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Impact of Flipped Learning Approach on Students Motivation for Learning Digital Electronics Course

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Introduction. Various educational institutes follow various approaches to teaching-learning. Compared to the conventional learning approach, a flipped learning/inverted classroom approach was chosen to test students' variability in academic performance and level of motivation through the ARCS model (attention, significance, confidence, satisfaction).
Materials and Methods. Keller's Motivation Survey of Instructional Materials was selected to assess the effect (in terms of motivation) of the flipped approach on the students. Keller's ARCS motivation model was the basis for this survey which includes four motivational factors: attention, significance, confidence, and satisfaction. The multiple-choice test was conducted to measure the students' academic performance.
Results. After completion of the module, it was noted that significant improvements took place in the students' academic performance, attention, confidence, and level of satisfaction. The relevance factor had not experienced much difference.
Discussion and Conclusion. The researchers' key goal, according to previous reports, is to integrate various teaching-learning approaches in primary, secondary, k-12, etc.; engineering education has yet to be explored. The research aims to determine the level of academic achievement and motivation of the second year B. E. students for digital electronics course in the flipped learning approach as opposed to conventional teaching approach. The results can be bettered by incorporating parameters such as students' perception, learning attitude, critical thinking skills, etc.

Keywords: active learning, flipped learning, digital electronics, the motivational model, traditional approach, millenial learners

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Влияние перевернутого подхода на мотивацию студентов при изучении дисциплины «Цифровая электроника»

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Введение. По сравнению с традиционными методами преподавания инверсионный подход в инженерном образовании (перевернутый класс) обладает рядом преимуществ. В «перевернутом» классе преподаватель использует радикальные учебные мероприятия, на которых учащиеся содержательно взаимодействуют друг с другом на основе критического мышления. Целью статьи является оценка эффективности перевернутого подхода на мотивацию студентов при изучении дисциплины «Цифровая электроника».
Материалы и методы. В исследовании приняли участие 66 студентов, обучающихся по специальности «Цифровая электроника». Для определения оценки влияния (с точки зрения мотивации) перевернутого подхода на учащихся был выбран метод повышения учебной мотивации Келлера, послуживший основой для данного исследования. Для определения оценки успеваемости студентов проведено онлайн-тестирование. Для анализа полученных данных применялась описательная статистика.
Результаты исследования. По итогам проведенного анализа результатов было установлено, что уровень внимания учащихся в классе, где использовался перевернутый подход, был выше, по сравнению с традиционным. Значительной разницы в компоненте релевантности не наблюдалось, поскольку студенты проявили большую заинтересованность к обучению. Степень уверенности и удовлетворенности при перевернутом подходе значительно возросла. Инвертированный подход в обучении способствовал повышению успеваемости студентов, изучающих цифровую электронику.
Обсуждение и заключение. Для успешного применения перевернутого подхода в учебном процессе необходим хорошо продуманный план выполнения разработанных мероприятий. Полученные результаты могут быть улучшены благодаря принятию в расчет таких параметров, как восприятие студентами учебного материала, отношение к обучению, навыки критического мышления и т. д.

Ключевые слова: активное обучение, перевернутое обучение, цифровая электроника, мотивационная модель, традиционный подход, учащиеся-миллениалы

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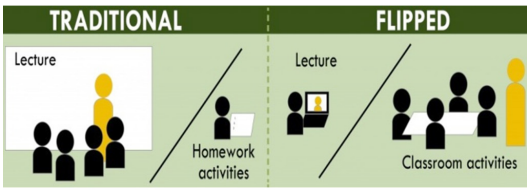
Introduction

