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Flipped Classroom and ManyChat Delivering Online-Offline (MCDOO) Learning for Science, Technology & Engineering Curriculum (STEC) Students

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FLIPPED CLASSROOM AND MANYCHAT DELIVERING ONLINE-OFFLINE (MCDOO) LEARNING FOR SCIENCE, TECHNOLOGY & ENGINEERING CURRICULUM (STEC) STUDENTS

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ABSTRACT

Low physics learning in the Philippines is a prevailing concern the education sector must resolve, so initiating technological interventions in teaching the subject, including flipped classrooms, and introducing a chatbot such as ManyChat Delivering Online-Offline learning could be helpful to improve scientific literacy in learning Electromagnetic (EM) waves. This study aimed to determine the significant learning differences between conventional teaching (CT), Flipped Classroom (FC), and ManyChat Delivering Online-Offline (MCDOO) Learning in teaching EM waves. Previous research showed that flipped classrooms are effective in Physics lessons. At the same time, only a few studies have been found using MCDOO learning effectively in other subjects, yet to be in Physics lessons. The researcher used the randomized posttest-only control group experimental research design with four groups; Conventional Teaching (CT) as the control group while the experimental groups are: Flipped Classroom (FC), ManyChat Delivering Online-Offline (MCDOO) Learning, and lastly, the combined FC+MCDOO learning who underwent different learning sessions (traditional teaching, FC session via google classroom, MCDOO session and FC+ MCDOO via Messenger App respectively). One-Way ANOVA was performed to determine whether there were any significant learning differences. The results showed in the first and second competencies; the null hypotheses are accepted, so all the differences in all four groups are not significant there is not much of a difference between the scores of CT and FC, CT and MCDOO, and FC and MCDOO learning; however, in the third learning competency, the null hypothesis is rejected so then the Tukey Post Hoc test was conducted to point out where is/are the significant difference/s. The Tukey Post Hoc test revealed that CT and FC+MCDOO learning differs significantly. It means that FC+MCDOO learning boosts higher learning achievement than conventional teaching, FC alone, or MCDOO alone. This study concludes that using just one technological intervention in Physics teaching simply cannot produce a significant impact on the physics literacy of the students in EM learning. Utilizing a combination of technological approaches can make a meaningful difference to the literacy rate in Physics lessons, specifically electromagnetic waves.

Keywords: *Conventional Teaching, Flipped Classroom, ManyChat Delivering Online-Offline Learning, Physics Learning, Randomized Posttest-Only Group Design*

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INTRODUCTION

Many centuries ago, education in the Philippines was traditional. The paradigm that the educational system was operating within before has changed. Students used to visit the library and read large books to find the information they required in the past. In the 20th century, searching for a certain item might provide thousands of hits in a split second.

In today's day and age, electronic devices like computers, laptops, smartphones, and tablets have become essential. These are no longer just for entertainment. The education sector in the country currently makes extensive use of them. Filipino learners need access to education even during times of crisis, making the power and significance of technology in education more apparent than ever. In line with this, the Department of Education has established the Digital Rise Program. This holistic framework will address the infrastructure software and capacity-building requirements for digital literacy skills, ICT-assisted teaching and learning, and automation of the department's administrative processes. (DepEd Highlights Digital Rise Program as Key Player in Addressing Challenges in Education Quality | Department of Education, 2022)

Admittedly, before these leaps in Philippine Education, problems regarding the scientific literacy of the students were observed. According to the 2018 findings of the Programme for International Students Assessment (PISA), Filipino students' scientific literacy is below average. Despite implementing the nation's revised basic education curriculum, the Trends in International Mathematics and Science Studies (TIMSS) 2019 scores are poor. These findings from foreign assessments compel academics and policymakers to investigate the combination of curricular components that might contribute to Filipino students' challenging scientific literacy. (PH Grade 4 Students Worst in Math and Science Proficiency: Study, 2020; Statement on the Philippines' Ranking in the 2018 PISA Results | Department of Education, 2019)

