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Industrial Engineering Students' Perceptions of Flipped Classroom Experience

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Abstract

One of the most pressing issues in today's engineering education is whether we need/need-not to change from conventional engineering education and explore more creative and innovative ways to educate engineers to be ready for today's dynamic and disruptive industry. Research indicates that employers are now seeking engineers with soft skills such as critical thinking, problem-solving, lifelong learning, and others in addition to their technical skills. Thus, one needs to ask the question, do we equip and prepare our students with the right soft skills, in addition to the technical skills, using conventional engineering education? Are there any other educational approach that could help in developing the student soft skills? To address these questions, we studied the implementation of the flipped classroom methodology in two of the upper-division Industrial Engineering courses. We explored, via a survey, the students' learning and perspective in two flipped classrooms from the lens of the reported advantages and advantages categories in the literature. The results of the survey indicated that the flipped classroom model improved the students' critical thinking skills, promote creativity, helped them focus on problem-solving, improved their ICT skills, and improved their learning performance. On the other hand, the top disadvantages based on the students' perspective included the not preferred method, time-consuming, unfair method, and resistance to change.

Keywords: Flipped classroom, Engineering, Indonesia, Transnational Education

1. Introduction

Engineering education has been established for decades and still continue in the same fashion and classroom settings until today (Aamer et al., 2017; Mason et al., 2013). One could claim, if conventional engineering education has worked successfully since the past, why do we need to change the way we teach our engineering students? One of the most pressing issues in today's engineering education is whether we need/need not change from conventional engineering education and explore more creative and innovative ways to educate engineers to be ready for today's dynamic and disruptive industry. Research indicates that employers are now seeking engineers with soft skills such as critical thinking, problem-solving, lifelong learning, and others in addition to their technical skills, (Gerwel Proches et al., 2018; Wnek and Williamson, 2010). Thus, one needs to ask the question, do we equip and prepare our students with the right soft skills, in addition to the technical skills, using conventional engineering education? Are there any other educational approach that could help in developing the student soft skills?

One of the recent emerging and popular instructional method in engineering education is the flipped classroom approach (Al-Hammoud, 2017; Castedo et al., 2019). The flipped classroom model is defined as the method of inverting the activities outside the classroom to be conducted inside and vice versa. This means that the activities the

students conduct outside the classroom such as homework and assignments would be conducted in class, and others activities that normally are conducted inside the classroom such as lectures by professors would be recorded and conducted outside the classroom (Akçayır and Akçayır, 2018; Bergmann and Sams, 2012; Sohrabi and Iraj, 2016). Like any other methods, the flipped classroom model brings with it a host of advantages and disadvantages. One of the most reported advantages of the flipped classroom is the improvement of student performance, and the most reported disadvantage is the time students and professors spend outside the classroom to prepare videos and other instructional activities. One of the most recent literature reviews was conducted by (Akçayır and Akçayır, 2018) where the authors reviewed a total of 71 articles and tabulated the most reported advantages and disadvantages. The highest ranked advantages reported by the authors included improving learning performance, flexible learning, more efficient class time, positive feedback from students, and more interaction with students. However, the authors reported a list of disadvantages in the literature where the highest ranked included limited student preparation before class, time-consuming for students, time-consuming for lecturers, issues with the quality of recorded videos.