In this technological era, electronic gadgets and devices like mobile phones, tablets, PDA, and internet supported devices continuously aid development in every field. Education is no different from any other field. Present-day, the learner is very habitual of using these devices and enjoys learning using them (inside/outside the classroom) [1], Due to intense interaction of the learner with these gadgets or devices, a new term over the social media has evoked, i.e. “Net Generation”, “Millennial Generation”, or “Generation Y”, which deals with the people who born between 1982 to 2001 [2]. Millennial learners learn better through hands-on experience in comparison to conventional classroom teaching using chalk and talk [3]. In the conventional classroom environment, communication between learner and teacher is simplex in nature [4], which means the teacher plays the role of an information source, and learners are supposed to listen and take notes. In such type of classroom environment, learners feel bore after a short span (15-20 minutes) [5]. Several learning strategies (as active learning, collaborative learning, cooperative learning, flipped learning) were adopted by the educators in the past few years to overcome the problem of the conventional classroom [6]. By incorporating such learning strategies in class, an educator can actively engage the learners for more time with the same course material as provided earlier. It may enhance

their understanding of the course they are undergoing and improve the learning gain of the learner. The present paper discusses the instructional technique known as "Inverted Classroom" [1].

"Inverted Classroom" is also popular with the name flipped classroom. In a flipped classroom, the teacher provides the course topic learning material to learners before the actual conduct of class and utilizes the class time to analyze the problem based on the given topic [7]. It includes radical learning activities during the in-class time, as shown in fig. 1, which means when a topic is taught in the form of activity the learners get more time to participate in meaningful interaction, peer discussion, and critical thinking. Research has shown that flipped classrooms being an innovative practice proves to have a positive impact on the learners learning gain in engineering education as it is more of an active learning and learner-centered model [8]. The flipped approach offers many advantages over traditional approach such as enhancing critical thinking skills in learners, retaining the lecture so that learners can watch lecture many times [9], utilize the lecture time by applying, analyzing, synthesizing and creating the solution to the problem, promotes the collaborative learning amongst the learners, etc. [9]. In spite of all such benefits, this approach has some of the demerits such as learners required to be motivated, technical skills required to be imparted, subject-specific, Class size-dependent [10]. Out of many challenges, learner motivation is one of the biggest challenges faced by every educator. When educators want to adopt a flipped classroom, then foremost thought that comes to mind of every educator is as to how to motivate the students to adopt a flipped learning environment? Undoubtedly, students learn more when they do the thing on their own. But we can't ignore the fact that they don't want to do extra work at home [11]. We should look after the evidence of one question "Are students truly ready for the flipped approach?" To check the effectiveness of the flipped approach, the ARCS motivational model is used in this paper (fig. 1).



F i g. 1. Traditional versus flipped classroom environment [1]

ARCS teaching model [12] is a student-centric teaching model which is developed by John Keller. The main aim of this model is to motivate the students for e-learning, since motivating the learners towards the online courses is more challenging than the face-to-face courses. It has four components: Attention, Relevance, Confidence, and Satisfaction. "Attention" deals with the interest of learners and maintaining the interest of learners throughout the class is a more challenging task for every educator [13]. Keller suggested three ways to manage the attention they are: by stimulating the senses, by hands-on experiences, and by adopting different teaching strategies. "Relevance "refers to the usefulness of the content, which means whether students can correlate the content with the real world or not. "Confidence" develops the success expectation amongst the learners, which helps the students to control their learning process. "Satisfaction" has a direct relation to motivation [12]. If a teacher can fulfill the needs of learners at the end of the lecture, then we can say that the learner is satisfied and its responsibility of teachers. The learner should be satisfied at the end of the lecture. Research shows that there are different studies of ARCS and flipped; few studies advocated them together. The Instructional Materials Motivation Survey (IMMS) survey is used to determine the effect of the flipped approach adapted to the ARCS motivation model in terms of academic score, student's motivation, student's confidence, and satisfaction.

Further, the research findings in the past discussed in section II elaborates on the various approaches used to measure the effectiveness of the inverted classroom. All the research findings are discussed in the

form of a table as shown in table 1. The methodology adopted to evaluate student's performance through the flipped classroom approach has been discussed in section III. The data received after the implementation of methodology has been analyzed, and the results were found to be similar to section IV. The conclusion of the findings is communicated in section V.

Literature Review

A lot of literature study is going on different teaching and learning strategies. Since 2007, the flipped learning approach came into existence, but in 2012, this approach was implemented by one of the researchers in real-time [14]. Table 1 summarized the literature survey from 2012 to 2018.