Recent initiatives have been made in the Philippines to improve physics education, both at the fundamental and teacher education levels. According to the annual reports from the Department of Science and Technology (DOST), the standard of science instruction in schools is significantly impacted by a lack of teaching resources and technology tools. (Framework for Philippine Science Teacher Education.pdf - FRAMEWORK FOR PHILIPPINE SCIENCE TEACHER EDUCATION Department of Science and | Course Hero, 2020)

The conventional or transmission method of teaching science is still frequently employed. With this approach, students are managed in their education and given knowledge and abilities as "empty vessels that the teacher fills." There is evidence that the transmission model of learning, particularly in elementary school, may, in part, be to blame for the prevalent lack of interest in science among kids in elementary and secondary schools across the nation today. The inadequate quality of science instruction in many Philippine secondary schools can be attributed to the low number of pupils pursuing jobs in science-related fields in higher education.

Another study by Cagande (n.d.) traced how a flipped classroom implementation affected the motivation and comprehension of kinematics graphs in college physics students. They used the Solomon four-group design incorporating quantitative and qualitative methods to collect the needed data. In their investigation, four college physics sections took part. Over the course of about eight sessions, two experimental groups received instructional material created by the researcher for a flipped classroom. The experimental groups considerably outperformed the control groups in terms of gain scores on the Test for Understanding Graphs in Kinematics.

The flipped classroom has been demonstrated to have improved students' knowledge of a Physics lesson in kinematics graphs. This technological intervention has not yet been used to determine its efficacy to more specific lessons in Physics, such as electromagnetism, optics, and other hard-core concepts. The researcher would like to explore this side of the teaching and learning process. To address this issue, the researcher integrated the identified technological interventions in teaching electromagnetics and learning instruction in the City of Naga Integrated Center for Science, Technology, Culture, and Arts in the City of Naga, Cebu, specifically for the Grade 10 learners enrolled in the Science, Technology & Engineering Curriculum (STEC) through the use of Flipped Classroom approach and

ManyChat Delivering Online-Offline (MCDOO) learning. In this study, four groups of STEC students were classified. One group engaged in conventional teaching, another group in flipped classroom approach, the other one in MCDOO learning, then the last group was the combined flipped classroom and MCDOO learning. This study aimed to find if there is a significant difference between these groups in learning Electromagnetic Waves and to see the difference between such interventions. Many will surely benefit from this undertaking, especially teachers who have different specializations and teach lessons in Physics. They will then be guided as to what technological resources or approaches to use, save time from lesson preparation, and gradually be at ease to handle the subject and the students for improved physics academic performance.

Research Questions

1. What are the students' academic performances after conventional teaching? Using a flipped classroom (FC) and ManyChat Delivering Online - Offline (MCDOO) learning in the following 2nd Quarter Most Essential Learning Competencies (MELCs):

1.1 Comparing the relative wavelengths of different forms of electromagnetic waves.
1.2 Citing examples of practical applications of the different regions of EM waves, such as the use of radio waves in telecommunications.
1.3 Explaining the effects of EM radiation on living things and the environment.

2. What are the students' academic performances after undergoing the flipped classroom with ManyChat Delivering Online - Offline learning approach?

3. Is there a significant difference in the academic performance of the students undergoing one approach compared to the combination of the flipped classroom and ManyChat Delivering Online - Offline learning in learning competency 1.1?

4. Is there a significant difference in the academic performance of the students undergoing one approach compared to the combination of the flipped classroom and ManyChat Delivering Online - Offline learning in learning competency 1.2?

5. Is there a significant difference in the academic performance of the students undergoing one approach compared to the combination of the flipped classroom and ManyChat Delivering Online - Offline learning in learning competency 1.3?

REVIEW OF RELATED LITERATURE

This study assumed that using flipped classrooms and ManyChat Delivering Online-Offline Learning to improve students' academic performance in learning electromagnetic waves in Physics is a successful approach. The digital learning theories Substitution & Augmentation, Modification & Redefinition (SAMR) developed by Ruben Puentadura in 2010, provided context for evaluating the quality of the technology task that we integrate into learning, and Technological, Pedagogical, Content, Knowledge (TPACK) developed by Mishra & Koehler (2006) which may prove to be very useful for framing effective learning approaches that leverage technology, serve as the foundation for this study.