Other research in the literature studied the impact of flipped classrooms on student learning (Awidi and Paynter, 2019; Zainuddin, 2018). In addition, the application of flipped classroom in engineering education has been addressed in several of the reported studies in the literature (Al-Hammoud, 2017; Castedo et al., 2019; Karimi and Manteufel, 2019; Mason et al., 2013; Shen et al., 2019; Wagner, 2019). Mason et al. (2013) conducted a quasi-experiment in one of the Mechanical Engineering courses, Control Systems, and compared the conventional engineering education to the flipped classroom settings. The authors concluded that the instructor had more time to cover more materials in the flipped classroom, students performed similar or better, and students adapted quickly to the new flipped classroom environment. Papadopoulos et al. (2010) evaluated the implementation of a flipped classroom in one of the Statics courses at the University of Puerto Rico. The authors reported that students and lecturers had a positive impression of the flipped classroom and learned more, allocated more time, and developed better study habits. Castedo et al. (2019) applied the flipped classroom model to a heat and mass transfer course. The authors reported that the students performed better in terms of their grades in the flipped classroom, but students were reluctant to change from conventional teaching and learning, and students had higher attendance. Al-Hammoud (2017) addressed some of the flipped classroom issues such the lack of more examples in the videos, the face to face environment to ask questions and get answers right away, and the unavailability of enough assistant to help with in-class activities and addressed issues in large engineering classes. The author developed an interactive online quiz tailored to the students' needs to address some of the aforementioned issues. Shen et al. (2019) developed an "iterative framework" to help instructors develop the materials for the flipped classroom model with an objective to minimize the instructors' workload. The authors utilized one of the mechanical engineering courses to implement the framework. According to the study, there was an improvement in the students' learning performance outcome in the targeted course. Wagner (2019) implemented the flipped classroom model in a Computer Integrated Manufacturing course and concluded that the students had an "effective learning experience" because they were prepared ahead of attending the classes. However, Karimi and Manteufel (2019) implemented the flipped classroom model in one an introductory course of Thermodynamics, but the outcome of the experiment was not successful. The main reason behind the failure of the flipped classroom model in Karimi's experiment was the unwillingness of the students to prepare by reading the assigned materials and PowerPoints before coming to the classroom.

According to Castedo (2018), there is a lack of quantitative data on the students' performance in the flipped classrooms. In this paper, we report the results of using the flipped classroom methodology in two of the upper-division Industrial Engineering courses. We explored the students' learning and perspective in two flipped classrooms from the lens of the reported advantages and advantages categories in the literature.

2. Methodology

The flipped classroom model was applied to the third year Industrial Engineering students in two courses namely: Design of Experiments and Engineering Statistics. The two courses were offered during spring 2019 and consisted of two times meeting per week for one hour and twenty minutes each meeting. Each meeting was dedicated to in-class active learning of discussion, exercises, and solving homework problems in the presence of a co-instructor. The course was set-up where lectures were delivered via online videos, where lectures were pre-recorded by the instructor and uploaded on the Learning Management System. The instructor used "Desire to Learn" (D2L) as a medium to upload videos and post assignments, homework, reading assignments, and quizzes. In addition to watching the lectures outside the classroom, the students were asked to do the pre-class reading. To ensure that the students read and watch

the materials before coming to the classroom, the instructor created online multiple choice question "reading check" quizzes to be taken at the beginning of each week meeting, which usually took about 5 to 10 minutes. During class time, the co-instructor had a list of preplanned activities to do in class depending on the topics. The activities included solving problems, discussions, presentations, and questions and answers. For example, a problem would be shown on the screen and, or a textbook problem could be assigned in class for students to work on together. The co-instructor would give the students, divided into groups of four or five, a time limit to try solving the problems and discuss it among the groups. Once the time was up, students would be given the solution. A series of follow-up questions and answers were facilitated and discussed by the co-instructor to help explain and clarify the concepts. Solutions of the problems were then posted on D2L along with homework solutions.

To assess the students' perceptions of the flipped classroom model, the researchers developed a survey composed of two parts: The first part (The Quantitative part) was based on the 18 determinants (advantages and disadvantages) affecting the flipped classroom as reported in the literature by Akçayır and Akçayır (2018). Each determinant has an associated question to measure the student perspective. Each question was rated on a Likert scale of 1 to 5, where 1 means strongly disagree, and 5 meaning strongly agree (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). The second review of questions for each determinant was conducted to minimize the redundancy of questions and words that provided the same measurement. As a result of the review, we edited some of the questions to fit the context of the targeted flipped classroom executed. The second part of the survey (The Qualitative part) included the following three open-ended questions:

1) What was your favorite experience in the flipped courses during the spring of 2019?
2) What was your least favorite experience in the flipped courses during the spring of 2019?
3) Please provide any feedback you might have to improve the future flipped courses.

The purpose of the open-ended questions was to explore qualitatively the students' perceptions of the flipped courses. In addition, the open-ended questions were intended to give the students a chance to express their experience with the flipped classroom, either positively or negatively.

