Flipped Classroom and Reflective Practice for Active Learning during Online Class: An Experience in Engineering Drawing Module

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Abstract. A flipped classroom is a pedagogical approach that reverses the traditional model of learning where students are provided with materials prior to class. Whereas reflective practice is an approach that encourages students to analyze their learning experiences and evaluate their progress in understanding course materials. The COVID-19 pandemic has challenged the traditional model of classroom instruction, leading to a shift in teaching and learning activities toward virtual/remote delivery methods. This study evaluates the flipped classroom approach and reflective practices in the Engineering Drawing module. The participants consisted of first-year engineering students (n=76). The result of the study shows positive outcomes from using flipped learning and reflective practice. Students felt that the module provided them with an engaging and challenging learning experience, enhancing not only their technical skills but also their overall learning capabilities.

Keywords: Flipped classroom; reflective practice; active learning.

INTRODUCTION:

The traditional model of classroom instruction has recently been challenged by the COVID-19 pandemic, creating a shift in teaching and learning activities toward virtual/remote delivery methods. The shifting from face-to-face learning may result in technological challenges such as difficulty accessing the classroom (McBrien et al., 2009) and bandwidth limitation (Patterson et al., 2012). In addition to that, remote teaching may negatively affect student motivation (Raes et al., 2020), teacher-student interactions (Blaine, 2019), and sense of community (Rovai & Wighting, 2005). This has led educators to explore alternative teaching methods that can effectively engage students and promote active learning.

While teaching and learning activities in some subject areas have been successfully transitioned to a digital learning environment (Tang et al., 2020), since some subjects that rely on physical assets cannot purely transition into virtual classrooms. Learners need to interact with the learning tools to develop the skills needed to meet the learning outcomes and demonstrate the required competence. Therefore, virtual teaching and learning are especially challenging for courses that require
the use of laboratory equipment, such as practical computer engineering-based subjects.

One such approach that has gained popularity in recent years is the flipped classroom, which reverses the traditional learning model by providing students with pre-recorded lectures, readings, and other resources before class, allowing for more interactive and personalized in-class activities. In a flipped classroom, students can access course materials before class, giving them the opportunity to review and study at their own pace. This approach helps students develop a deeper understanding of the subject matter and promotes active learning through collaborative activities, discussions, and problem-solving exercises in the classroom. Such an approach has been found to be effective in improving student engagement and academic performance in traditional classroom settings (Awidi & Paynter, 2019; Goedhart et al., 2019; Jdaitawi, 2019).

Reflective practice is another active learning technique that has been shown to be effective in promoting deeper learning and self-awareness. It involves asking students to analyze their learning experiences and evaluate their own progress and understanding of the course material. This approach can help students develop critical thinking skills and improve their overall academic performance (Bruno & Dell’Aversana, 2018; Griggs et al., 2018; Priddis & Rogers, 2018).

Since COVID-19, the use of a flipped classroom approach has attracted much attention from researchers (Lo et al., 2021; Salvador, 2021). However, studies concerning flipped classrooms for engineering modules are still limited. Further, the implementation of reflective practice in engineering modules, especially for online classes has not been extensively studied. Thus, this study aims to fill the gap and extend the literature on flipped learning and reflective practice for active learning during online classes.

**METHOD**

The participants of this study were first-year Industrial engineering students at Universitas Gadjah Mada (Indonesia) during the 2021 – 2022 academic year. Due to COVID-19 restrictions, face-to-face sessions have ceased since mid-2020, after which all on-campus activities moved to online platforms. Since Engineering Drawing is a core module for the Industrial Engineering discipline and taught in the first semester of the year, the module was fully taught through an online platform for the first year of the 2021-2022 academic year. The participants of this study, as shown in Figure 1, were 76 students out of 89 students, 38 of which were female, and the rest were male.