The SAMR provides an essential base for assessing the complexity of the technological activities we employ for learning. Substitution and Augmentation (SA) is the enhancement side of the model that may serve some useful purpose (i.e., using word processing software applications is more convenient and efficient than manuscript handwriting), and tasks are grouped under the Transformation side of the model (Modification and Redefinition) give opportunities for learning that nonexistent without technology. An online shared document, for instance, provides chances for collaborative writing and knowledge development that would not otherwise be possible.

The SAMR model should not be viewed as a progression that needs to be completed to be effective. The rich resource of functions that remodel conventional learning methods and provide opportunities that do not exist without the use of technology is what makes the use of technology effective. A substitution or augmentation task might accomplish a certain goal, but it is unlikely to use technology to enhance learning. The efficient application of technology is, without a doubt. This model is beneficial when thinking about learning in school digital/ information learning commons, where technology is plaited into learning constructs, resources, and surroundings. To think about using technology for learning and how to support the learners in the communities, other industries may find the approach useful.

The TPACK model offers a framework for determining the teacher expertise needed to successfully integrate technology into the complicated nature of the larger instructional setting. In TPACK, deep Content Knowledge (the subjects covered in the curriculum) and Pedagogical Knowledge (PK) are best paired with technology knowledge (TK) (teaching strategies and knowledge of the learner). Although it is generally accepted that the confluence of content and pedagogical knowledge forms the basis of good teaching, adding technological knowledge to the equation gives teachers a valuable filter to consider how they approach technology integration truly. By putting instructional preparation via the TPACK model, teachers should be motivated to develop deeper linkages to all facets of effective instruction while removing unnecessary or pointless technology usage. There is no question that the core of teachers is the effective use of technology for learning, and teachers are frequently the "go-to" people at their schools for tech-related issues. When using the TPACK method for instructional planning and evaluating learning activities using the SAMR model as a filter, the teacher can be a key player within the context of a learner. A collaborative teacher inquiry into technology-enhanced learning can be enriched by the additional context that teachers can contribute. So then teachers can provide further assistance for related instruction on digital citizenship.

Learning institutions should be in the business of prioritizing the welfare of learners in creating memories and meaning. One can make more exciting things and learn a lot more by making things generated by utilizing technology. Utilizing technology constructively helps to achieve those goals (Rogerson-Revell, 2015). Teachers and leaders will be better able to concentrate on advancing toward something meaningful if they have a deeper knowledge of how technology is incorporated, infused, absorbed, and diffused within educational contexts. That foundation for advancing toward efficacy with educational technologies is provided by the SAMR and TPACK models.

As a summary of the major findings to date, flipped classrooms utilized in physics courses at two Secondary schools in Germany had a favorable impact. The pupils scored better in the flipped classroom during a topic knowledge test than their peers in the traditional courses. However, during the brief time in the regularly taught courses after three months, interest and motivation drastically declined. In the flipped courses, both variables' values remained constant. This allows for greater development of both cognition and associated non-cognitive attitudes than in typical school environments. It makes better use of class time and encourages deeper learning, and increases student interest in learning. Additional research will examine additional main impacts and moderators on the cognitive and non-cognitive. (Finkenberg, 2019)

Astuti et al. (2021) said that the ideal environment for physics education should integrate ideas through technology. Conventional physics instruction harms students to not be eager to understand physics. There must be improvements in physics education to make it more interactive learning. One of these involved flipping the classroom. Flipping using internet games like Kahoot to supplement classroom instruction gets students to move more. Their objective is that Kahoot-based activities can boost students' desire to study flipped classroom instruction. The procedure employed in their study is, first, the research design used the quasi-experimental technique. Second, flipped classrooms backed by Kahoot as a gauge of evaluation.

