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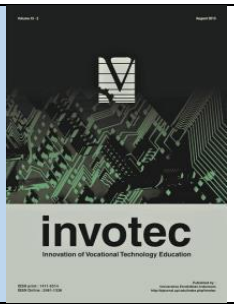

# Electrical Engineering Students' Perception in a Flipped Classroom Pedagogy

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**ABSTRACT**

Tertiary learning institutions are under immense pressure to evolve within the realms of the fourth industrial revolution. The flipped classroom model externalizes in-class traditional learning and internalizes outside class activities in an attempt to move students from lower order cognitive skills to higher order cognitive skills. Training institutions are anticipated to minimize learning costs in the face of increasing enrollments. The broad aim of the study was to establish whether a flipped pedagogy would enhance performance and improve students' perceptions over the conventional classroom pedagogy. To examine the impact of a flipped learning model, an experiment was conducted on two classes studying fundamentals of electrical engineering course. The participants were 64 pure electrical engineering students sampled from a population of 156 first year electrical engineering students. 32 students were assigned to the experimental group which was exposed to both the flipped classroom model and traditional classroom model. The remaining 32 were solely exposed to the traditional classroom pedagogy. Evaluation survey was administered on both the flipped and traditional cohort. Although students revealed positive perceptions of the flipped classroom model, empirically, there was no significant differences in academic achievements of students taught using either instructional approach. 83.87% of the flipped students were better off with a conflated instructional pedagogy as canvassed through the questionnaire survey. Educational practitioners ought to move up with the fourth industrial revolution demands by adopting a blended instructional approach.

## 1. Introduction

The "flipped classroom" instructional model is credited to Sams and Bergmann (2013). The model was developed as a means to save time and ensure that absent students catch up after accessing pre-recorded instructional materials. The flipped/ inverted classroom concept is partially

credited to Salman Khan who founded the Khan Academy, a free online system that covers numerous topics and subjects (Roach, 2014). The traditional teacher-centered methods of learning are fast being substituted because of some limitations among them the promotion of rote memorization and side tracking at the expense of attaining higher order cognitive skills (Kurbanoğlu & Akkoyunlu, 2016). The obsoleteness of the traditional lecture transmissive model is paving way for the flipped classroom model packaged with active in-class tasks and pre-/post-class work (Abeysekera & Dawson, 2015). In this instructional pedagogy, the teacher acts as a guide or facilitator (Lopes & Soares, 2018). Flipped classroom is sometimes known as inverted classroom or peer instruction. In a flipped classroom, subject materials are learnt in the form of videos, podcasts, online tutorials, voice over PowerPoint slides or audiovisuals in advance of class attendance (Gulley & Jackson, 2016). The class time is reserved for active learning which enables learners to attain higher-order cognitive skills of the Bloom's taxonomy (Kurbanoğlu & Akkoyunlu, 2016). In a flipped learning set up, videos, audiovisuals or podcasts are issued in advance of class attendanceravi. Content is usually accessed outside the classroom through various e-platforms (Gulley & Jackson, 2016).

### 1.1 Students' preference and satisfaction

Most students were impressed by the flipped classroom instructional pedagogy (Ravishankar, Epps, & Ambikairajah, 2018) although limited number of students maintained their passive learning habits (Chen, Wang, & Chen, 2014). In an action research involving two lecturers and varying number of students at each and every case (2 or 3 or 4), flipped students enjoyed the active learning component of the flipped classroom model (Pappalepore & Farrell, 2017). In a questionnaire survey by Hao (2016) with 84 undergraduates studying Information Technology and Education (79.1% females and 20.9% males), 60% of the students reported that they preferred the flipped instructional pedagogy than the traditional lecture method.

In most questionnaire surveys, students were seen to prefer a flipped classroom model over the lecture-based model. For example, 92% of group 1 and 100% of group 2 students liked flipped learning (Sohrabi & Iraj, 2016), 95% were satisfied and 37% suggested that they would wish if flipped learning could be extended to all topics (Ravishankar et al., 2018), and 90% of engineering students endorsed the flipped model (Kakosimos, 2015; Munir et al., 2018). Some unique students were also found to prefer some elements of the flipped classroom model. A questionnaire survey involving two courses (Professional Skills in Dietetics, n = 148 and Community Nutrition, n = 48) revealed that 70%, 64% and 70% of the students liked video lectures, active learning and student-teacher interaction respectively (Gilboy, Heinerichs, & Pazzaglia, 2015). A descriptive and exploratory study involving nursing students studying Public Health Science and Population Health flipped courses (3$^{rd}$ year, n = 64 and 2$^{nd}$ year, n = 93) showed no significant differences in course evaluation with regards to flipped learning or traditional learning (Liebert et al., 2016).