3. Data Analysis and Discussion

The survey was given to the students after the final exam. The survey was uploaded online and the students were asked to complete the survey in an attempt to understand their experience in the flipped classroom model. A total of 44 Industrial Engineering students completed the survey, which is 100% of the targeted population. Table 1 presents the total number of participates and GPA distribution. The average GPA of the forty-four students participating in the survey was 3.28 out of 4, with a minimum GPA of 2.75 and a maximum GPA of 3.86. Among the surveyed population, there were 15 male and 29 female students as indicated in Table 2. We added a question at the beginning of the survey just to understand whether the results of the survey is reflective of the students' capability and capacity by asking whether the students did their best effort in the class or not. The result in Table 3 shows a total of 86.4% who indicated that they did their best effort in the flipped classroom and they were not procrastinating, while 13.6 % did not do their best in the courses and they could have done better.

Table 1. Total number of participates and GPA distribution

	N	Minimum	Maximum	Mean	Std. Deviation
GPA	44	2.750	3.86	3.28	.257

Table 2. Gender distribution

	Frequency	Percentage
Male	15	34.1%
Female	29	65.9%
Total	44	100.0%

Table 3. Best effort spent in the flipped classroom

	Frequency	Percentage
Yes	38	86.4%
No	6	13.6%
Total	44	100.0%

Even though the survey questions were measured using a Likert scale of 1 to 5, for simplicity we combined 1 and 2 to account for the disagreement category, and 4 and 5 to account for the agreement category. This way we could measure whether the students agree or disagree, or natural on the list of questions we asked in the survey. Table 4 presents the results of the 18 determinants of flipped classroom model advantages and disadvantages.

Table 4. Survey results

		Disagree	**Neutral**	**Agree**
Advantages				
1	Improve learning performance	18%	27%	55%
2	Increase knowledge	32%	36%	32%
3	Improve ICT skills	5%	34%	61%
4	Feeling more confident	41%	36%	23%
5	Feeling motived	23%	30%	48%
6	Engaged	57%	20%	23%
7	Satisfied	32%	32%	36%
8	Improve critical thinking skills	17%	24%	59%
9	Promote creativity	27%	21%	52%
10	Focus on problem-solving	18%	16%	66%
11	Better retention	27%	30%	43%
Disadvantages				
12	Not preferred method	14%	41%	45%
13	Time-consuming	41%	18%	41%
14	Increased workload	45%	27%	27%
15	Unfair method	41%	18%	41%
16	Adoption problems	34%	32%	34%
17	Feeling anxious	48%	32%	20%
18	Resistance to change	25%	36%	39%

As already mentioned, in addition to the closed-ended questions, we formed three open-ended questions in order to get a better insight and understanding of the resulted percentages in the quantitative part of the survey.

For the first question “What was your favorite experience in the flipped courses during the spring of 2019?” we grouped the students’ answers into four different categories based on the context, as follows:

1) Learning at own pace:

Many students expressed their satisfaction that the course enabled them to work at their own pace and on their own time. Below are some of the comments that we received in this regard:

- "I can watch the lectures via videos many times, so when I feel sleepy I can pause the video and continue it later. Also, when I was sick, I did not lag behind and still get the same lessons as the other students since I had access to the videos even though I did not attend classes. This was very beneficial compared to the conventional method."
- "I could repeat the videos until I understand the topic. The videos given by the lecturer were really helpful."

2) Class discussion and group work:

Students found working with their peers very helpful and enjoyable as we can see in the following comments:

- "I enjoyed the group discussion."
- "The discussion among peers was the best part of the flipped class especially in term of solving problems."

3) Online materials and quizzes:

Multiple students agreed on the benefits of the quizzes and the course's materials organization:

- "The study materials were well organized and easy to access."
- "[The] class knowledge check enriched my understanding of the materials and got me more engaged in the class."

4) Problem-solving and lifelong learning:

Several positive feedbacks were given regarding the problem solving and lifelong learning, amongst the most significant ones we mention:

- "My favorite experience was trying to learn more, trying to understand what I hadn't understood, and then trying to solve it myself. If I hadn't found the answer to my questions, I chose to ask questions and discuss with friends."
- "We were trying to solve the problem by ourselves and if we do it really by ourselves, it will give us more understanding."

