.	Slider

The data was analyzed in Excel and plotted using both Excel and MATLAB. The open-ended responses were analyzed by breaking responses into categories and feedback was noted for future improvements. The ranking was counted based on how many received a 1, 2, 3, 4, 5… and so on for each of the ranking questions. Each ranking questions were also counted to see how many received a 1-1,1-2, 1-3….7-7. These results were plotted in a matrix of favorite vs. understand and the trace of all the matrices were summed to understand how many were ranked in the same order. Blank answers and "I prefer not to answer" responses were removed for each given question. Frequency was counted on the multiple-choice questions and descriptive statistics in Excel were run on the slider data.

Results

Demographics

The total class population across the three sections for the semester polled was 79. Of the 79, 58 completed the survey and were an engineering technology major. Additionally, of the 58 some chose to leave the question blank or preferred not to answer. The lowest response rate was the open-ended question. Tables 4-6 lay out the demographic questions focused on.

Table 4: Results to Understand Transfer Students and First-Generation Percentage

	First Semester at PFW	**First Semester in College**	**First Generation Student**
Yes	53	44	28
No	5	12	26
I Prefer Not to Answer	0	2	4
Total	58	58	58

Diving into Table 4, the majority of the students are first-year students starting college for the first time at PFW. About half of the students are first-generation students while there are a few transfer students and a few students who have been at PFW for at least one semester. The results are enlightening to understand how much time should be spent "onboarding" to college in the redesign.

Table 5: Response on the Current Math Level of Students

Current Math Level	Frequency
I Prefer Not to Answer	4
Remedial Math	5
College Algebra	19
Algebra and Trigonometry I	9
Precalculus	8
Calculus	13
Total	58

Table 5 demonstrates the wide variety of math levels of students in the course. This was a main challenge in teaching the course, especially the approach taken to teach algebra and trigonometry-heavy modules of the course.

Table 6: Results of How Many Hours a Week Students are Working.

Number of Hours	Frequency
~0	22
1-5	4
6-20	13
21-30	10
31-40	5
40+	1
I Prefer Not to Answer	3
Total	58

Table 6 showed that over half of the students were working a job and attending college with at least 16 students working 12+ hours. It was also found that only one of the 58 students was considered a part-time student.

Survey Results

The students' rankings of the different methods for completing the ICAs can be seen in Figure 2. The favorite way to complete and understand had a submission count of 43 while the favorite way to receive and understand (class structure) had a submission count of 48.