According to the Goncharenko (2020) study findings, in the context of the ongoing transformation in Ukraine's education system, special focus should be placed on a range of novel learning methods, techniques, technologies, and procedures. Mobile technology is a learning tool based on the usage of numerous digital and fully portable mobile gadgets that allow operations to receive, operate, and store data, such as cellphones, tablets, and e-books information; using it at general schools, in particular, to apply effectively in Physics research. The principal applications of mobile technology in physics instruction are students must use cloud environments, web services, mobile applications, and websites and browsers carrying on a virtual physical activity while reading theoretical content experimentation, physical problem-solving, homework completion, and control assessments. The potential outcome of an additional investigation will be the creation of their mobile application in physics, which will not only encourage students to pursue a physics course education but also raise the standard of students' education.

Even after graduating from high school and beginning college, students frequently retain their naive understanding of ideas in Physics, like energy and force. To assist them in understanding these ideas in regard to pulleys and the application of simple machines that are challenging to assemble and apply in the real world, a study created a learning environment called the Virtual Physics System (VIPS). The VIPs is notable for several features, including its integration of simulation and tutoring, customization of tutoring to address common misconceptions and use of a pedagogical strategy that identifies misconceptions among students and directs them toward problem-solving through virtual experimentation. Their findings show that the ViPS is effective in assisting students in learning and clearing up their misconceptions and that virtual experimentation in the ViPS is more efficient than actual experimentation with pulleys (Myneni et al., 2013).

In a study conducted by Aşıksoy and Ozdamli (2016), in two classes of a physics course, 66 students were involved in the study. In the first class, the usual lecture format was used, and in the second, the flipped classroom model. The physics self-sufficiency scale, motivation survey, physics concept test, and semi-structured interviews were used to collect the research data. Students in the flipped classroom were found to have higher achievement levels than those in the lecture format. Additionally, the students in the experimental group showed an improvement in motivation and self-sufficiency. After that, semi-structured interviews with the participants in the flipped classroom were administered. They were shown to have favorable opinions of the flipped classroom strategy.

In Turkey, 61 college students enrolled in a Physics-2 course participated in a study. Students in the experimental group learned in a flipped classroom that had been gamified, whereas students in the control group learned in a flipped classroom that had not been gamified. Data were gathered through semi-structured interviews, an electromagnetism accomplishment test, and a physics motivation questionnaire. In comparison to the children in the control group, students have favorable views of the gamified classroom setting. The students who participated in the interviews added that the strategy improved their interest in physics class. Lecturers can benefit from the study's findings (Şengel, 2014).

Another study by He et al. (2015) examined the flipped classroom procedure based on updated teaching technologies and investigated the outcome of the flipped classroom on the participants' understanding of physics models and skills using a three-stage method of literature review, expert Delphi method, open-ended questionnaires, and focus interviews. By comparing the pre-and post-class performance of students who participated in three different learning strategies—a model-based flipped classroom assisted by modern teaching technology (MFC), a flipped classroom (FC), and a model-based classroom—this study used a quasi-experimental methodology. Students who used the MFC method saw significant improvements in all five stages of the physics modeling process and scored higher in all four areas used to measure the effectiveness of classroom instruction, including (1) communication and cooperation, (2) application and learning, and (3) critical thinking.

Amanah et al. (2021) reviewed flipped classroom (FC) research trends for physics education. Their purpose is to discuss the general trends of the available studies, the integration of integrated models or strategies and media into the flipped classroom method, the benefits of flipped learning for physics courses, and the difficulties of these studies. This organized review looked at 33 articles from journals about flipped learning in physics. The data that were derived were passed through content analysis. It was discovered that studies in this sector were typically conducted with undergraduate students, using a pure flipped paradigm, discussion techniques, and institution websites for online media. When compared to standard teaching methods, using the flipping classroom strategy in a physics course improved student achievement.

Prasetyo et al. (2018) evaluated how well the flipped classroom learning paradigm worked in a secondary physics classroom during the 2017 fall semester in Kelapa Gading's Secondary School in Singapore. Three (3) Physics served as the study's subject. Pre-testing was done as the first step in this study, and then the flipped classroom learning approach was used as the treatment. A post-test and questionnaire were presented to the students after the learning process to gauge their opinions of the flipped classroom learning paradigm. 89% of students met the basic requirements for standardization, according to data analysis. The normalized n-gain method was used to analyze the students' increment level in grade, and it produced a normalized n-gain score of 0.4 that falls within the medium category range. Ugwuanyia et al. (2020) determined the impact of the think-pair-share technique and the flipped classroom on student achievement and student retention in physics at the senior level. As a result, it was determined that flipped classrooms are superior in improving physics students' academic performance and retention. Thus, compared to students who were taught using the think pair share technique, flipped classroom pupils performed and remembered information better.