As for the second question "What was your least favorite experience in the flipped courses during the spring of 2019?" some of the answers to this question were also categorized based on the context:

1) Online videos:

For some students, watching online videos was dull and boring. The duration of the videos and the self-studying process were problematic:

- "I feel sleepy when I watch video lectures. I need to have higher self-discipline to read the book, watch the video lectures, do the homework, do the assignments, and do the project on time."
- "Video lectures sometimes do not clearly explain the topics and it was a little difficult when we actually had questions, but we couldn't ask the lecture directly."
- "For some videos, the duration was too long and sometimes made me feel sleepy."

2) Class and group discussion:

Some students lacked enthusiasm during the group discussion, for some others it was considered as a source of confusion;

- "The discussion in the class was not effective. Students sometimes assumed the wrong answers to be correct answers, which caused confusion after the class session."

- "Working with the same group in each session was a little bit boring."
- "Students were hesitant to voice their opinions which made the discussion boring and not interesting."

3) Struggle with lifelong learning:

For some students, lifelong learning was an issue because of the lack of information on how to solve that kind of problems:

- "How I struggled in solving the problem that I did not understand."
- "Lack of information."

4) Technical issues:

Among the most significant technical issues, the Wi-Fi was the most reported from the students.

- "The Wi-Fi connection was an issue."

5) Adoption of the new method:

Some students were uncomfortable because of the new learning approach, which didn't conform to the traditional approach:

- "It was so challenging to understand the course topics via video lectures."
- "Flipped courses were not really effective for me because as a learner, I still need a direct guide to understand the material even though there were videos from the lecturer. But we still need a direct teaching-learning in the class."

For the third question in which students were asked to give any additional feedback on the course in order to improve it, we received many helpful remarks to be taken into consideration. Here are some examples:

- The flipped courses will be better and more enjoyable if the lecturer dedicates one meeting for lecturing and one meeting for discussion with the group.
- Flipped Class was an interesting way to study since the lecturer gave us videos and this really helped us. However, in watching the videos, we sometimes did not understand some materials and we need a direct explanation. If only, in every class there will be a review and the students have put best effort, it will be more effective.
- Personally, I was "shocked" because flipped classes required more self-discipline compared to traditional classed, and I struggled to make the transition (forcing myself to watch the video before class, read the materials, etc.) in the middle of the semester. However, if I had another flipped class, I know now what I should be doing and I won't overestimate myself by procrastinating and learning the materials before class.
- To be honest, I did not like the class discussion. Mostly, my groupmate did not read or watch the video before attending the class. It is okay for me to explain to them, but, the challenging part was they did not understand the basics of the course. I found some of my friends did not know how to use +/- table in the Design of Experiment. When we did class discussion, they prefer to discuss another topic rather than discuss the class discussion. I think it is not effective and efficient learning method if the students do not support the method. When I did the final project with my friends, there was one person who did not contribute his work to this project.
- I am actually with flipped class however there needs to be an additional engagement of teaching from the lecturer.
- For the lecturer to spend around 15 to 30 minutes to teach and discuss the material in front of the class, then use the rest of the time for us to do the in-class activities.
- I wish the video duration could shorter so I don't get bored quickly.

Based on the results in Table 4 and the open-ended questions above, there are five high levels of agreements to the advantages of flipped classroom based on the students' perspective. The students believed that flipped classroom improve critical thinking skills, promote creativity, helped them focus on problem-solving, improved their ICT skills, and improve their learning performance. At the same time, the students did not feel confident nor engaged in the flipped classroom since the percentage is a low 23%. The remaining three determinants of feeling motivated, satisfied, and better retention received an average percentage of 36% to 48%. An aggregate percentage of the students'

agreement on the advantages is 47% which is not a high percentage of positive experience of the flipped classroom. If we compare our findings from this research to the highest ranked advantages reported in the literature, we can see a match with improving learning performance, but it is not that high. However, more interaction with students was not among the reported advantages in our study since the engagement factor scored a low agreement percentage of 23%. Other factors that reported in the literature such as flexible learning is evident in some of the open-ended questions reported by the students in terms of the convenience of watching videos at home and being able to slow down or speed up the videos. The positive feedback reported in the literature was not reflected in our survey results since the overall agreement of advantages was 47%, but some students expressed their positive feedback in the open-ended questions. One explanation could be due to the first exposure of students to the flipped classroom model and could be an adoption issue.

