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Student Reflections Encourage Self-Regulated Learning and Faculty Just-In-Time Teaching

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Abstract

The authors report on a pedagogical feedback strategy employed in a first-year engineering graphics course, which implemented a flipped classroom model for self-regulated learning. Class time was reserved for activities and content clarifications. To encourage self-regulated learning and just-in-time teaching modifications, students completed a weekly mixed methods survey. Over the semester, 12 weeks of student data were collected. The authors found that the instructor could be timelier and more responsive with adjusting course materials based on student's needs. Findings also suggested the process built a mutual constructive communication between the students and the instructor. It allowed the instructor to recognize patterns of student conceptual difficulties, skill development obstacles, and behaviors that may affect their learning.

Introduction

Due to the COVID-19 pandemic, a first-year engineering graphics course at a southeastern private institution was flipped in 2020 to encourage self-regulated learning (SRL) and applied Just in time teaching (JiTT) to not only better assist students learning of concepts, but also address classroom management issues that came to light. Self-regulated learning focuses on one's ability think metacognitively, motivationally, and behaviorally [1]. Learners can use this process with many strategies including self-evaluation [2] and goal setting, time management, and organization [3]. Self-regulation does not only occur at the individual level, but also as Watson [2] notes, it is impacted by interactions with one's environment and can be learned through modelling, scaffolding, and direct instruction. Just-in-time teaching (JiTT) combines the use of out-of-class, web-based exercises with active-learning pedagogy in a traditional classroom setting to create a feedback loop that "(a) encourages outside-of-class preparation by students, (b) provides prompt feedback on students' conceptual understanding of course material, and (c) informs just-in-time modifications of class activities and discussion" [1].

The course materials were redesigned to accommodate online self-regulated learning; the classroom was dedicated to class activities including time for questions and answers, Poll Everywhere (an audience response system) competitions, and assignments completion. To encourage SRL, understand students' needs and address their concerns immediately, weekly reflection surveys were implemented. There were six multiple-choice questions and two open-ended questions which allowed students to reflect on the weekly study and offer feedback and suggestions so that the instructor could do a timely and responsive adjustment for a better study experience in the following week.

From weekly reflection survey results, the instructor had a better understanding of the difficulty level of weekly course materials, if students watched given videos and prepared for classes, if the workload was at the appropriate level, how much time they spent on the weekly study, and if they needed help from teaching assistants or the professor. Two open-ended questions included one, "what could you do to be more successful next week?" and two, "what can the instructor do to help you be more successful next week?". The results indicated that students often took ownership of their learning, or lack thereof, and saw the benefit of the flipped classroom design. The instructor could be timelier and more responsive with adjusting course materials based on

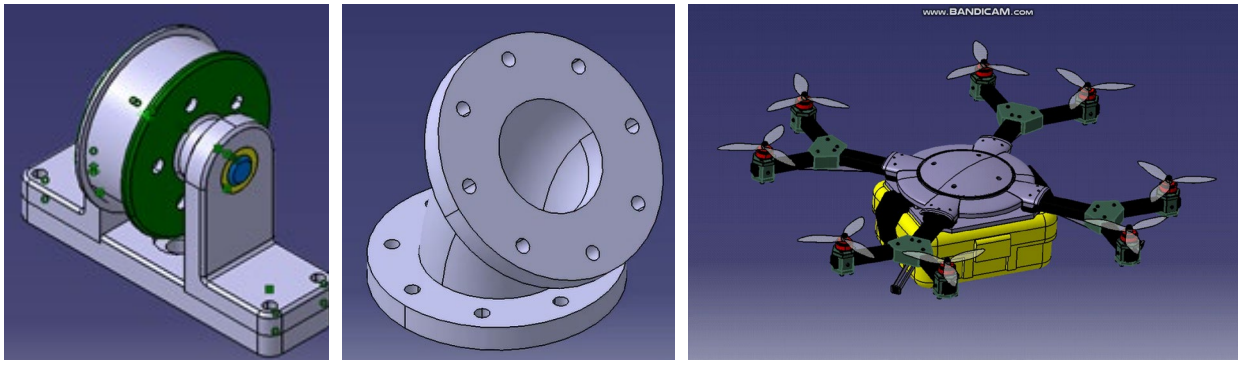
student's needs and built a mutual constructive communication between the students and the instructor accordingly. These weekly surveys were so successful in encouraging students' SRL and providing the instructor with immediate feedback on the course that the practice was continued when the course returned to face-to-face modality in fall 2021. This paper focuses on the results collected in fall 2021.

Engineering graphics course

The engineering graphics course covers freehand engineering drawings, and fundamentals of computer-aided design (CAD), CATIA V5-6R2020. Face-to-face classes were offered three times a week and lasted fifty minutes each to fulfill the requirements of the three-credit-hour semester-long course. Table 1 lists the topics covered in each week. After week 12, the last two weeks were dedicated to students' final project. There were no more course topics or assignments given. Figure 1 shows selected CATIA work including CATIA bottom-up assembly, Advanced CATIA, and selected student's final project design.