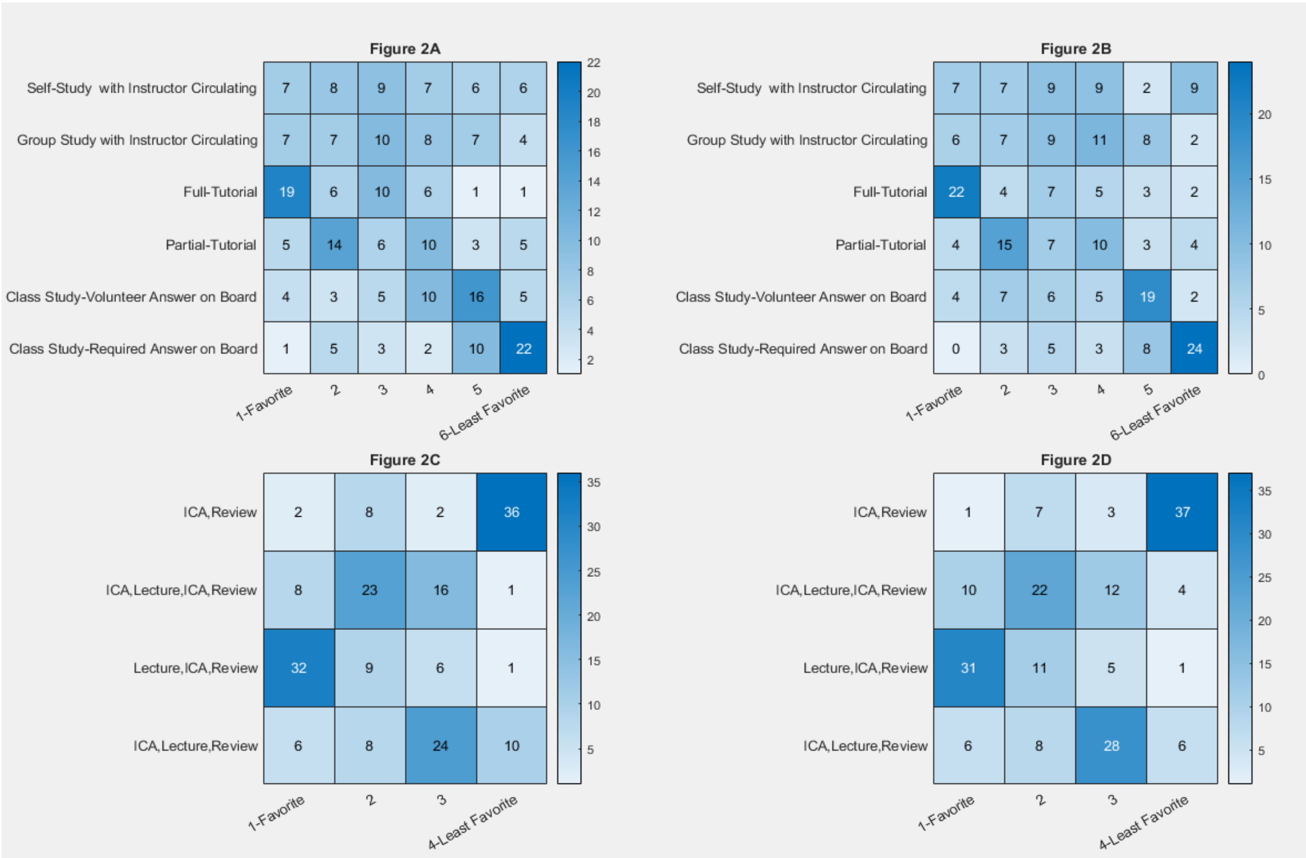

Figure 2: (A)Favorite Way to Complete, (B), Best Way to Understand, (C) Favorite Way to Receive (Structure), (D) Best Way to Understand (Structure)

Analyzing Figure 2 students appreciated having a lecture before they worked but were not opposed to a productive failure approach [17] as long as they had a chance to work after the lecture. Furthermore, students appreciated being led through the ICAs as much as possible. They appear to be neutral on the Group and Self-Study approaches and against putting answers on the board, especially if required.

Additionally, a matrix was made for each method that plotted favorite versus understanding for each student response to see if students tended to enjoy and understand from the same method or if they potentially enjoyed one but did not understand from a given method. An example of a matrix can be found in Table 7.

Table 7: Matrix of Favorite vs. Understand for ICA, Lecture, ICA, Review

		Understand Ranking			
		#1	**#2**	**#3**	**#4**
Favorite Ranking	**#1**	1	4	1	2
	#2	2	3	13	5
	#3	3	3	7	5
	#4	4	0	1	0

The trace of all the matrices (10 matrices in total) was summed and accounted for 60% of all recorded responses which shows that students tended to rank their favorite methods and best way to understand in the same positions.

Descriptive statistics were run on the slider survey question of how beneficial were the ICAs to their success in the course and understanding of the content. The statistics are as follows: Mean = 88.5, Median = 95, Mode = 100, Standard Deviation = 15.5, Range = 81, Count = 56.

Finally, the open-ended question has been aggregated into bins as can be seen in Figure 3. "No Changes" accounts for every response that provided either encouragement to continue them or stated no changes. Suggested changes are comments that provide critical feedback or displeasure. Common comments had to do with (1) room setup and projector resolution, (2) keeping the ICAs in class and not as additional assignments if not completed in class, and (3) connecting the ICAs to the project. Overall, students tended to appreciate the ICAs and were considered a critical part of learning in the course. The total count was out of 79.