Additionally, intriguing findings were found some studies. For instance, in a mixed method, crossover repeated measures study, nursing students learnt pharmacology were more satisfied by the traditional classroom approach than the flipped classroom approach (El-Banna, Whitlow, & McNelis, 2017). In addition, a small contingent (10-15%) of flipped students were reported to prefer the traditional lecture-based method following 4 weeks and 6 weeks of being exposed to traditional lecture method and flipped classroom method respectively (Street et al., 2015). Flipped learning did not completely satisfy all learners in some instances. Quite a number of studies have shown flipped students resisting and hesitant when exposed to flipped learning for the first time although some students gradually adjusted to the new learning set up (Elliott, 2015).

### 1.2 Students' performance

In some studies, flipped students slightly performed better than traditionally taught students (Ravishankar et al., 2018). For instance, flipped engineering students studying Dynamics of structures (Flipped class: n = 21, Traditional class: n = 24) obtained slightly higher test/quiz scores than students in traditional classes (Baytiyeh & Naja, 2017). A limited number of studies concluded that flipped students were significantly better in terms of grades than traditional classroom students (Olitsky & Cosgrove, 2016). In a different study, the adoption of a flipped classroom model also improved learning grades for both gifted and less gifted students (Lombardini, Lakkala, & Muukkonen, 2018).

Conversely, other studies revealed opposing findings. For example, in a comparative study involving Team-Based Learning and flipped learning approaches, faculty referential exam results and students results confirmed Team-Based Learning approach as a better model than the flipped classroom model (Nishigawa et al., 2017). In addition, Taglieri et al. (2017) discovered that in terms of knowledge retention, traditionally taught students were better than the Flipped Team-based students ($62.9 \pm 19.3$ vs $54.9 \pm 15.53$, $p = 0.001$). However, most studies found insignificant effect of a flipped classroom pedagogy on students' achievement. For example, flipped classroom model was used to lecture 793 engineering students studying computer programming course. Students from various engineering disciplines constituted the class. As a result, there was no significant evidence to conclude that flipped learning improves discipline grades (Nikolic, Ros, & Hastie, 2018).

The adoption of the flipped classroom pedagogy has been very limited in the vocational and technology area. Furthermore, there are very few studies which revealed sufficient evidence on the effectiveness of the flipped classroom model in increasing students' grades over the traditional face to face pedagogy (Gilboy et al., 2015; Tang et al., 2017; Thai, De Wever, & Valcke, 2017). For instance in a pro-flipped classroom study, learning achievement was found to be greater in three consecutive years (Lopes & Soares, 2018). However, most positive findings about a flipped classroom model were centered on participants perceptions. In addition, a limited number of researchers used the pretest/posttest design in establishing the impact of the flipped classroom

(Rivera, 2015).The broad aim of the research was to establish whether a flipped classroom has incremental benefits over the traditional lecture-based method.

## 2. Methods

### 2.1 Research design

This study was of the mixed method design. The quantitative part was of the crossover repeated measure design (Cohort A) and the non-equivalent control group design was adopted for both cohorts A and B. The crossover repeated measure was chosen because participants served as their own control and this reduced influences of unexpected covariates (El-Banna et al., 2017). The qualitative method addressed students' perceptions with regards to the instructional pedagogy and the quantitative part of the mixed method focused on the student achievement (in terms of grades) after the adoption of flipped classroom model. The study was conducted in 8 weeks. The twin instructional pedagogies were successively applied to the principles of electrical engineering course offered under the Electrical engineering first degree at Indonesia University of Education. The course is offered in the first semester of each and every academic year to all first-year students taking a Bachelor's degree in Electrical Engineering.

### 2.2 Participants, population and sample

The participants were electrical engineering students, course lecturers and the researcher. The population was composed of 156 enrolled students at Indonesia University of Education. 64 students participated in the study. These were divided into two homogeneous cohorts. Cohort A and B were equally composed of 32 students. Both classes were taught by one lecturer with vast experience. Additionally, there was an assistant lecturer. 11 (17%) of the participants were females while 53 (83%) were males. The mean age of the participants was 18 years. The researcher deliberately chose the two pure electrical engineering classes and excluded the other two class that dwelt on educational electrical engineering.