Table 1 *Weekly study topics*

Week	Topics
1	Lettering, Lines and Scales (Freehand sketching)
2	Normal surfaces, and inclined surfaces (Freehand sketching)
3	Dimensions and CATIA introduction (freehand sketching and CATIA work)
4	Oblique surface and CATIA constraints (freehand sketching and CATIA work)
5	Cylindrical surface and CATIA features (freehand sketching and CATIA work)
6	CATIA drafting (CATIA work)
7	CATIA top-down assembly (CATIA work)
8	CATIA bottom-up assembly (CATIA work)
9	Advanced CATIA (CATIA work)
10	Advanced CATIA (CATIA work)
11	Tolerance and threads (freehand sketching and CATIA work)
12	Section view, and auxiliary view (freehand sketching and CATIA work)



A B C

Figure 1 Selected CATIA work (A. Bottom-up assembly, B. Advanced CATIA design, C. Selected student's final project)

Because of the flipped classroom to encourage SRL, JiTT teaching class was used to answer students' questions and facilitate the completion of their assignments. Students' final weighted

grade is determined by online lesson (10%), emulate videos (20%), class activity (30%), reflection surveys (5%), next step (15%), and final project (20%).

Flipped classroom for SRL and JiTT

Since a flipped classroom can be offered both online and in person to engage students through active learning in education [4]–[6], an ***ILEARN*** framework on Canvas in a flipped classroom setting was developed by a group of engineering graphics instructors in 2020 to accommodate students' needs during the pandemic. Students learned online ***I***nteractive ***L***essons for background knowledge including videos, audios, PowerPoints, and quizzes, then ***E***mulated one or two problems by following recorded videos online. Students were encouraged to complete class ***A***ctivities in class to demonstrate a higher-level understanding. During the class meeting, PollEverywhere competitions as one of the gamified activities were implemented to test students' understanding, clarify misconceptions [7], [8] and give students opportunities to earn gamification points. Gamified activities were implemented to motivate students to study more and improve their time management skills. For example, students could earn gamification points if they submitted their assignments before the early due dates. After the early due dates, students were allowed to submit their assignments using one-week submission window without late penalty. After one-week submission window, students could still earn up to 50% points. Periodically more challenging problems were given so that students could earn more gamification points. Gamification points could be added to students' emulate video or class activity assignments at the end of semester to improve their weighted grades but were capped at 3%.

A weekly ***R***eflection survey was given to understand their SRL and collect their feedback. The weekly reflection survey was available to take by Friday night once students completed weekly study and closed by Sunday night so that the instructor could compile the comments and share the results with students on the first-class day of the following week for JiTT modifications. Certain course adjustments were taken according to students' feedback to improve their SRL in the following weeks. The ***N***ext step tasks were related to a final project so that students could build up their understanding and apply their study to an open-ended semester long project. These weekly surveys were so successful in encouraging students' SRL and providing faculty with immediate feedback on the course that the practice was continued when the course returned to face-to-face modality in fall 2021. Because of pandemic, Zoom meetings were conducted and recorded simultaneously so that students who could not come to the face-to-face classes could still attend classes remotely or watch recorded meetings afterward.

Results

There were 80 students enrolled in three class sections in fall 2021. From twelve reflection surveys conducted, the average response rate was 89% with the lowest being 82.5%. As with any indirect assessment there are some limitations, primarily relying on student perceptions and their ability to communicate those perceptions reliably and clearly. In this case, the instructor provided students with questions that directly related to their personal learning experience and attempted to not make it onerous for students with 8 questions. The indirect assessment did allow the instructor to assess student views quickly and track opinions over time. The first 6 multiple-choice questions highlighted weekly workload, stress level and students' behavior and learning.

The last two open-ended questions asked students for their self-flection on the weekly study and called for their feedback and suggestions for coming week study respectively.

Figure 2 shows students' response to Question 1(*Q1*), "How CHALLENGING were the tasks this week?" from week 1 to week 12. 5-point Likert from 1 (very low) to 5 (very high) was used to evaluate their workload assessment. Overall, over 65% students felt that the difficulty level was moderate. From week 3 to week 4, when the CATIA, a new CAD software was introduced in the class, students felt more challenging work since over 20% students indicated high challenging work. The same trend was also reflected in CATIA drafting and assembly study in week 6 and week 7 since both were new workbenches which require a steep learning curve. As more practices continued over the semester, students achieved more confidence and over 70% students felt moderate challenging work from week 8 to week 12.