Students from Sto. Nino National High School in Grade 9 had their TLE MPS improved through the study using blended learning and the Manychat app. Two groups of junior secondary learners with the lowest ranking scores were chosen through the use of purposeful sampling. Blended learning or hybrid learning is a theory used to depict educational strategies that combine traditional classroom instruction with online education and resources. However, we may create chatbots for Facebook Messenger using the service known as Manychat. Numerous industries, including marketing and customer support, use chatbots. Pre-test and post-test administration for both the experimental and control groups were evaluated in the study using the performance of Grade 9 Dressmaking students. The study also examined whether there was a statistically significant difference between the results from the pre-test and post-test for both the experimental and control groups. An action plan was put forth for the usage of the Manychat as a teaching tool with T.L.E. 9 students or anybody else interested in the intervention. An experimental approach was taken in the exploration of the study. The following metrics were utilized to evaluate the performance of the intervention program in students: mean scores, standard deviation, dependent and independent t-tests. The study ascertained that by teaching T.L.E. - Dressmaking to grade 9 students effectively using the Blended Method and Manychat, their performance and results on the pretest and post-test have significantly increased through MCDOO and the Blended Method. The study concluded that TLE could be taught using the Blended Method with Manychat to continuously raise student competency levels in the topic (Cadavos, 2022).

RESEARCH METHODOLOGY

Research Design

This study used a randomized posttest-only control group experimental design to find the significant difference between using flipped classroom and ManyChat Delivering Online-Offline learning approach to students in Grade 10 Physics MELCs, which intends to determine the necessary output of the study to help address the need of the students in Physics learning. This study also utilized One Way ANOVA and Tukey Post Hoc Test to undergo the analysis and determine the significant difference between groups with different technological interventions.

Research Respondents

The respondents of the research were the randomly selected 48 Grade 10 learners equally divided into four (4) different groups who have electromagnetic lessons in the second quarter of the school year at the City of Naga Integrated Center for Science, Technology, Culture and Arts, City of Naga Division.

The breakdown of the respondent groups is shown in Table 1.

Table 1 Frequency Distribution of Participants

Test Group	Respondents	Total Population		Total
		Male	Female	
Conventional Teaching	Grade 10 Einstein	4	8	12
Flipped Classroom	Grade 10 – Einstein	4	8	12
MCDOO	Grade 10- Darwin	4	8	12
FC + MCDOO	Grade 10- Darwin	4	8	12
	Total	16	32	48

Research Instrument

The researcher adopted a 10-item post-test of every indicated competency from the Grade 10 Science Quarter 2 module of the Department of Education to get the score or academic performance of the Grade 10 learners in electromagnetic waves. There are a total of 30 item test questions for this research which was used for all four test groups in the post-test. Each item of the test is a multiple-choice type and students will select the most appropriate response from the list of alternatives.

Data Analysis

In analyzing and interpreting the data collected from the respondents, the following statistical tools were used in the research.

Mean Averaging
The scores were tabulated, and the mean scores were calculated.
One Way ANOVA
It was used to determine if there is a significant difference in the performance of the students in the indicated competencies between groups of flipped classrooms and the ManyChat Delivering Online Offline learning approach with conventional teaching and a combination of FC+MCDOO.
Tukey Post Hoc Test.

Post Hoc Test is a supplementary statistical treatment to One-Way ANOVA for determining which groups of technological interventions have significant differences in the scores in Physics. Post hoc (Latin for "after this") tests are used when an analysis of variance (ANOVA) F test reveals that there are significant differences between three or more group means to identify the precise discrepancies. The general nature of the F test is that it will only tell researchers whether there is a difference between the groups, but not between the groups specifically. Only if the measured F test is significant are post hoc tests calculated, which help researchers find those precise differences. The researcher need not look for any differences if the overall F test is nonsignificant. Post hoc tests are only utilized side by side with tests of group difference, such as ANOVA (Wiedmaier, 2020).