On the other hand, the top disadvantages based on the students' perspective included the not preferred method, time-consuming, unfair method, and resistance to change. The lowest percentage of the disadvantage is the feeling anxious followed by increased workload and adoption problems. The aggregate percentage of the students' agreement on the disadvantages is 36%. The parentage results matched with some of the most reported of disadvantages in the literature such as the limited student preparation before class, time-consuming for students, but no issues with the quality of recorded videos. However, some students expressed their concerns in the open-ended questions when they talked about the preparation time outside the classroom, but interestingly enough the students in our study did not find the workload time to be a major factor or a disadvantage of the flipped classroom model.

4. Conclusion

In response to employers' interest in seeking engineers with soft skills such as critical thinking, problem solving, lifelong learning, and others in addition to their technical skills, we explored the flipped classroom model to assess if it is an effective active learning model to equip and prepare students with the right soft and technical skills. A survey composed of 18 determinants/questions (advantages and disadvantages) affecting the flipped classroom, along with three open-ended questions, was given to a total of 44 third year Industrial Engineering students. The results of the survey indicated that the flipped classroom improved the students' critical thinking skills, promote creativity, helped them focus on problem-solving, improved their ICT skills, and improved their learning performance. The aggregate percentage of the students' agreement on the advantages is 47% which was not a high percentage of positive experience of the flipped classroom. On the contrary, the top disadvantages based on the students' perspective included the not preferred method, time-consuming, unfair method, and resistance to change. The aggregate percentage of the students' agreement on the disadvantages is 36%.

All in all, based on our survey and analysis, there was no conclusive evidence of the preference, or not, of using the flipped classroom model in higher level Industrial Engineering courses. The aggregate percentages of the students' agreement on the flipped classroom model advantages and disadvantages do not outweigh one side over the other. Therefore, a follow-up study in future semesters should be conducted to verify the results and collect more data, and perhaps employ more in-depth statistical analysis.

References

Aamer, A., Greene, B., Toney, C., 2017. An Empirical Study of Industrial Engineering Curriculum 8, 39–45.

Akçayır, G., Akçayır, M., 2018. The flipped classroom: A review of its advantages and challenges. Comput. Educ. 126, 334–345.

Al-Hammoud, 2017. Molding the Interactive Flipped Classroom Based on Students' Feedback. Presented at the 2017 ASEE Annual Conference & Exposition.

Awidi, I.T., Paynter, M., 2019. The impact of a flipped classroom approach on student learning experience. Comput. Educ. 128, 269–283.

Bergmann, J., Sams, A., 2012. Flip your classroom: reach every student in every class every day. International Society for Technology in Education, Eugene, Or.

Castedo, R., López, L.M., Chiquito, M., Navarro, J., Cabrera, J.D., Ortega, M.F., 2019. Flipped classroom—comparative case study in engineering higher education. Comput. Appl. Eng. Educ. 27, 206–216.

Gerwel Proches, C.N., Chelin, N., Rouvrais, S., 2018. Think first job! Preferences and expectations of engineering students in a French "Grande Ecole." Eur. J. Eng. Educ. 43, 309–325.
Karimi, A., Manteufel, R., 2019. An Experiment with Flipped Classroom Concept in a Thermodynamics Course. Presented at the 2018 ASEE Gulf-Southwest Section Annual Meeting.
Mason, G.S., Shuman, T.R., Cook, K.E., 2013. Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. IEEE Trans. Educ. 56, 430–435.
Shen, H., Warter-Perez, N., Dong, J., Li, N., 2019. Iterative Improvement in Flipped Classroom Teaching of Lower Division Engineering Courses. Presented at the 2019 Pacific Southwest Section Meeting.
Sohrabi, B., Iraj, H., 2016. Implementing Flipped Classroom Using Digital Media. Comput Hum Behav 60, 514–524. https://doi.org/10.1016/j.chb.2016.02.056
Wagner, N., 2019. Flipping a Computer-Integrated Manufacturing Course. Presented at the 2019 Pacific Southwest Section Meeting.
Wnek, G.E., Williamson, S., 2010. Engineering value propositions: Professional and personal needs, in: Holistic Engineering Education. Springer, pp. 137–144.
Zainuddin, Z., 2018. Students' learning performance and perceived motivation in gamified flipped-class instruction. Comput. Educ. 126, 75–88.

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