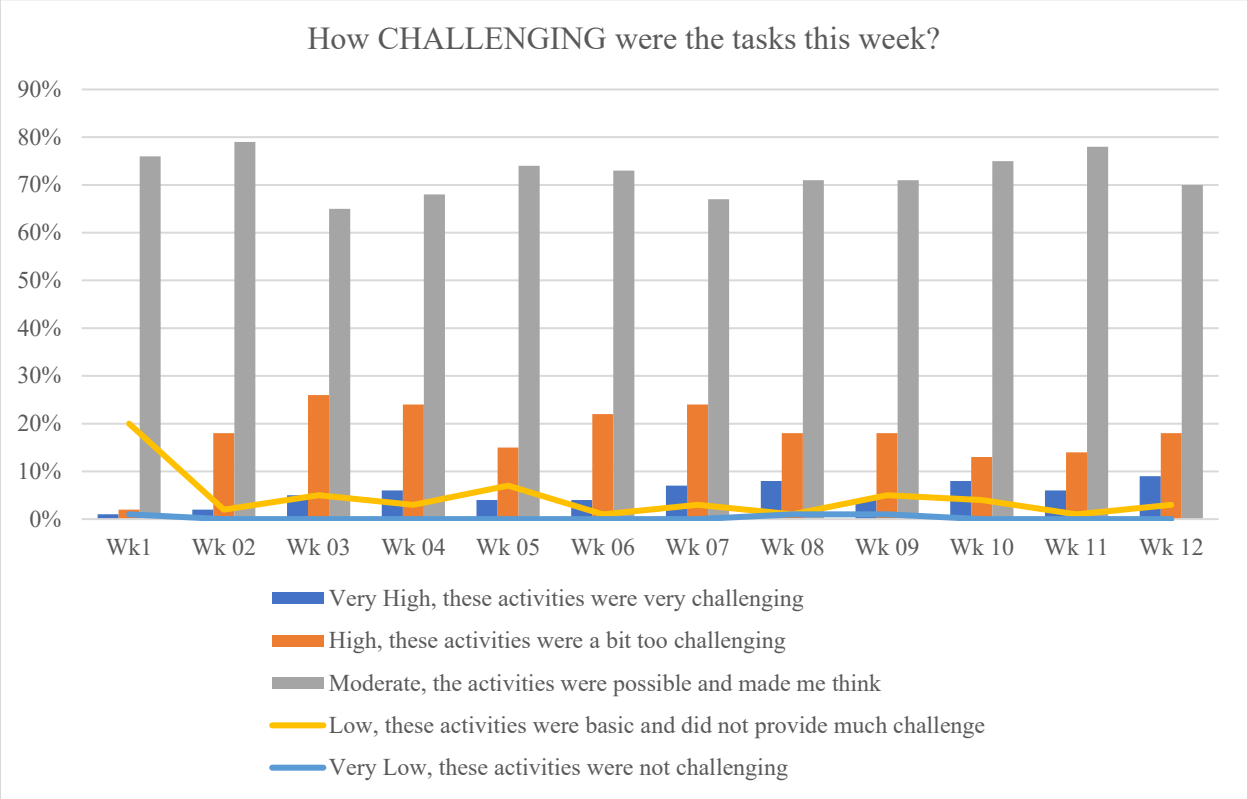


Figure 2. *Students' response to Q1 "How CHALLENGING were the tasks this week?"*

Figure 3 shows skills students applied to each weekly study. All course topics were correlated and built upon each other. Overall majority students felt that they could apply skills they learned to complete challenging tasks. Figure 4 depicts students' video access from week 1 to week 12. There were one or two videos included in each emulate video module. The length of each video varied from 7 minutes to 20 minutes. Over 70% students watched all videos in the first three weeks. After it, the rate started to drop to the lower point at 53% when midterm exams approached in week 7. After week 7 the rate was improved a little bit but dropped again since the final weeks were close. Perhaps as students were getting familiar with flipped classroom, they had a better ability to identify key content in the videos in a more efficient way. The trend is similar to the findings mentioned in [9], [10]. Overall, the vast majority of students (90% or

above) watched most of videos throughout 12 weeks online study. Students also complimented the effectiveness of emulate videos in the reflection surveys and the university end of course evaluation.