### 2.3 Data collection

Informed consent was physically sought in the first learning meeting. The researcher created a 12-item questionnaire of 1 to 4 Likert scale (see Table 1). This was meant to collect qualitative data on what students thought about the flipped classroom model and the traditional lecture model. Item 1 was about out of class preparations, item 2 was about learning pace, item 5-6 focused on student' preference and satisfaction, item 4 and 12 were concerned with instructional engagement, and item 3 and 7 focused on knowledge while 5, 8 and 9 focused on cognitive skills formation. The questionnaire was administered at the end of the flipped learning period**.**

Table 1. Questionnaire

| Research items | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| **Scale** | 1 | 2 | 3 | 4 |
| 1. E-lectures compelled me to prepare for the class. | | | | |
| 2. E-lectures assisted me learn content at my own pace. | | | | |
| 3. In-class quiz and subsequent discussions broadened my view of concepts. | | | | |
| 4. Peer-peer interaction helped me learn faster. | | | | |
| 5. Self-directed learning and in-class problem solving is more effective than class lecture and subsequent problem solving at home. | | | | |
| 6. Active learning enhanced my problem-solving self-efficacy. | | | | |
| 7. Peer views of concepts improved my knowledge. | | | | |
| 8. Sharing my understanding improved my knowledge retention. | | | | |
| 9. Flipped instructional model improved my collaborative skills | | | | |
| 10. Flipped class saves time and resources e.g. (materials and tools) | | | | |
| 11. Online learning is relatively cheap in terms of internet costs and ICT hardware. | | | | |
| 12. Flipped classroom model increases student-lecturer interaction. | | | | |

Lecturer created assignments and quizzes were administered in each of the of the classes. The researcher assisted in the marking of the assignments. Qualitative data was collected through participatory class observation by the researcher. The researcher attended all the classes and came up with a lecture observation report.

## 2.4 Research procedures

Both classes were exposed to the traditional classroom (TC) model. Each class was taught by the same lecturer. Class B learnt using the TC model in the first three weeks and class A was sequentially exposed to the same lecture model in three weeks that followed. The researcher observed all lectures. Students first interacted with the learning materials in class. Lecturer incentivized inquiry-based learning. Students paid attention as they were exposed to the new materials. At the end of each and every lecture, students were assigned homework which they

completed outside class. The homework was due for submission before coming to class. Before the commencement of each lecture, lecturer revised with the students the previously assigned homework.

In the flipped classroom (FC), students interfaced with the learning materials before attending class. Learning materials were accompanied with compulsory assignments that were due for presentation. Learning materials and presentation assignments were retrieved through multiple links namely WhatsApp, spot.upi.edu and Khan Academy. The lecturer posted the learning videos, assignments, performance feedback and also interacted with the students through the mentioned platforms. During class, to initiate collaborative learning (peer to peer interaction and small group discussions), the lecturer superintended students' presentations. Each group was given 30 minutes to present and attend questions from the attentive class. To keep the students on track and motivated, the lecturer made evaluative comments and discussed gray areas. Lecturer facilitated and engaged students in either one on one style or group format. After class, the lecturer assigned students extended work which required them to think critically, replay learning videos and review supplementary materials. At the end of the flipped learning period, an evaluative survey was administered.

### 2.5 Data analysis

The researcher used the survey findings to evaluate students in terms of; preference and satisfaction, out of class preparation, instructional engagement, learning space and cognitive skills formation. To establish the relevance of flipped learning on students' performance, the researcher conducted a factorial analysis (2-way ANOVA) and two-sample t-test for paired (matched) data. SPSS 22.0 was used to process the quantitative data. The researcher also produced lecture reports of each learning meeting. All lecture reports were also validated by the lecturer.

## 3. Results and Discussion

### 3.1 Results

Cohort A learnt using the traditional lecture (TC) model and the flipped classroom (FC) model while cohort B was only exposed to the TC model. Following the mid-semester exams, cohort A students were exposed to the TC in the first three weeks and consequently taught using the FC model in the following two weeks while cohort B learnt using the TC model in three weeks preceding the mid-semester exams. Cohort A's broader topic was, "Fundamentals of Electrical Circuits". In both the traditional and flipped sections, students learnt how resistors, diodes, transistors, capacitors and inverters work. Cohort B's topic of focus in its three weeks were, "Power Plant (week 1), Hydro Power Plant (week 2) and Steam Power Plant (week 3)."