![Figure 1. Survey responses of first-year Industrial Engineering students in the 2021-2022 academic year.](image)

A survey was used in this study to measure students’ interest and effectiveness of teaching approaches used in the module. Since this module is based on team teaching of 3 educators, the proposed approach of flipped classroom and reflection were only conducted for the last 4 weeks of the module (Week 12 – Week 15). Each week, students were asked to fill out an online survey to monitor their learning progress. The survey each week consisted of the same questions. First, students were asked if they had watched the pre-uploaded videos prior to the synchronous sessions. They were also asked to rate whether of the week’s course materials and workload were appropriate for the course level, to rate whether the course assignments facilitated their learning and helped them understand the course materials, and to rate the quality and effectiveness of the week’s lecture. Students were also asked to reflect on their learning for that week and give any further feedback if they wished to do so.

**RESULTS AND DISCUSSION**

**Result**

**Module Design.** The Engineering Drawing Module for the first year of the 2021-2022 academic year was conducted online for the whole 14 weeks. The remaining four weeks of the 14 weeks were conducted using a flipped
teaching and reflection approach. Each week, students attended synchronous sessions at the scheduled date and time. Students were given pre-uploaded videos (multiple videos with a short duration of no more than 15 minutes) covering the week’s materials and assignments prior to the synchronous sessions. The synchronous sessions were utilized to foster deeper discussion on students’ understanding of the topic and evaluate the assignment they have done previously. The topic of each week is as follows: W12 on improving 3D modeling with CAD software Fusion 360. Here, the students were given videos on the difference between bodies and components in Fusion 360 and different types of modeling, i.e., parametric, and freeform modeling. In W13, students learned to collaborate to do group work using Fusion 360. The following week, they learned how to assemble components in Fusion 360. Lastly, in W15, the students were taught how to create an output for their design such as creating a rendered image and animation videos. For each week, they were given assignments based on the material for that week.

**Survey Result.** As seen in Table 1, the result shows that the majority of students (>80%) watched the pre-uploaded videos prior to the synchronous sessions. Less than 20% of them watched only some videos or watched after the synchronous session. There were no students who did not watch the video at all. The result also shows that students had positive experiences with their course materials, assignments, and lectures. In terms of the appropriateness of the course materials and workloads, as shown in Figure 2, the average rating for week 12 was 4.431, with a standard deviation of 0.596. This improved slightly in week 13, with an average rating of 4.527 and a standard deviation of 0.576. The highest rating was for week 14, with an average of 4.620 and a standard deviation of 0.517. Week 15 saw a further increase, with an average rating of 4.645 and a standard deviation of 0.534. Overall, it seems that students felt that the course materials and workloads were appropriate for the course level. The results were also positive for the course assignments as seen in Figure 3. The average rating for week 12 was 4.431, with a standard deviation of 0.652. This increased in week 13, with an average rating of 4.554 and a standard deviation of 0.577. The highest rating was for week 14, with an average of 4.634 and a standard deviation of 0.514. Week 15 again saw an improvement, with an average rating of 4.671 and a standard deviation of 0.500. This suggests that students felt that the course assignments were helping them to understand the course materials. Finally, the quality and effectiveness of the lecture were also rated highly (Figure 4). The average rating for week 12 was 4.414, with a standard deviation of 0.593. This improved slightly in week 13, with an average rating of 4.459 and a standard deviation of 0.578. The highest rating was for week 124, with an average of 4.549 and a standard deviation of 0.555. Week 15 saw a significant improvement, with an average rating of 4.658 and a standard deviation of 0.505. This suggests that students felt that the lectures were effective in helping them to learn and understand the course materials.
Reflections. Based on the students’ reflections in W12, it can be inferred that most of them found freeform modeling challenging. They struggled with selecting the right parameters for their drawings and making the shapes look smooth and artistic. However, they managed to overcome the difficulties by seeking help from various sources such as YouTube, Quora, and friends. Some students also mentioned that they found it hard to differentiate between bodies and components and were confused about which dimensions to parameterize. Nevertheless, they found the material interesting and engaging, especially the use of freeform modeling to create more artistic and intricate objects. The students seem to be motivated to keep practicing and improving their skills. In W13, they learned how to use Fusion 360 for design and collaboration, as well as the difficulties they encountered in the process. Many students mentioned the importance of practice and learning from other sources, such as video tutorials and discussions with friends. Students also learned how to work as a team, including how to create a project, share it with others, and manage team members' roles. Some students faced difficulties in understanding the purpose of different project types, but over time, they were able to overcome these difficulties. Reflections in W14 show that the students have learned about various concepts related to engineering, such as assembly, joints, screw nuts, and ball joints. Most of the students found the material difficult at first but managed to understand it with the help of the lecture videos provided. However, some students still found certain parts confusing and had to rely on external sources such as internet tutorials to understand them better. The students also mentioned the importance of practice in mastering the skills taught. Finally, reflections in W15 show that they have been learning various technical skills related to engineering. Specifically, they have been learning how to create 2D drawings from 3D objects, create technical sketches, render 3D objects, make exploded-view animations, and assemble components. Many students have reported difficulty in transforming 3D objects to 2D drawings, making joints and motions, and managing the many details involved in the process. However, they seem to have found solutions to these difficulties, such as practicing more, watching videos, or discussing with their peers. Some students have also mentioned group projects and their collaboration with other students. Overall, the students’ reflections demonstrate their engagement in the course and their eagerness to improve their skills in engineering.