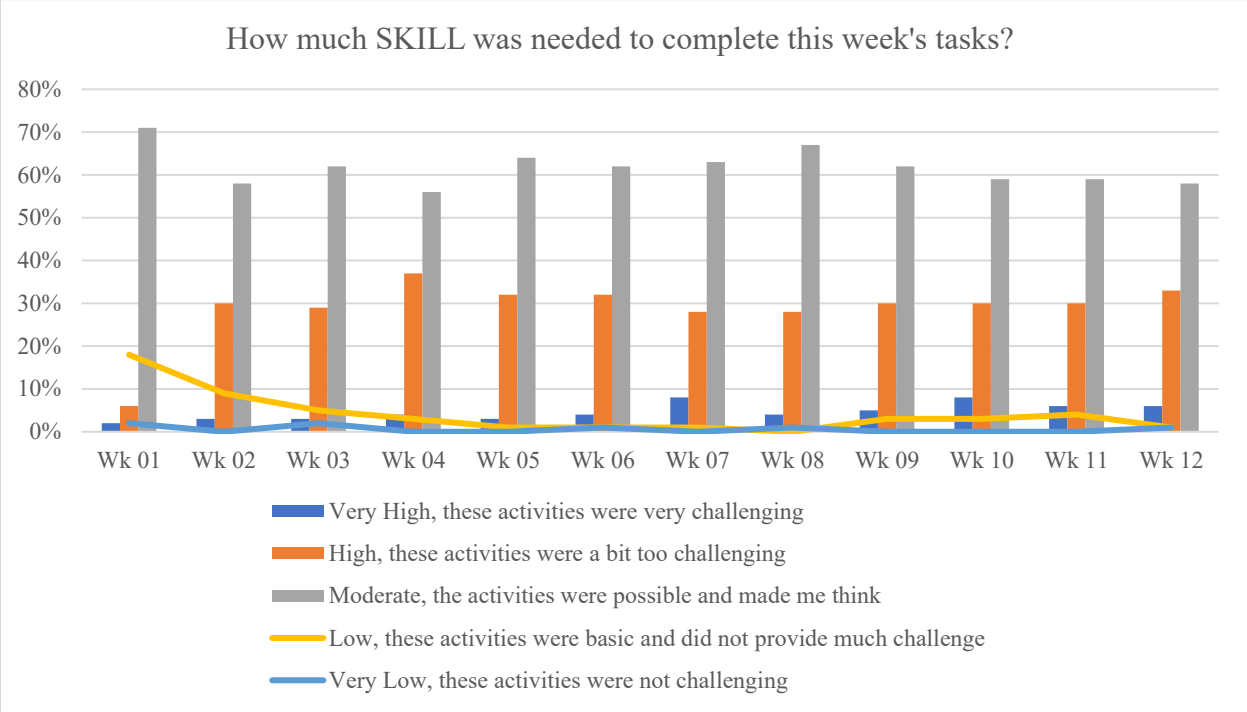


Figure 3. *Students' response to Q2" How much SKILL was needed to complete this week's tasks?"*

Figure 5 indicates students' stressfulness over 12 weeks. Over 70% students felt the workload was either ideal or medium. Noticeably there were 19% students who described much higher workload in week 8 and week 11. In week 8, CATIA bottom-up assembly was covered which requested a comprehensive understanding of constraining parts and generating exploded views on the engineering drawing. In week 11, tolerance and threads were covered, which were rated as the hardest topics over the years. In the future, perhaps spread the content out over more classes with supplemental instructions which can help alleviate students' stress and enhance their learning experience. Figure 6 shows how many hours students spent on their weekly study from week 1 to week 12. Majority students read and studied 3-5 hours each week out of class, which was consistent with ideal workload reflected by the majority from Figure 1.

When students were asked if they needed assistance from their teaching assistant or the professor to review any of the topics, almost over 80% students mentioned no except week 1 as shown in Figure 7. Since it was the first week of the class, 18 out of 82 students indicated that they needed help. The instructor was able to look for their questions from the last two open-ended questions and answer their questions on the following days.