R. Brewer et al. surveyed the impact of inverted classroom learning on k-12 and college/universities [15]. Research has shown that the flipped classroom transforms the learning environment of class into a dynamic, interactive one. As this approach is not applied too much of the domains, so it may not be applicable to all the domains or subjects as discussed by the author. The future challenge could focus on finding the context in which the flipped model works best, such as education, engineering, nursing, etc. S. Park et al. advocated the influence of flipped learning on engineering students and an interdis-

Table 1. **Literature Survey**

Author	Approach	Environment	Measures
R. Brewer, S. Movahedazarhouligh	Flipped classroom	Dynamic & Interactive	Student's efficacy, quality, and impact of student's evaluation
S. Park, H. Kaplan, R. Schlaf	Flipped classroom and Interdisciplinary flipped classroom	Collaborative environment for undergraduates	Aesthetic design achievement
A. Karabulut-Ilgu, N. J. Cherrez, and C. T. Jahren	Flipped classroom	Utilization of flipped classrooms in various domains	Empirical research on flipped learning
Y. Hao	Flipped classroom	Undergraduate students	The perspective of undergraduates flipped learning readiness, and individual characteristics
G. Aşıksoy, F. Özdamlı	Flipped classroom with ARCS Model	Physics course for undergraduate students	Achievement, self-sufficiency, motivation, and students opinion about the flipped approach
J. Lee, C. Lim, H. Kim	Flipped classroom	Algebra class in a Korean university	Maturity of mathematical views, quality of reflections, and satisfaction of students
G. J. Hwang, C. Lai, S. Y. Wang	Flipped classroom	Collaborative and interactive	Benefits and challenges of the flipped classroom
M. L. Maher, C. Latulipe, H. Lipford, A. Rorrer	Strategies for the flipped classroom	Online courses, MOOC courses, youtube, etc.	Teachers and students perception about flipped learning strategies
T. Roach	Flipped classroom	Economics course for undergraduates	Student's perception and learning outcome
J. Enfield	Flipped classroom	Undergraduates multimedia students	Students learning experience, self-efficacy, learning ability

ciplinary group of students (engineering students and art major students) [16]. The research experiment was conducted on 51 students. Out of which 29 belongs to engineering students and 22 from the interdisciplinary inverted classroom (IIC). The result showed that IIC exhibited higher aesthetic design achievement. Here, the author conducted an experiment based on the student's interest. Results could be improved by comparing student's performance through pre-test and post-test. A. Karabulut-Ilgu et al. presented the pros and cons of flipped learning after reviewing 62 articles [17]. One of the main benefits of flipped learning addressed here, it enhances professional skills in students, which makes them lifelong learners, and two significant challenges were addressed by author, heavy workload and technical issue. Further, the author advised adopting the systematic approach for flipped learning in engineering education (at the discipline level rather than course level). Y. Hao advised using an inverted classroom approach to check the student's perspective, readiness level, and their characteristics [18]. To check the readiness level of students, the online Learning Readiness Scale was used. The challenge faced by students was the large class size, which affects the performance of students. This can be further improved by taking care of class size and student's willingness. G. Aşıksoy et al. determined the impact of the inverted classroom on physics courses by adapting the ARCS motivation model [12]. Research showed that the flipped approach with the ARCS model gave a positive impact in terms of the student's achievement, motivation, and self-sufficiency. This approach could be further improved by incorporating various teaching and learning strategies. J. Lee et al. adopted the flipped method to teach mathematics subjects in a Korean university [19]. The author implemented this model under the topic algebra and noticed the significant improvement in the maturity of mathematical views, quality of reflections, and satisfaction of students. G. J. Hwang et al. surveyed the challenges and benefits of the flipped learning approach [10]. Two major challenges were presented by the author, The first challenge addressed by the author is how to incorporate emerging technologies ("such as cloud computing, augmented reality, etc") to facilitate seamlessly flipped learning. The second challenge, whether flipped learning helps the researchers to promote problem-solving skills, self-efficacy, critical thinking, and creative performance, etc. M. L. Maher et al. discussed the different strategies to deliver online content for the flipped classroom [20]. Results proved that teachers and students have a positive perception to adopt the flipped learning strategies. T. Roach checks the student's perception of the flipped approach; the author implemented a partial-flipped approach for economics course for one semester [11]. The experiment was conducted on 92 students, out of which 76% of students agree with the point that the flipped approach helps them to learn and 94% of students gave a response that class was more interactive as compared to other courses. The author suggested that it could be further improved by taking an academic score of students into consideration. J. Enfield proposed a flipped classroom for undergraduate multimedia students [21]. The results had shown that students gave positive feedback that the inverted classroom approach provides them engaging learning experience also increased the ability of students to learn independently.