RESEARCH FINDINGS AND DISCUSSION

This chapter comprises the presentation, analysis, and interpretation of data of the scores of the respondents after the conventional teaching, flipped classroom, and MCDOO learning of Science, Technology & Engineering Curriculum (STEC) students. With these data, ANOVA and post hoc tests were also presented to show if there is a significant difference in using such teaching instructions in Electromagnetism. As well as to show the significant relationship between such interventions. The data collected in this chapter were arranged following the issues addressed in this study.

1.1 Conventional Teaching

Table 3 Scores of the Students Participants in the Conventional Teaching

Student	First Competency	Descriptor	Second Competency	Descriptor	Third Competency	Descriptor
CT1	7	VS	8	VS	5	S
CT2	8	VS	2	DNM	6	S
CT3	8	VS	3	FS	5	S
CT4	5	S	4	FS	5	S
CT5	8	VS	8	VS	6	S
CT6	10	O	5	S	5	S
CT7	10	O	8	VS	10	O
CT8	5	S	3	FE	7	VS
CT9	6	S	7	VS	8	VS
CT10	7	VS	5	S	4	FS
CT11	8	VS	3	FS	7	VS
CT12	10	O	8	VS	8	VS
Mean	7.67	VS	5.33	S	6.33	S

As shown in the table, three out of twelve students in the group got an outstanding score while the same number of students got the lowest scores of five to six out of ten items which were satisfactory in the first competency. In the second competency, where students related the uses of EM waves, their scores were relatively lower compared to the first competency, where they compared the relative wavelengths of EM. No student got an outstanding score, while the lowest score was two which means they did not meet the expectations, and four students got three to four out of ten. In the third competency which is to explain the effects of EM waves on living things and the environment, most of the students got low scores within the score range of five to six. Most of the student participants, about nine out of twelve got a very satisfactory rating in the first competency but decreased to five students only in the second and third competencies. The mean score of the participants in conventional teaching is 7.67 which is very satisfactory in the first competency, 5.33 which is satisfactory in the second competency, and 6.33 which is satisfactory in the third competency. Students in conventional teaching performed better in the first competency compared to the second and third competencies. These scores are consistent with the Higher Order Thinking Skills (HOTS) of Bloom's Taxonomy of Educational Objectives: The Classification of Educational Goal which explains that higher-order thinking skills take thinking to higher levels than just understanding the facts. It requires doing something from the acquired knowledge which is why the higher the skill required, the harder it is to attain excellent performance. In this case, the second and third learning, competencies (citing practical applications and explaining the effects on living things and the environment) are higher ordered compared to the first, which is to compare the wavelengths of EM waves. The students in this group, like the rest of the groups, were randomly selected from the Science, Technology, and Engineering Curriculum Grade 10 Students who passed the three entrance screening procedures required by the policy standard of the special science curriculum of the Department of Education upon entry to Grade 7. Thus, all the student participants are homogenous in grouping, and no extraneous variables might affect their performance.

1.2 Flipped Classroom

Table 4 Scores of the Student Participants in the Flipped Classroom

Student	1st competency	Descriptor	2nd competency	Descriptor	3rd competency	Descriptor
FC1	10	O	6	S	8	VS
FC2	9	O	8	VS	9	O
FC3	9	O	6	S	8	VS
FC4	2	DNM	6	S	6	S
FC5	3	FS	7	VS	7	VS
FC6	9	O	7	VS	8	VS
FC7	3	FS	5	S	3	FS
FC8	10	O	7	VS	9	O