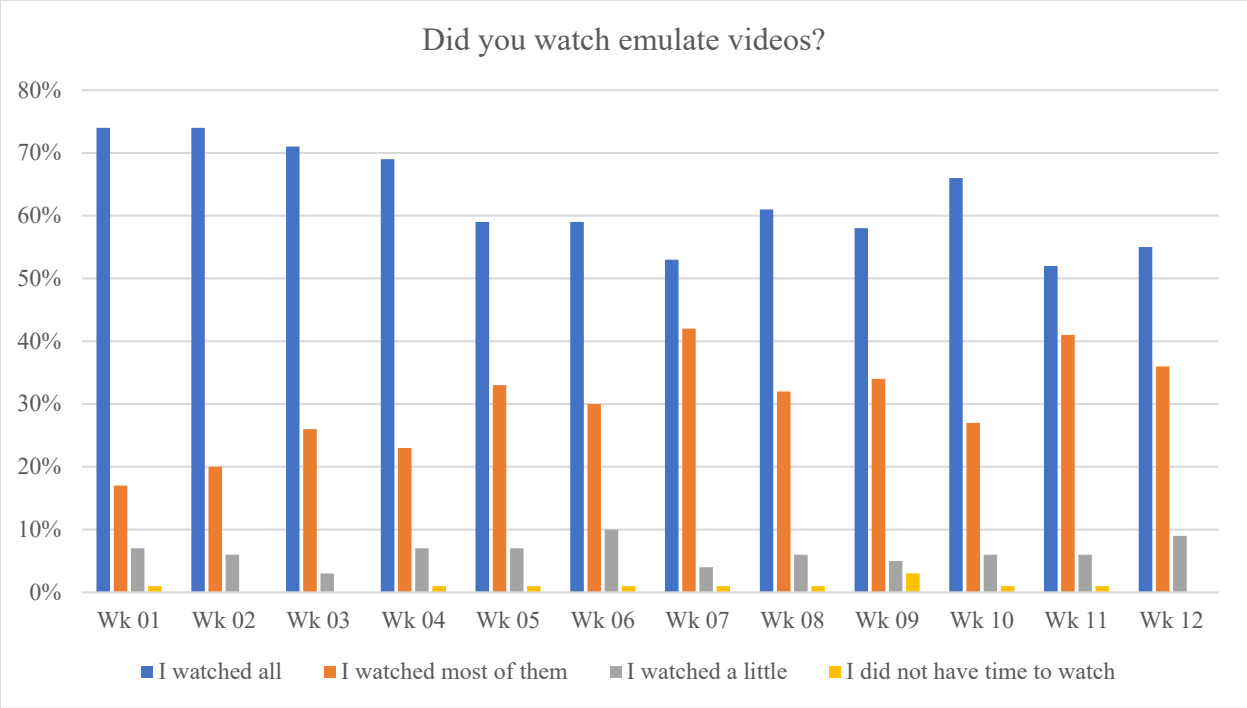


Figure 4. *Students' response to Q3 "Did you watch emulate videos?"*

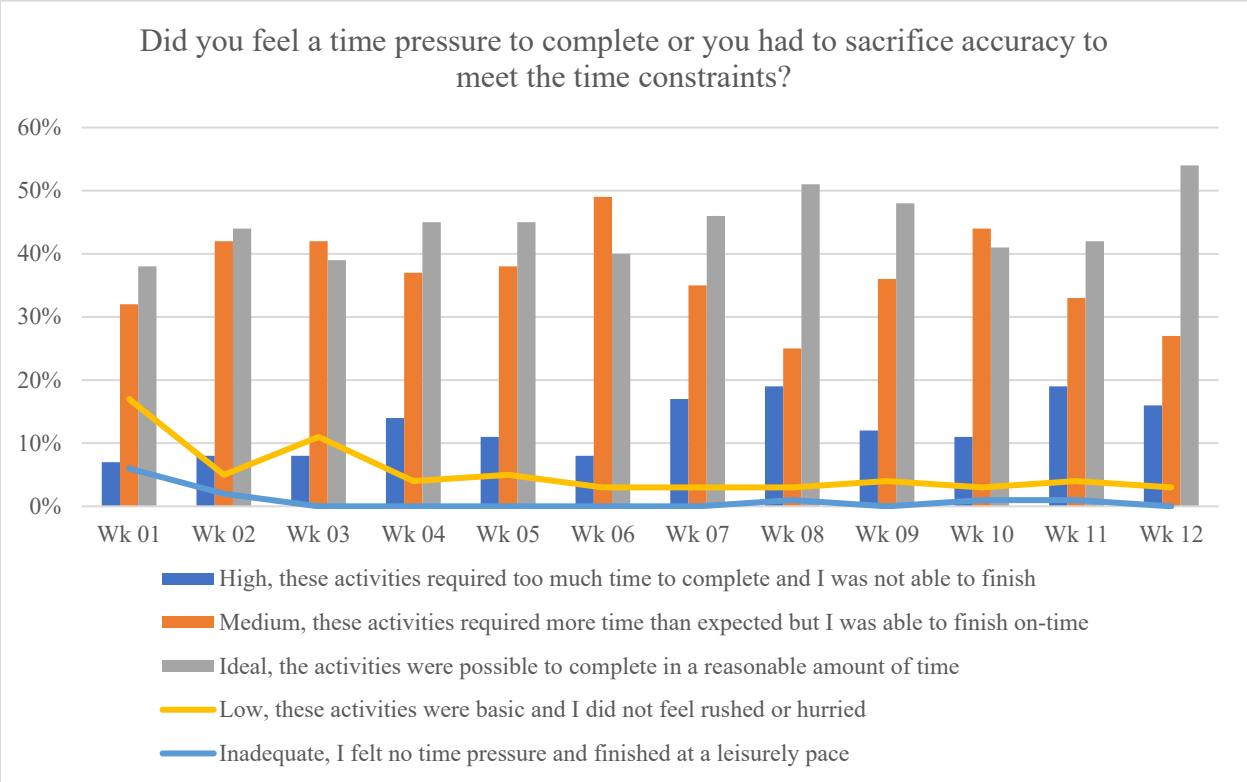


Figure 5. *Students' response to Q4 "Did you feel a time pressure to complete or you had to sacrifice accuracy to meet the time constraints?"*