Research Questions.

In terms of academic score, do the students learning with the flipped learning system outperform those learning with the traditional learning approach?

In terms of attention, relevance, confidence, and satisfaction (through ARCS Model), do the students learning with the flipped learning system outperform those learning with the traditional learning approach?

Materials and Methods

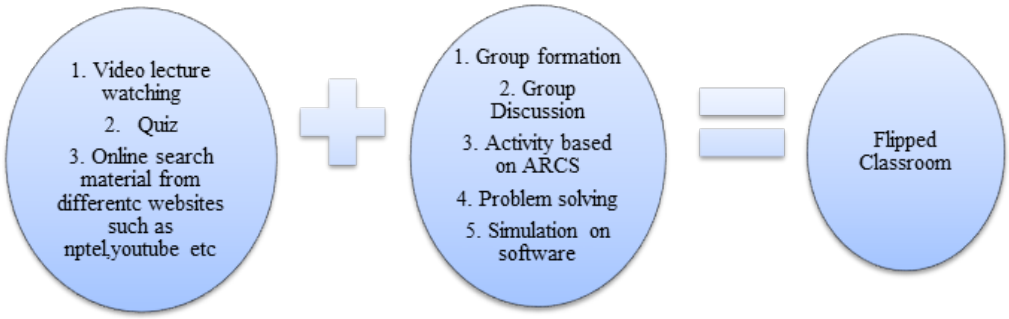
To conduct the experiment the interested participant were divided into two groups namely, EG and CG. Quantitative

data was collected based on academic performance and by the motivational measurement IMMS [22]. Descriptive statistics were applied to analyze the data received from the students. The online test was conducted to check the academic performance of students in both the teaching scenarios.

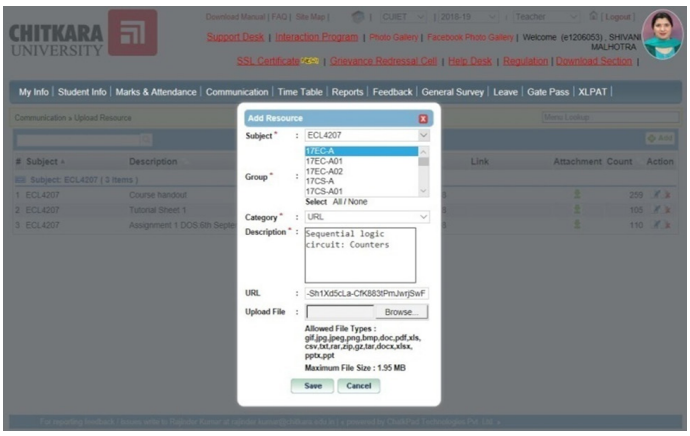
Participants. The present study involved an undergraduate course "Digital Electronics". In total, 66 students (32 control, 34 experimental) voluntarily took part in the study.

Research Design. In both the groups (CG and EG) the same instructor taught the whole subject. In order to check the student's performance, we chose a counter chapter for the evaluation as it covers almost the basics of previous chapters. So, the learning content is prepared from the topic counter which is a type of sequential circuit. Another reason for choosing this topic is that sequential circuit designing is possible with the help of state and timing diagram representation and it becomes difficult for a student to visualize and analyze the working of sequential circuits by conventional teaching style. The number of participants in this class is 66. In the experimental group, 34 students participated while others participated in the control group.