FC9	10	O	10	O	10	O
FC10	10	O	6	S	5	S
FC11	7	VS	6	S	6	S
FC12	9	O	7	VS	9	O
Mean	7.58	VS	6.75	S	7.33	VS

Table 4 shows the scores of the students in the flipped classroom with a total of twelve participants. The tabular data shows that the scores are consistently very satisfactory from the first to the third competency. Eight were marked with outstanding scores, while only one did not meet the expectation in the first learning competency. In the second and third learning competencies, there was a decrease in the scores of the students, but still, their average was very satisfactory. One of the students gained an outstanding score, while the rest was very satisfactory and satisfactory in the second learning competency, while four students in the third competency were outstanding, and the rest were very satisfactory and satisfactory. The mean average scores showed that the student participants performed very satisfactorily, better in the first competency than in the second and third competencies, which were consistent with HOTS. The same with other groups; they were randomly selected. Because they were randomly selected, some students in this group need access to a stable internet connection, and they need to log in to google classroom and watch videos. This might be the factor why their scores were not that significantly higher than the conventional group.

1.3 MCDOO Learning

Table 5 Scores of the Student Participants in the MCDOO Learning

Students	First Competency	Descriptor	Second Competency	Descriptor	Third Competency	Descriptor
ML1	10	O	9	O	7	VS
ML2	10	O	5	S	7	VS
ML3	10	O	8	VS	9	VS
ML4	2	DNM	6	S	5	S
ML5	10	O	10	O	9	O
ML6	10	O	6	VS	7	VS

ML7	10	O	6	VS	8	VS
ML8	10	O	9	O	8	VS
ML9	10	O	10	O	7	VS
ML10	10	O	6	S	8	VS
ML11	9	O	5	S	9	O
ML12	10	O	6	S	10	O
Mean	9.25	O	7.17	VS	7.83	VS

As shown in Table 5, out of twelve students, a whopping eleven were outstanding in the first competency. The same in conventional and flipped classrooms; their scores tend to lower in the second and third learning competencies, wherein four are outstanding. Most students in the second competency were satisfactory, while very satisfactory in the third competency. The students were outstanding in the first competency and very satisfactory in the second and third learning competencies. Like the preceding groups, their scores in the first competency are higher compared to the last two competencies consistent with Higher Order Thinking Skills (HOTS). They were highest in the first competency and lowest in the second competency, which was to cite practical examples. Students also were randomly selected, but unlike the FC group, access to a stable internet connection was not a problem since MCDOO learning can deliver instruction and chatbot responses offline, so students can access learning with or without the internet. Compared to the preceding groups, this group performed better since most were outstanding in the first competency and very satisfactory in the rest of the competencies. Some factors like social media distraction might affect their focus, but MCDOO has an automatic chatbot follow-up message when students are unresponsive for a particular hour and sees their responses through time.

2. Flipped Classroom with MCDOO Learning

Table 6 Scores of the Student Participants in FC+MCDOO

Students	1st competency	Descriptor	2nd competency	Descriptor	3rd competency	Descriptor
FC+MCDOO1	10	O	8	VS	7	VS
FC+MCDOO2	9	O	8	VS	9	O
FC+MCDOO3	10	O	4	FS	8	VS

FC+MCDOO4	10	O	5	S	7	VS
FC+MCDOO5	9	O	6	S	10	O
FC+MCDOO6	2	DNM	7	VS	7	VS
FC+MCDOO7	9	O	6	S	8	VS
FC+MCDOO8	9	O	7	VS	10	O
FC+MCDOO9	10	O	9	O	10	O
FC+MCDOO10	10	O	6	S	9	VS
FC+MCDOO11	10	O	9	O	6	S
FC+MCDOO12	10	O	10	O	10	O
Mean	9	O	7.08	VS	8.42	VS

Table 6 shows the scores and the descriptor of the third group with flipped and MCDOO learning. The scores of the students were still astonishing, with eleven out of twelve outstanding in the first competency, three outstanding in the second competency, and six outstanding in the third competency. Remarkably, No one got below satisfactory in the first and third competencies, while only one got fairly satisfactory in the second learning competency. Students show an average score of nine out of ten in the first learning competency while 7.08 and 8.43 in the second competency, respectively. It shows that the students were outstanding in the first competency and very satisfactory in electromagnetic waves' second and third competencies. Same with all groups, the students were randomly selected. They were homogenous in the grouping, and like the rest of the groups, they performed academically well in the first competency but lower in the third competency. They were lowest in the second competency inherent with HOTS. In this FC+MCDOO group, students with an internet connection can benefit from FC and MCDOO. However, students in this group without access to stable internet were not left behind since MCDOO was available offline and monitored responses over time. Optimal Resource theory supports this notion that if adequate resources were integrated into one place, student development, and learning would occur.