3.1.1 Students' preference and satisfaction

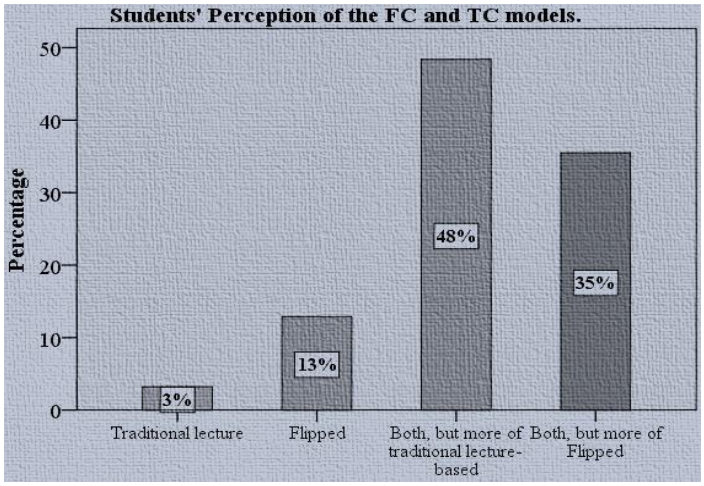


Figure 1. Instructional model

Students' satisfaction level for cohort A was measured through a 4-point Likert scale paper and pencil-based questionnaire survey. In order to establish the overall student impression on flipped classroom, students' responses on the research items number 5, 6, and 13 were sought. Although literature argued that a flipped learning environment was conducive for clarity seeking, appealing, encourages collaboration, increases student engagement and ideal for students with heterogeneous learning needs (Engel, Heinz, & Sonntag, 2017), most flipped students in the flipped cohort preferred a blended pedagogical approach of learning. From figure 1, most cohort A students (48%) preferred to learn through both instructional pedagogies but more of the traditional lecture-based method. 35% of cohort A students preferred to learn through both models but more of the flipped model. Cumulatively, 83.87 % were better off with learning through a combination of both methods. However, 13 % of the flipped students exclusively preferred to learn using the flipped classroom model while only 3% of cohort A had confidence in the traditional classroom. Although students in favour of the traditional model were extremely low, it does confirm Elliott (2015)'s study findings that some students tend to resist changes brought along by new pedagogical methods like the flipped classroom pedagogy when exposed to them for the first time.

Most flipped students concurred that active learning enhanced their problem-solving capabilities. Cumulatively, 93.5% (agree and strongly agree) of the students acknowledged active learning was an essential component of learning. In a nutshell, this showed that the majority of the students were impressed by face to face interaction part of the flipped classroom model over the TC model. The findings were consistent with literature (Kakosimos, 2015; Munir et al., 2018; Ravishankar et al., 2018). However, only 2 out the 31 surveyed students felt active learning had nothing to do with their problem-solving self-efficacy. This could be due to their dislike of the model because of several reasons among them the need to prepare before coming to class.

Furthermore, 90.3% of the students belonging to the treatment class either agreed or strongly agreed that the flipped learning paradigm was more effective than the traditional classroom

paradigm. However, approximately 10% of the flipped students felt that the flipped classroom pedagogy was ineffective. The students were both intrinsically and extrinsically motivated as revealed by the quality of their presentations. The autonomy, lateral and vertical interaction and the opportunity to show what they understood was partly the reason behind their motivation.

To establish whether gender and ICT self-efficacy (computer self-efficacy, online self-efficacy and social media self-efficacy) influences students' pedagogical perception, a two-way ANOVA was performed. It was found that there was insufficient evidence to reject all the three null hypotheses namely, $\mathbf{H_a}$: ICT self-efficacy has no significant effect on students' satisfaction rating of the flipped classroom model ($F_{4,22} = 0.328$, $p = 0.856 > 0.05$), $\mathbf{H_b}$: Gender has no significant effect on students' satisfaction rating of the flipped classroom model ($F_{1,22} = 0.0.084$, $p = 0.775 > 0.05$) and ultimately, $\mathbf{H_c}$: The interaction effect between gender and ICT self-efficacy has no significant effect on students' satisfaction rating of the flipped classroom model ($F_{3,22} = 0.196$, $p = 0.898 > 0.05$). In short, group A students' perception of the flipped classroom model was neither associated with gender nor their varying computer self-efficacy, internet self-efficacy and social media self-efficacy.

### 3.1.2 Instructional engagement/interaction

Judging on the level of interaction observed during the implementation of the FC model, students were overjoyed by the FC format. All flipped groups prepared their presentation timeously and were of high quality. Presentations were submitted ahead of the actual presentation. Students prepared their presentation as guided by the instructional videos shared through Khan Academy and WhatsApp platform. In order to escalate outside class instructor-student interaction, the WhatsApp group was used regularly.

Table 2. Peer-peer and student-instructor interaction

| **Scale** | **Peer-peer interaction helped me learn faster (%)** | **Flipped classroom model increases students-lecturer interaction (%)** |
|---|---|---|
| Disagree | 3.3 | 3.2 |
| Agree | 61.3 | 61.3 |
| Strongly Agree | 35.5 | 12.9 |

Based on Table 2, cumulatively, 96.8% (Agree and Strongly Agree) of the flipped students concurred that peer to peer interaction helped them to learn faster while 74.2% concurred that student-instructor interaction was enhanced by the flipped classroom model. The findings were consistent with existing literature. Previous authors also reported that the FC model enhances P2P interaction as well as Student to Instructor interaction (Calimeris, 2018; Trpkovska & Bexheti, 2017).