Action plan Before Class. The first step of implementation is the selection of introductory learning material. Sources like NPTEL/MIT or You-tube video channels were explored and video of maximum 10min length is selected for the introduction of the course topic as shown in fig. 2. This video link as shown in fig. 3, as well as a self-reading document related to course topic, was posted on the university ERP-portal (link) after posting a video, we instruct the students about the platform which helps them to study the learning content



F i g. 2. The flipped Digital Electronics classroom adapted to the ARCS Motivation Model



F i g. 3. Reference video link for the course topic

before coming back to the next class. We also posted an audio message along with a video that instructs the students to remain more attentive on particular time slots of the posted video lecture. The related topic and the plan of the activity related to the topic shared with students in advance and then the activity related to that topic conducted in class. For evaluation, rubrics of the designed activity was also shared with the students. On the other hand, for the traditional classroom, no reading material was provided. Students came to class with some pre-requisites of the topic going to be covered in the class. It can be concluded from the discussion that the flipped classroom instructor spent much time before the class for collecting relevant data for the students.

Proposed Strategies during class. Table 2 shows the proposed strategies for classroom activity based on the counter. The time taken by this activity is 40 min. 10 minutes are allotted to evaluate a short quiz to form the groups. Based on the marks of a short quiz, we preferred to form heterogeneous groups. The heterogeneous group consists of a blend of above average, average and below-average students. The idea behind the formation of the heterogeneous group is that effective learning takes place amongst the students. In such type of formation, below-average students learn from the average or above-average students or vice versa. Furthermore, 15 minutes are allotted for group activity and the last 5 min to evaluate the activity and to solve the queries. On the other hand, the instructor delivers the lecture in the first half of the lecture. In the next half instructor solve the queries, distribute the question paper and feedback form to students (for academic score and to check ARCS parameters).

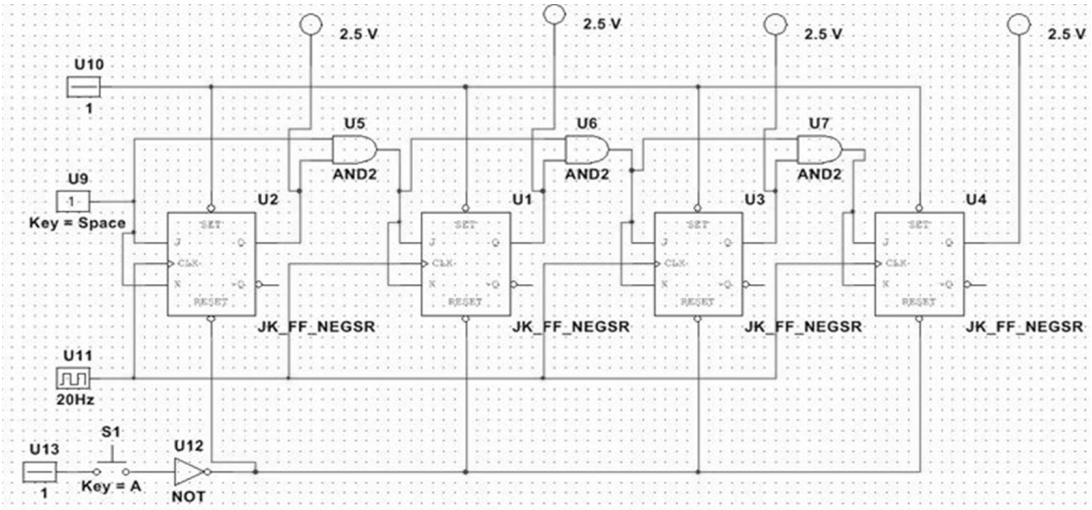
The problem statement based on the counter is, "How to design mod 6 and mod 10 counter using JK and T flip flop? (As discussed in the video). The main objective of conducting activity is that students will be able to design mod 6 and mod 10 counter using any flip flop. This video fulfills all the required steps which are used for the designing of mod n counter. The video covers the designing of mod 9 counter using JK flip flop followed by a truth table. For classroom activity, all the students have a truth table with them as discussed in the previous class. Now, their main task is to verify the same truth table using T flip flop and scan the changes between these two on Multisim software as shown in fig. 4. Multisim is a simulator[1] provided by National Instrument for the design and analysis of analog and digital electronics. The output received from the multisim has also been verified by the logic analyzer as shown in fig. 5.