Discussion

The flipped learning approach for the Engineering Drawing module in the 2021-2022 academic year showed positive results based on the survey conducted among students. The majority of students watched the pre-uploaded videos prior to the synchronous sessions, which indicates that they were motivated to engage with the material before the discussion sessions. The use of short videos with a duration of no more than 15 minutes was effective in conveying the week’s materials and assignments. The survey results show that the appropriateness of the course materials and workload, as well as the course assignments, were rated positively by the students. The ratings for each week's materials, assignments, and lectures increased consistently over the four weeks of flipped learning, indicating that the approach was effective in helping students to understand and learn the course materials. The flipped learning approach allowed students to collaborate and engage in deeper discussions during synchronous sessions, which helped to foster their understanding of the topics.

The approach also gave students the flexibility to learn at their own pace and access the material at any time. The use of Fusion 360 software to teach 3D modeling and design was effective, as students were able to create output
for their designs such as rendered images and animation videos.

The engineering drawing module has been a challenging but engaging experience for the students. From their reflections, it is clear that the students faced difficulties in different aspects of the course, including freeform modeling, collaboration, and technical skills. However, their eagerness to learn and improve their skills is evident in the way they sought help from various sources and practiced regularly.

One of the key takeaways from the students' reflections is the importance of practice in mastering the skills taught in the module. Many students have mentioned the need to practice more to improve their freeform modeling, technical drawing, and collaboration skills. They have also found that watching tutorial videos, discussing with peers, and seeking help from online sources like Quora and YouTube have been effective ways to overcome difficulties.

Another important aspect highlighted in the students' reflections is the collaborative nature of the course. They have learned how to work in teams, share projects, and manage team members' roles effectively. While some students initially found it difficult to understand the purpose of different project types, they were able to overcome these challenges through practice and understanding.

### Table 1. Students’ responses on whether they have watched the pre-uploaded materials before the synchronous sessions.

<table>
<thead>
<tr>
<th></th>
<th>W12</th>
<th>W13</th>
<th>W14</th>
<th>W15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, all of them</td>
<td>88%</td>
<td>82%</td>
<td>84%</td>
<td>92%</td>
</tr>
<tr>
<td>Only some videos</td>
<td>9%</td>
<td>11%</td>
<td>10%</td>
<td>4%</td>
</tr>
<tr>
<td>No, but I watched after the synchronous sessions</td>
<td>3%</td>
<td>7%</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>No, I don't watch the videos</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

### CONCLUSIONS AND SUGGESTIONS

Active learning utilizing flipped classroom and reflection methods have been evaluated for an Engineering Drawing Module. Based on the survey conducted, the flipped learning approach for the Engineering Drawing module in the 2021-2022 academic year showed positive results. The approach allowed students to engage with the material before synchronous sessions, collaborate, and engage in deeper discussions. The use of short videos, appropriate course materials and workload, and effective lectures were factors that contributed to the success of the approach. The use of Fusion 360 software was also an effective tool for teaching 3D modeling and design. Further, the module has provided the students with an engaging and challenging learning experience. The students' reflections demonstrate their active engagement in the course and their eagerness to improve their skills in engineering. The module has not only taught them technical skills but has also helped them develop collaboration skills and the importance of practice in mastering skills.

### REFERENCES