3.1.3 Out-of-class preparations

From the perspective of the students, learning at own pace was better in a flipped learning environment because there was no room for information overload. According to the Cognitive Load Theory (CLT), working memory is subject to certain type of load and the overloading of the working memory disrupt learning (Clark, Nguyen, & Sweller, 2005). The major finding that the FC model enabled students to study at their own pace confirms literature.

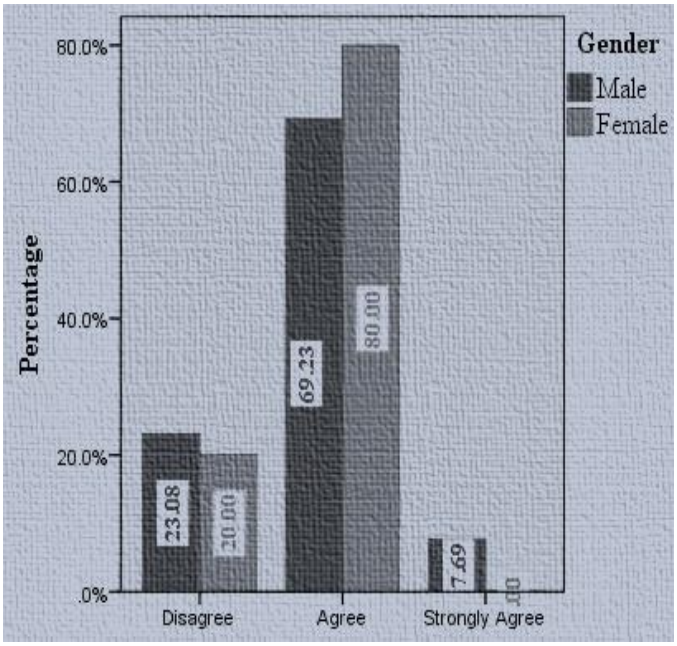


Figure 2. Preparation pace

This was consistent with the high participatory levels seen during the implementation of the FC model. 84.61% and 60% of the flipped male and female students acknowledged the importance of preparation (See Figure 2). Additionally, all flipped groups did their assigned presentation work timeously and the quality of presentation showed that great effort occurred. The desire to obtain good grades could be the main catalyst for students' completion of pre-class activities rather than intrinsic motivation as continuous assessment is incentivized at the university. The researcher observed that the flipped model increased the sense of purpose in students with regards to assignment preparation. Students were motivated to search on the internet alternative ways of discussing the operations of components of electrical circuits.

3.1.4 Higher order thinking skills

Based on the result, about 67.74% off the flipped students agreed that in-class and subsequent discussions deepened their understanding of learned contents while 12.9% strongly agreed with what is asserted by the item. In total, 80.64% of the flipped students were happy with the learning structure. Conversely, 19.35% of the flipped students disagreed with the item. This was in-line with the researcher's observation that some students were frightened by the in-class quizzes. The

instructor had to consistently state that the quizzes were not meant to fail anyone but to check their progress. The researcher noted that flipped students increased their interaction with their instructor in preparation of the final exam than traditionally taught students. On the social media platform, there was increased peer to peer and student to instructor interaction. The majority of the flipped students (83.87%) were pleased with active learning characterized by cooperative learning, application of key concepts and feedback as shown by figure 1. This conclusion was consistent with findings of Munir et al. (2018) and previous related research findings.

A total of 90.32% of the flipped students either agreed or strongly agreed that peer views increased their knowledge while only 9.68% disagreed with the statement. The result shows that the creation of a conducive active learning environment enabled students to share knowledge and seek understanding from fellow learners. Peer views enabled students to reconcile what they already knew with the views of their significant others. Unlike the traditional learning approach in which students are compelled to come to terms with the instructor prepared learning materials, flipped learning environment allowed students to supplement instructor generated materials with alternative instructional materials. The fact that each group member had a part to present in their respective class presentation made all students to prepare and cooperate during group discussions. The flipped discussions were livelier than the traditional ones. Students' in-class contributions reflected high levels of critical (analytical) thinking and creativity. The findings confirmed the previous literature that the flipped classroom model enabled students to develop analytical, communication, problem solving, creativity, collaborative and heutagogy skills (Baytiyeh & Naja, 2017) (Morosan, Dawson, & Whalen, 2017).