In order to check the knowledge of students, we conducted an online short quiz (created Google Form)[2]. At the end of the activity, it's mandatory for every student to appear for the quiz. The responses received from students were collected in an Excel sheet. Post conduct review of activity helps us to analyze the learning gain of students.

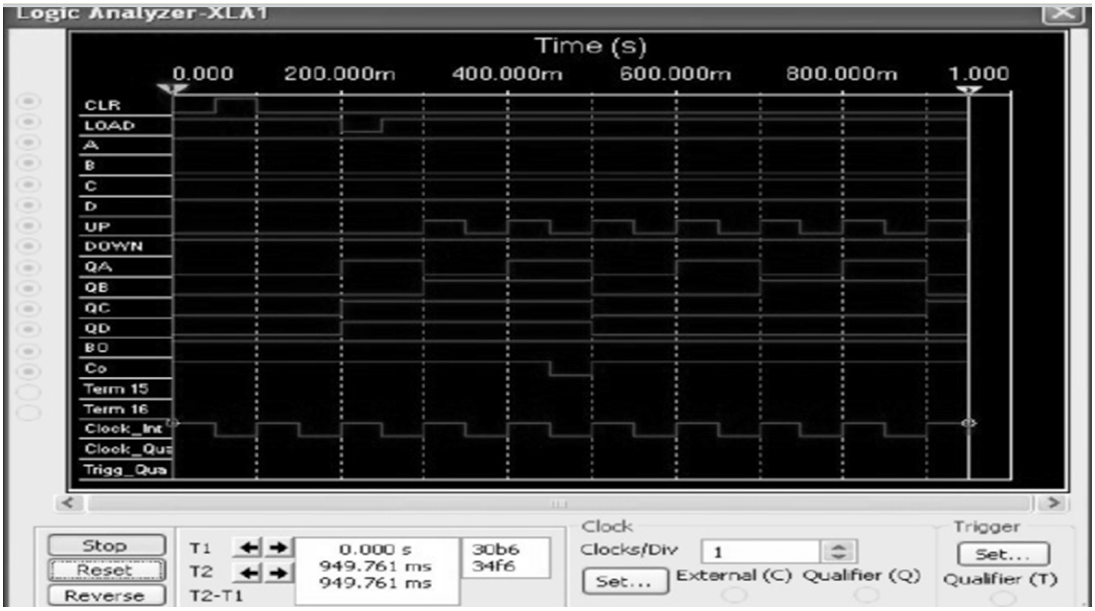
Table 2. **A Proposed strategy for the activity**

Time	Activity
10 min	Conducted quiz and form heterogeneous groups based on marks (scored in pre-test)
15 min	Group activity (designing and verification of truth table)
10 min	Solve online quiz (Google form)
5 min	Evaluation and solve queries

[1] Link to download Multisim simulator: https://www.multisim.com.
[2] Online multiple quizzes.



F i g. 4. Counter circuit design on Multisim simulator



F i g. 5. Timing diagram generated using logic analyzer of Multisim

Result and Discussion

The outcome of this research work is to measure the academic performance of students and analyze the quantitative measures of the ARCS model so implemented. The proposed approach of teaching digital electronics using flipped learning has shown significant improvement in the academic performance of the students. To measure the academic performance multiple-choice questions were framed[3] as per the activity performed in the class. The test was conducted in the form of a quiz using Google form via online mode. Their responses to the activity collected in an excel sheet and analyzed using SPSS software. The Independent t-test is used to check the difference in the mean of two groups.

[3] Google form design for ARCS.