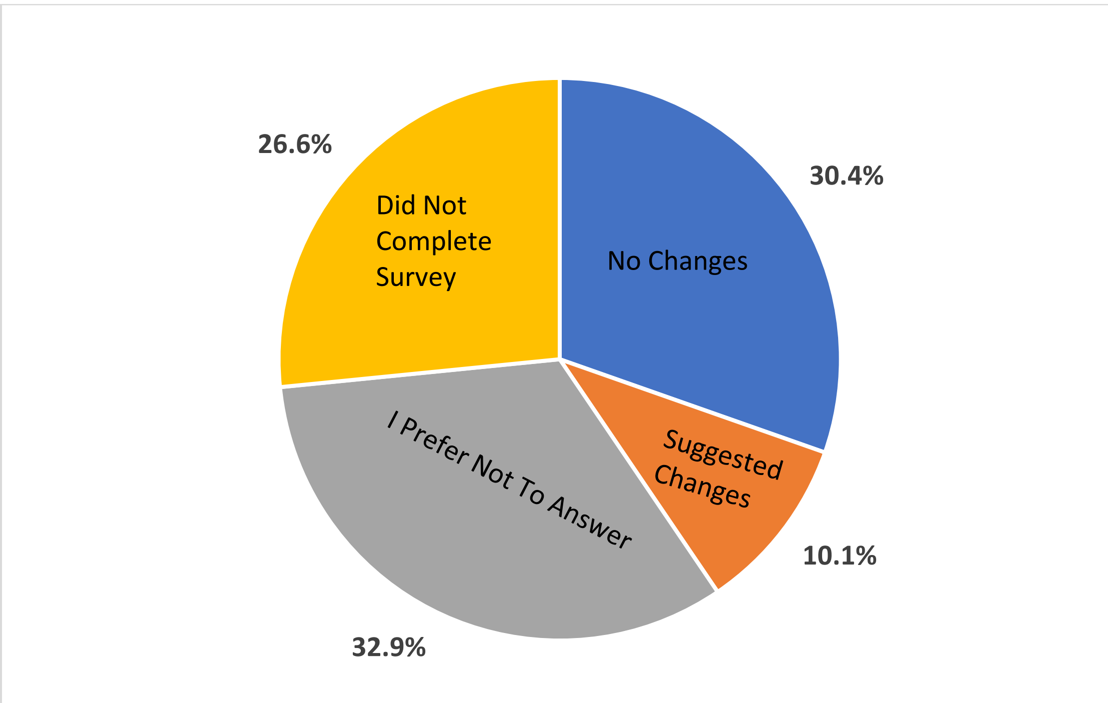

Figure 3: Responses of Recommendation on ICAs

Discussion

Student Perspective

The student demographic was under a significant amount of pressure from most of them working and being full-time students. Additionally, almost half of them were first-generation college students in their first semester. Finally, their math backgrounds were quite diverse. Although it may not necessarily link directly to college success, math preparation does suggest different levels of college readiness [18]. Because of this, there are several unique challenges for the students in the first-year engineering technology course at the given regional campus. All of these factors need to be considered when redesigning the course in future iterations.

The students thought the ICAs were important to the course and appreciated having lectures before work. Students perceive to enjoy and understand content the best by being shown how to complete the ICAs through a tutorial. They especially do not enjoy putting answers on the board. Our results indicated that students often link enjoyment with understanding which shows that either enjoyment leads to understanding or enjoyment and understanding are conflated by the students. This result was found from the high number of responses that were in the same order when computing the total trace. Because of the exploratory nature of this study, it is hoped to further collect data to understand the role that enjoyment plays in the learning process during the first year in future studies.

Instructors Perspective

Despite the survey results it appeared in the classroom that students were least engaged during the tutorials and lectures. This could be from instructor bias or suggest that despite students appearing to be bored they still preferred these methods. Switching up the environment provided respite and new energy in the course for the instructor. However, when answers were put on the board it was difficult to navigate when students got the answers wrong, and it was clear students were conscious of embarrassment. The same students would tend to volunteer which led to assigning problems to each person in the class. The answers on the board method allowed for the most problems to be solved and most content to be covered in the classroom. When students did self-study, it was common for a few students to not participate and work. During group study it could be seen some students would still work by themselves either by choice or from being shy as the groups were set by those nearest. Also, only the same few students would ask the instructor for help. The study methods and partial tutorial would commonly run out of class time and students would need to continue at home. The tutorials were hard to navigate as students would fall behind, especially with the Excel tutorials. At times there would be three different versions of Excel in the classroom which was difficult to navigate as well.

The instructor's favorite methods did not align with the students', but the instructor could relate and understand why considering the pressure and unfamiliarity of college for the student demographic. The tutorials and traditional lecture setup may be what first-generation students perceive to be a typical college class layout.

Conclusions and limitations

Overall ICAs were important to the course which is helpful when redesigning the course as they were a tool that was marked to be cut out initially. In the redesign, lectures will be given in a flipped approach and not assigned readings as few did the readings. It is unsure from the survey if students dislike the flipped approach or the readings as lectures were not given in the pre-recorded flipped format. To account for this unknown, a brief review of the lecture may be added at the start of the first class. The new mini-projects will be designed to align with the content in the ICAs. Students will be assigned teams and put in pods to promote working together when group work is assigned and to help promote a learning community. If board work is chosen, it will be from group work where one group will be responsible for putting answers on the board to limit embarrassment. Some form of tutorial should be done for each ICA and a full tutorial is recommended for the difficult content and then additional problems could be practiced in a subsequent ICA or optional practice handouts. The work outside of class needs to be reduced and managed. One option would be something that is easy to schedule, like a timed lecture outside of class (flipped) and then the difficult application can be completed in the classroom to help guide students (ICA & mini-project).

It is understood that most of the usable results are from 43-48 students out of 79. This was also done in one semester and the demographic can vary from semester to semester. Also, students were asked to rank the methods but were never asked if they did not like a method or to what level more did they prefer a method. Considering this, none of the methods will be fully removed, but each will be modified to address the concerns of the instructor through the approach of the implementation. The frequency of each method will also be modified to favor tutorials and all lectures will be given first through a flipped approach out of necessity for the new design of the next iteration of the course.

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