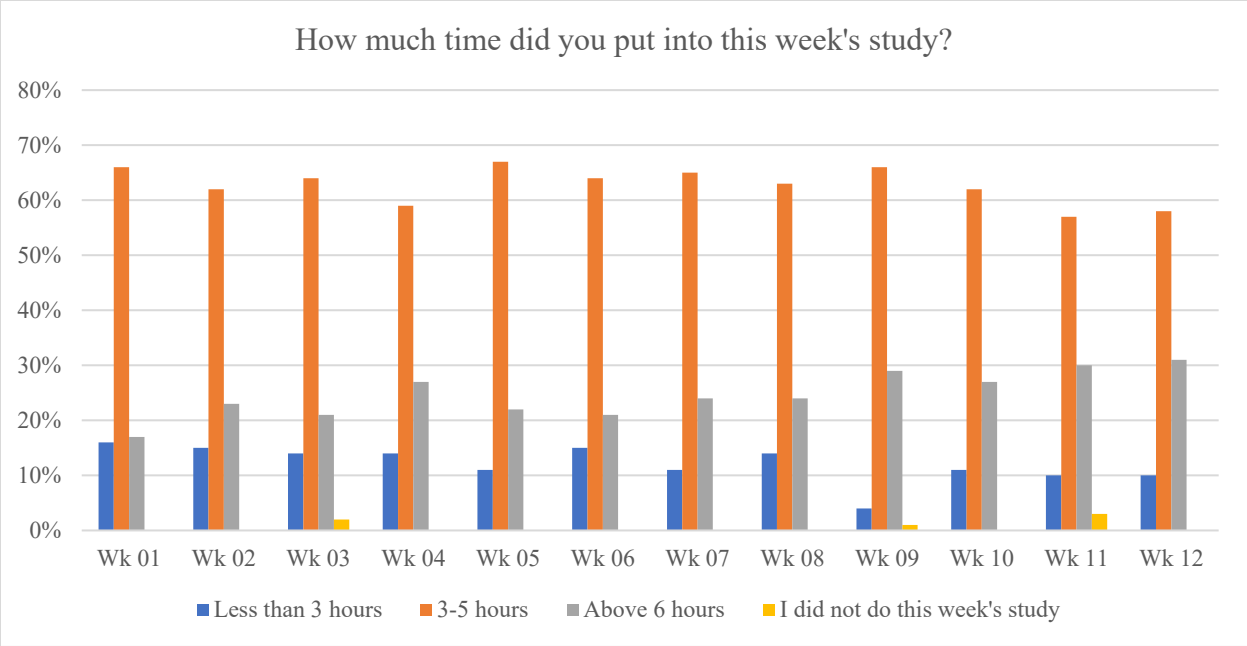


Figure 6. *Students' response to Q5 " How much time did you put into this week's study?"*

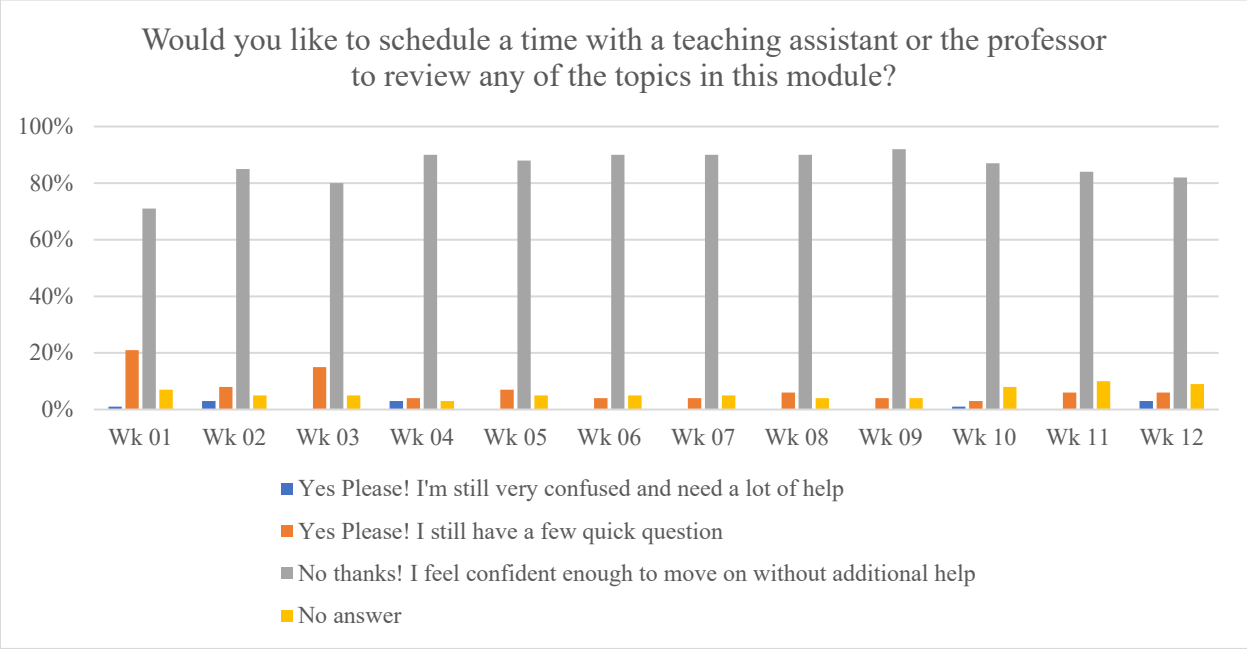


Figure 7. *Students' response to Q6 "Would you like to schedule a time with a teaching assistant or the professor to review any of the topics in this module?"*