Feedback on the item concerning impact of sharing in knowledge retention of the evaluation survey showed that 90.32% of the flipped students (agree and strongly agree) concurred with the item. The way students articulated discussions points proved that the flipped model enabled students to understand and retain knowledge. The students were of the view that team sharing of knowledge had an incremental effect on knowledge retention. The outcome proved that increased knowledge sharing is directly correlated with increased knowledge retention. This finding was consistent with the findings of O'Flaherty and Phillips (2015) who posited that flipped learning works very well if students participate and prepare outside class. Most students were participative. They shared their views during class presentations and discussions. The instructor had ample time for point-of-need assistance as presented in literature. Unlike in AlJarrah, Thomas, and Shehab (2018)'s study in which the authors discovered that some students procrastinated with regards to preparation, in this study high participation proved that students prepared.

About **77**.42% of the flipped students concurred that the flipped learning experiences positively enhanced their collaborative skills. 6.45% of the flipped students strongly concurred that the flipped model improved their collaborative learning skills. This finding was consistent with findings reported in literature. Previous literature reported that a flipped pedagogy enabled students to develop analytical thinking, communication, problem-solving, creativity and fostered team work (Tang et al.,

2017). However, only 16.13% of the flipped students disagreed with the notion that flipped instructional model improves students' collaborative skills.

Previously, in week 4, 5 and 6 students had learnt the same concepts through the traditional lecture method. However, from the observation made, most students concentrated on writing notes and rote memorization, the active learning was minimal, and insufficient time was given to collaborative learning. Similarly, the same style featured in cohort B's lectures. The researcher also found out that during the traditional lectures, most students were hesitant to ask questions as they interfaced with the learning materials for the first time in class. Conversely, flipped learning environment compelled group work outside class and students obtained lower order cognitive skills before class attendance.

3.1.5 Performance results: Flipped Vs Traditional students

**$H_0$**: There is no significant differences in achievement of students (as measured by gain scores) who are taught using the flipped classroom model and those taught using the traditional lecture-based model - $\mu_A = \mu_B$. Levene's test was utilized whether the variance of two samples are approximately equal. It is one of the necessary conditions for conducting a one-way ANOVA. The Levene's test should be non-significant (assumes sample variance equality), that is, the p-value should be greater than 0.05.

**$H_0$**: $Var_{\text{Flipped class}(\mathbf{A})} = Var_{\text{Traditional class}(\mathbf{B})}$

Table 3. Test of homogeneity of variances

| **Levene Statistic** | **$df_1$** | **$df_2$** | **Sig.** |
|---|---|---|---|
| 0.770 | 1 | 62 | 0.384 |

Since the p-value was above 0.05 (Sig.= 0.384), the null hypothesis was kept and equality of variance was assumed. As per table 3, the Levene's test explicitly verified the equality of variance between the flipped cohort and traditional cohort (homogeneity of variance) ($p > 0.05$).

Table 4. Descriptives: FC vs TC

| **Score** | **N** | **Mean** | **Std Deviation** | **Std. Error** | **95% Confidence. I for mean** | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Flipped Class | 32 | 81.03 | 6.823 | 1.206 | 78.57 | 83.49 |
| Traditional Class | 32 | 83.06 | 7.573 | 1.339 | 80.33 | 85.79 |
| Total | 64 | 82.05 | 7.223 | 0.903 | 80.24 | 83.85 |

From the descriptive statistics reported in Table 4, it can be seen that the flipped cohort and traditional cohort slightly varied from each other in terms of measures of central tendency and

measures of dispersion, that is, flipped class (M = 81.03, SD = 6.82, 95% CI: 78.57-83.49) and traditional class (M = 83.05, SD = 7.57, 95% CI: 80.33 - 85.79). The Glass's Δ effect size of 0.27 was small and it showed that flipped students scored 0.27 standard deviation higher than traditionally taught students. The traditionally taught student performed slightly better than the flipped students although the two groups learnt different topics in the first and second half of the semester as shown by the Glass's Δ and means. Group A dwelt on the function of components of electrical circuits in the second half of the semester while group B concentrated on power generation in the first half of the semester. Students in both sections wrote exams at the end of their respective study duration. The insignificant variation in performance could also be due to other exogeneous factors like first time full exposure to flipped learning. Additionally, the performance variation could be due to differences in student characteristics across the treatment and control groups. However, basing on students' sentiments, the majority of the students were impressed with the instructional pedagogy and suggested that alternating the two instructional pedagogies would be good for them. Despite the low average scores by the flipped class, it was seen that the flipped technique makes learning enjoyable and enables students' misconceptions to be corrected before sitting for the exam.