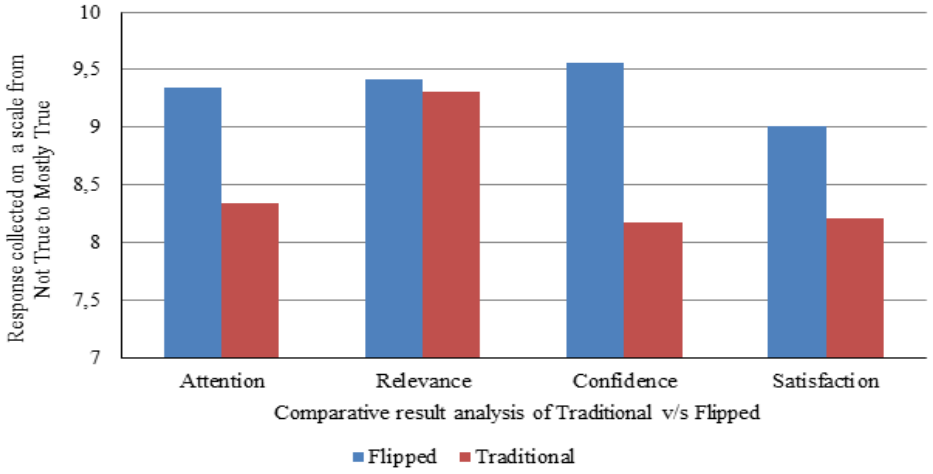
Research Question 1. Analysis of Academic Performance based on Academic Score. In order to check the equality invariance, Levene's test was conducted. The p-value and F value obtained from the results is .017 and 0.050 (shown in table 3) which suggests that there is a significant difference between the mean of two different teaching approaches. So it is concluded from the results that the flipped approach has shown a positive impact on student's academic performance. Cohen's d value obtained from the result was 0.491 which shows a large effect size between two approaches.

Research Question 2. Analysis of Learning Motivation using ARCS Model. While the post quantitative measures of the components under[4] the ARCS model, when evaluated between traditional and flipped approach, the results obtained are as shown in fig. 6. In total there were 16 open-ended questions[5] related to the ARCS model that was asked to students. The analysis posted in this work will aid the researchers in understanding the link between the components of the ARCS model using traditional and flipped teaching approach. For example, "the topic taught through flipped learning had stimulated my curiosity for learning". For relevance, "it is clear to me how the content of this material is related to the things I already know". Similarly, questions were designed to check their confidence and satisfaction level.

The questions designed for evaluation of the relation between traditional and flipped learning approaches were of a five-point Likert scale. The scale varies from Not true to Mostly true. Student responses were collected and analyzed for the components of the ARCS model. The analysis shows that the attention level of students in

T a b l e 3. **T-test analysis for academic score**

Dependent Variable	Groups	N	Mean	SD	t	df	P value	Cohen's d	95% confidence interval of the difference Lower	Upper
Academic Score	Flipped	34	3.62	.922	1.997	64	0.017	0.491	.000	1.173
	Traditional	32	3.03	1.425						



F i g. 6. Students responding "MOSTLY TRUE" to "NOT TRUE" to IMMS mapped to ARCS components (N = 34 for flipped and N = 32 for traditional)

[4] Students response.
[5] Google form design for ARCS.

the flipped classroom has been increased by 12% in comparison with the traditional approach. That means students were more attentive when they do the things of their own. There is no much significant difference noticed in the relevance component and it was not surprising for us to see such a response. The reason being technology does not remedy for education; students want to learn the things of their own interest. The confidence and satisfaction level in the flipped approach has increased by 17% and 10% as compared to the traditional approach. Overall stating, the flipped approach of teaching have shown a great impact on student learning gain while studying digital electronics course at graduation level.

Conclusions

The flipped classroom teaching approach is an interactive way of teaching students. Students enjoyed a lot during the learning phase and showed a positive response towards learning. Usage of technology poses minor challenges during the implementation phase of the activity in this approach. For successful implementation of activities, a well-thought plan of execution is required and the teacher should be flexible enough to solve on-the-spot problems that occurred. The overall learning experience of both students and teachers is significantly affected by this learning style.

The quantitative measure of the study presented in this paper proves that the flipped classroom environment has put a positive impact on undergraduate students learning in terms of academic results. When this model was compared with the traditional one theme a score of the flipped approach and traditional approach are as $M = 9.34$ and $M = 8.345$ respectively. A clear improvement was noticed for the attention and satisfaction motivational component. The above results were supported by the quantitative measure of Student's responses varies from "MOSTLY TRUE" to "NOT TRUE". Confidence and satisfaction levels were rated highest with the mean score of $M = 9.56$ and $M = 9.005$ respectively.

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