A text mining tool, monkeylearning was used to analyze students' responses to two open-ended reflection survey questions [11]–[14]. The software can extract sentiment polarities based on Negative, Neutral and Positive sentiments extracted from the collected sentences with an affiliation score between -1 and 1. The past studies showed good agreement between the automatic sentiment analysis and the assessment of human reviewers [12], [15]. Students'

comments collected from two open-ended questions were manually updated to the website to record their relative output as shown in Figure 8.

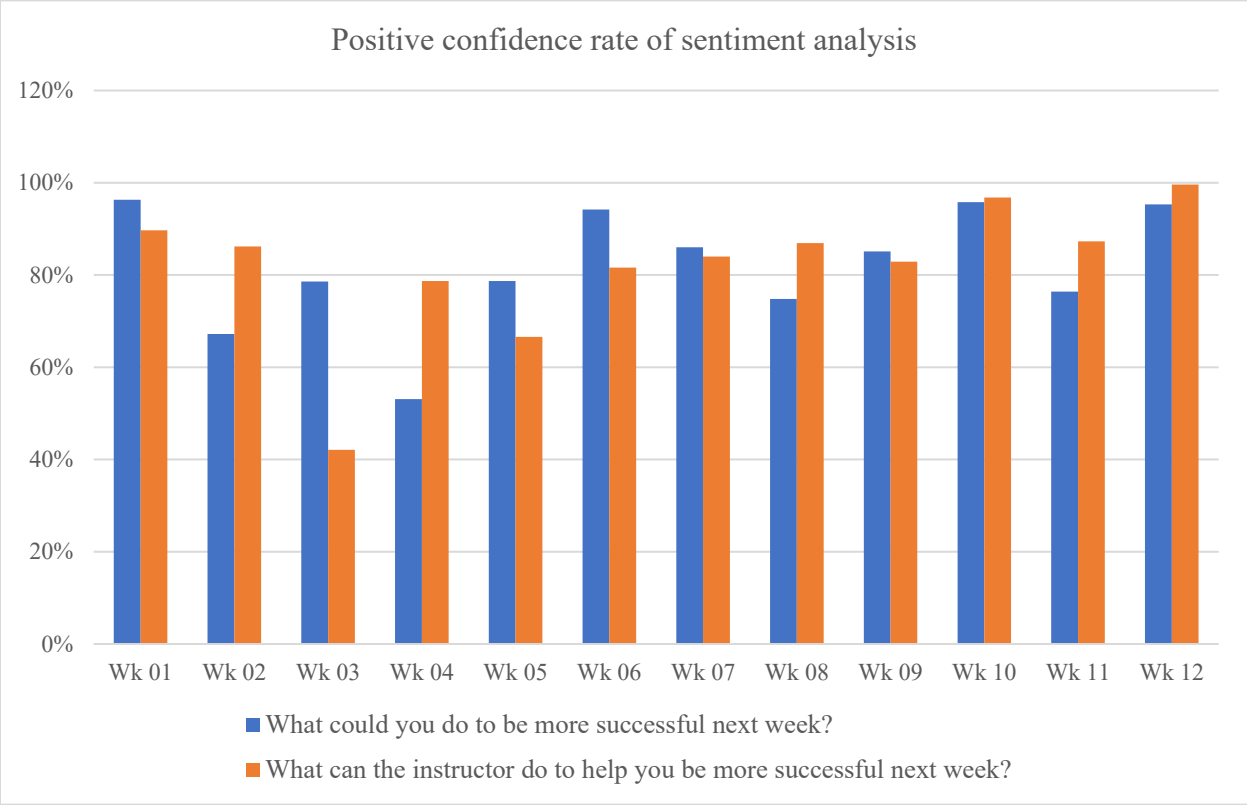


Figure 8. *Analysis of students' responses to two open-ended reflection survey questions by using the sentiment analyzer*

Table 2, Table 3, and Table 4 show selected positive, negative, and neutral student comments collected after week 1, week 6, and week12 regarding the question, "What could you do to be more successful next week?". Concerning SRL, many students' comments centered around recognition for time management, personal workflow responsibilities, and importance of practice to understanding of concepts. Students acknowledged that they had to focus on individual goal setting, behaviors, and motivations. The instructor could use students' comments to remind the upcoming assignments or study strategies shared by students.