Table 5. ANOVA: FC vs TC

| **Score** | **ANOVA** | | | | |
|---|---|---|---|---|---|
| | Sum of Squares | df | Mean Square | F | Sig. |
| Between Groups | 66.016 | 1 | 66.016 | 1.271 | 0.264 |
| Within Groups | 3220.844 | 62 | 51.949 | | |
| Total | 3286.859 | 63 | | | |

The one-way ANOVA was performed to compare the effects of instructional pedagogy on students' academic achievement. Participants were categorized into two groups. Group A was the intervention while group B was the control. The outcome variable was found to be normally distributed and equal variance was assumed based on Levene's test ($F_{1, 62} = 0.77$, P = 0. 384). There were statistically insignificant differences in academic achievements by the candidates exposed to varying instructional pedagogies ($F_{1, 62} = 1.271$, p = 0.264), thus the null hypothesis was accepted (see Table 5). There was no sufficient evidence to suggest that students exposed to flipped learning performed better than traditionally taught students. Students in either group could have adjusted to either pedagogical style as they sought to attain excellent course grades. The results confirm past literature which concurred that flipped learning have little impact on students' academic achievements.

The impact of a flipping instructional pedagogy was also investigated. Cohort A students learnt through the traditional classroom model and flipped classroom model in five successive weeks. Three weeks were set aside for the implementation of a traditional classroom pedagogy and two

weeks were set aside for a flipped instruction. To investigate the impact of flipping in the fundamentals of electrical engineering course, a two-sample t-test for paired (matched) data was opted as the equality of variance condition that would enable the use of one-way ANOVA.

**$H_0$**: There is no significant differences in achievement of students before and after flipping - $\mu_{\text{Flipped session (A)}} = \mu_{\text{Traditional session (A)}}$.

Table 6. Effect of flipping on students' academic performance (Cohort A)

| | **Mean** | **S. D** | **t** | **df** | **Sig (2-tailed)** |
|---|---|---|---|---|---|
| Pair 1: Before flipping – After flipping | -5.656 | 25.116 | -1.274 | 31 | 0.212 |

From paired samples test results shown in table 6, $t_{calc} = -1.274$, $p = 0.212$. Again, there were statistically insignificant differences in academic achievements by the candidates when exposed to both the traditional and flipped classroom model in succession therefore the null hypothesis was retained. The reasoning behind could be that the students were motivated to work hard when exposed to either method as they sought to achieve better grades.

Table 7. Paired sample statistics

| | **Paired Sample Statistics** | | | |
|---|---|---|---|---|
| | Mean | N | Std Deviation | Standard. Error Mean |
| Pair 1 Before flipping | 76.88 | 32 | 24.683 | 4.363 |
| After Flipping | 82.53 | 32 | 3.182 | 0.563 |

However, there was a slight improvement in performance following flipping as shown in table 7, that is, 5.95% (82.53% - 76.88%). Before flipping, the students' mean score and standard deviation was (M = 76.88, SD = 24.683) while after flipping, mean and standard deviation were as follows (M = 82.53, SD = 3.182). The Glass's Δ effect size of 0.23 was small and it showed that following flipping, students scored 0.23 standard deviation higher than before flipping. The Glass's Δ effect size of 0.23 shows that flipping had a small effect on the performance of students. Before flipping the variation, the assessment scores were extremely high (SD = 24.683), unlike following flipping. The variation could be attributed to rote memorization among many other possible reasons. This concurred with literature which argued that traditional classroom approach enables students to obtain lower order cognitive skills and very few students might attain higher order cognitive skills such as critical thinking and problem solving to mention a few.

### 3.2 Discussion

Presently, most instructors are either consciously or unconsciously using the flipped classroom model or somehow partially flipping their classrooms. The pure use of the traditional classroom model is slowly becoming utopian because of the inevitable adoption of the Information and Communication Technology in the classroom. Flipped classroom model is advantageous to all classroom stakeholders in that it enhances efficient use of class time, it is conducive for instructor-student and student-student engagement, enables students to take charge of their learning process, allows students to prepare for classroom activities at own pace or time and enables students to get higher order cognitive skills through the flipped learning cycle. The learning of components of electrical circuits through either method was challenging, aesthetic and novel. Secondly, the reason why the majority of the students preferred an integrated learning environment could be because some learning materials are better understood using the traditional lecture method while some could be better understood using the flipped approach. Thirdly, in traditional lectures, materials were delivered at one go and this only enabled some of the students to attain lower order cognitive skills while higher order cognitive skills remained beyond their reach. Fourthly, flipped learning proved to be flexible in terms of pacing, that is, students had an opportunity to view learning materials at own time, replay, pause, rewind and even search for alternative learning videos covering the same learning concepts.