Table 2"What could you do to be more successful next week?" – Positive Examples

Wk	Explanations
1	"I feel that I was able to complete the work and understand the material pretty well this week. It was not too challenging but I definitely had to put some brainpower into wrapping my head around the concepts. I think that I could start working ahead if I get extra time. This week, I completed the work on time and that was it, but next week I plan to work ahead if the opportunity arises"
6	"I felt good with the methods that I took this week"
12	"I can finish strong and create an accurate plan for my final few weeks of assignments."

Table 3"What could you do to be more successful next week?" – Negative Examples

Wk	Explanations
1	"This week, I fell behind a little and let the assignments pile on, which wasn't a good idea. However, I need to keep working ahead and finish my tasks on time, so I don't stress completing them."
6	"Actually do the stuff... my mom came to visit so I was distracted and didn't really do anything"
12	"Manage my time better"

Table 4"What could you do to be more successful next week?" – Neutral Examples

Wk	Explanations
1	"Do all of the homework assignments ahead of time in order to not worry about time constraints."
6	"Get ahead on homework and not procrastinate it."
12	"Working on my final project is a big things, I really need to focus on that over break."

Table 5, Table 6, and Table 7 show typical positive, negative and neutral student comments collected after week 1, week 6, and week 12 regarding the question, "What could your instructor do to help you be more successful next week?". Many students' comments centered around video instruction online, effectiveness of the classroom activities, and suggestions on classroom management. For example, instructor turned down the classroom lights after week 1 to clarify screen. The instructor redesigned some videos and developed more videos following student's comments. The instructor started to wear a portable voice amplifier in the classroom to enhance the volume of her voice. Because of the pandemic, students had to wear masks and keep social distancing, which negatively effected students' social anxiety and ability to effectively collaborate on assignments, however students communicating what worked and what did not work in terms of their learning was helpful for instructor's JiTT modifications. When the instructor read the constructive comments left in the weekly reflection survey each time, the instructor understood their needs, was motivated to adjust the course materials and improve student's learning experience immediately.

The weekly qualitative comments to the questions provided the instructor some unique insight into the student's thinking as they moved through the semester. This perspective was helpful in challenging the students to self-regulate their learning which included monitoring their goal setting and in and out-of-class behaviors that related to the course content. Nilson [16] suggests that instructor's "consciously establish a positive atmosphere of emotional safety, encouragement, trust and support" (p. 79) which this process seemed to encourage. Students openly and honestly shared their own internal difficulties as well as identifying specific actionable ways the instructor could assist them in their learning. The ability to map the curriculum to the student responses also afforded the instructor an objective view of the student experience providing the instructor opportunities to adjust the timing of content, resources, and due dates without diminishing the challenges of the course.

Table 5 "What could your instructor do to help you be more successful next week?" – Positive Examples

Wk	Explanations
1	"Dr. XX is perfect, she is clear about her expectations and is very helpful with answering questions."
6	"Dr. XX can continue making in depth emulate videos as they have more detailed instructions and are really helpful when following along"
12	"Dr. XX can continue to provide great instruction, her flexibility in the classroom is extremely helpful to me as a student. Instruction is always excellent and I have learned a lot."

Table 6"What could your instructor do to help you be more successful next week?" – Negative Examples

Wk	Explanations
1	"I would appreciate it if we could turn the lights down in the classroom when you use the projector, as it is very faint and hard to see in the back of the classroom."
6	"Speak more clearly, difficult to understand her, it would be easier to hear her if she wasn't wearing a mask."
12	"Maybe redo some of the videos because I would love to do some more especially the gamification ones but the older videos with music are extremely difficult to follow."

Table 7"What could your instructor do to help you be more successful next week?" – Neutral Examples

Wk	Explanations
1	"Receiving a copy of the class notes would be highly beneficial to me. That way, I can look at them as opposed to having to replay a recording."
6	"Do the same as always."
12	"Keep doing the class activities in class and post more videos."

Conclusion

This paper described weekly reflection surveys that were conducted in a face-to-face engineering graphics course in fall 2021. Multiple choice, and open-ended questions were available to students on Friday night and closed by Sunday midnight. Results were shared with students on the first day of the following week for understanding their SRL experience and JiTT modifications. From weekly reflection survey results, the instructor had a better understanding of the difficulty level of weekly course materials, if students watched given videos prepared for class, if the workload was at the appropriate level, how much time they spent on the weekly study, and if they needed help from teaching assistants or the professor. The results indicated that students often took ownership of their learning, or lack thereof, and saw the benefit of the flipped design. The faculty member could be timelier and more responsive with adjusting course materials based on student's needs. The weekly reflection survey built a mutual constructive communication between the students and the instructor accordingly. Positive responses were received, and students appreciated the timely feedback.

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