Despite the popularity of the flipped classroom model in medicinal related study programs, its usage in the area of vocational and engineering education is still limited as articulated by literature. This is because some course topics are perceived abstract and challenging if moved outside of classroom. Secondly, experience might have shown that students disengage if recorded videos are poorly presented and if students do not have enough probing opportunities. The qualitative findings proved beyond reasonable doubt that flipped classroom approach is effective (83.87% of the flipped cohort students preferred the model) although few students raised displeasure in learning through it. The researcher was intrigued that there was no association between ICT literacy and gender on pedagogical satisfaction ($p > 0.05$) as reported by Kurbanoğlu and Akkoyunlu (2016).

It was found that partially flipped students were better off with a blended learning pedagogy. Conversely, flipped class exam scores ($M_A = 81.03$, $SD_A = 6.82$) were insignificantly lower than those of the traditional class ($M_B = 83.06$, $SD_B = 7.57$). The findings were consistent with literature that flipping the classroom does not necessarily result in improvements in grades due to some exogenous factors like the influence of student characteristics. Although some previous researchers like Calimeris and Sauer (2015) reported that students in flipped classes performs significantly better than their traditional classroom counterparts, in this study it was found that student characteristics influences the success of flipped learning. Students should actively participate in class for deeper understanding. Taking real learning online without intensive F2F (face to face) learning might produce similar outcomes with the traditional classroom which is gradually becoming obsolete. This

was consistent to the findings of Figlio, Rush, and Yin (2010) who found that test scores of students in live class were considerably higher than the e-learning students. In this study, flipped instruction improved mean score of group A students by 5.95% following the implementation traditional and flipped classroom paradigms in succession and the Glass's Δ effect size of 0.23 standard deviation also confirmed a small improvement in students' grades. This study proved that students in the flipped class performed better in flipped sessions than in their traditional sessions (M = 82. 53, SD = 3.182) to M = 76.88, SD = 24.683) although by an insignificant magnitude. However, implementing a flipped or partially flipped pedagogy to a class of introverts might yield similar or less lucrative outcomes with the implementation of a traditional classroom pedagogy. Likewise, without extensive preparation, F2F learning will be less intensive. It is also imperative to note that F2F learning should be instructor moderated for constructive learning to take place. Left by themselves, some students' behavior and attitudes might be retrogressive to active learning.

It was seen that following the traditional class sessions, group A (flipped) students obtained higher order thinking skills during discussions. By being exposed to the twin extreme pedagogical styles, students realized that both learning models were invaluable as suggested by 83.87% of the flipped students who opted for a blended learning approach. From the observation made students obtained the lower order cognitive skills during the preliminary TC sessions and subsequently developed higher order cognitive skills during the flipped learning sessions. It was found that if students drive the learning process, they desist from engaging in rote memorization that is a common feature of traditional classroom approach. The presentation assignments extended to the students pushed them to prepare as every group member was required to present. This implied that all the students were to be awarded individual assignments to ensure increasing learning outcomes. For trainee engineers, alternating flipped classroom and traditional classroom models might enable them to develop technical or spatial skills and soft skills. The fact that the individual learning gains are considerable is good news to training institutions in that they might minimize training costs at the same time maximizing usage of limited resources (learning space) by increasing enrolment. The present study showed that flipped learning is ideal for resource constrained training institutions.

## 4. Conclusion

Flipped classroom model is advantageous to all classroom stakeholders in that it enhances efficient use of class time. It is conducive for both instructor-student and student-student engagement, enables students to take charge of their learning process, allows students to prepare for classroom activities at own pace or time and enables students to get higher order cognitive skills through the flipped learning cycle. Despite the popularity of the flipped classroom model in medicinal related study programs, its usage in the area of vocational and engineering education is still limited. It was also found that partially flipped students were better off with a blended learning pedagogy and not necessarily result in improvements in grades due to some exogenous factors like the influence

of student characteristics. In addition, this study proved that students in the flipped class performed better in flipped sessions than in their traditional ones although the magnitude was nor significant. However, implementing a flipped or partially flipped pedagogy to a class of introverts might yield similar or less lucrative outcomes with the implementation of a traditional classroom pedagogy. In the future, the testing of the flipped classroom model should be done over a long period of time in order to enhance objectivity in test results. This follows that instructors should not only confine students to their own generated learning materials but encourage students to search for alternative learning materials as guided by what they provide them. In electrical engineering, instructors and curriculum developer should promote the flipping of certain areas of course curriculum as concurred by literature and results of this study.

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