2.2 Average scores of all four groups: Conventional Teaching, Flipped Classroom, MCDOO Learning & Flipped Classroom with MCDOO Learning

Table 7 Mean Posttest Scores of all four groups

	Fist Competency	Second Competency	Third Competency

Teaching Approaches	Mean Score	Descriptor	Mean Score	Descriptor	Mean Score	Descriptor
CT	7.67	VS	5.33	S	6.33	S
FC	7.58	VS	6.75	S	7.33	VS
MCDOO	9.25	O	7.17	VS	7.83	VS
FC+MCDOO	9	O	7.08	VS	8.42	VS

Table 7 shows the average scores of all four groups in the three learning competencies in EM waves. The mean score in conventional teaching for the first competency was 7.67, which was very satisfactory, while 5.33 was satisfactory and 6.33 or satisfactory in the second and third competencies. On the other hand, in the flipped classroom, the group is consistently very satisfactory for all three competencies. In MCDOO learning, students are outstanding, with an average score of 9.25 in the first competency, 7.17, and 7.83, which were very satisfactory in the corresponding competencies. The flipped classroom with MCDOO learning students' performance was outstanding, with nine out of ten in the first competency and 7.08 and 8.43 very satisfactory in the last two competencies, respectively. The MCDOO group performed best of all the groups, while the FC group performed the lowest in the first competency. Students in the conventional groups performed lowest, while the MCDOO group performed the highest in the second competency. In explaining the effects of EM waves on living things and the environment, students in the FC+MCDOO group performed the highest, while the conventional group was the lowest. The Optimal Resource theory framework for enhancing student achievement discussed by Anderson (2015) supports this idea that if adequate resources are integrated into one place, student development and learning will occur.

3. Mean Standard Deviation, ANOVA Table, and F Table of all four groups for the first competency

Table 8 Mean Standard Deviation Table of the Four Groups in the First Competency

X_1	X_1^2	X_2	X_2^2	X_3	X_3^2	X_4	X_4^2	
10	100	10	100	10	100	7	49	
9	81	10	100	9	81	8	64	
9	81	10	100	10	100	8	64	k= 4
2	4	2	4	10	100	5	25	n= 12
3	9	10	100	9	81	8	64	N= 48

9	81	10	100	2	4	10	100	G= 402
3	9	10	100	9	81	10	100	$\sum X^2$=3648
10	100	10	100	9	81	5	25	
10	100	10	100	10	100	6	36	
10	100	10	100	10	100	7	49	
7	49	9	81	10	100	8	64	
9	81	10	100	10	100	10	100	
91	795	111	1085	108	1028	92	740	
7.583333333		9.25		9		7.666666667		
104.9166667		58.25		56			34.66666667	

Table 8 shows the scores of the four groups of students taking the first competency. The conventional method has an average of 7.67 which is very satisfactory.

Table 9. ANOVA Table of the Four Groups for the First Competency

Source	SS	df	MS	F
Between treatments	27.41666667	3	9.138888889	1.620157
Within Treatments	253.8333333	45	5.640740	
Total	281.25	48		

Table 9 shows the ANOVA Table for the first competency with the f value of 1.62.

Table 10 Tabular F and Computed F in the First Competency

Tabular F=	2.798
Compute f=	1.620157

Table 10 shows the computed F value of 1.62 and the tabular F of 2.798. Since the computed F is not greater than the tabular f, the null hypothesis is accepted for the first competency.

4. Mean Standard Deviation, ANOVA Table, and F table of all four groups for the second competency

Table 11 Mean Standard Deviation Table of the Four Groups in the Second Competency

X_1	X_1^2	X_2	X_2^2	X_3	X_3^2	X_4	X_4^2	
6	36	9	81	8	64	8	64	
8	64	5	25	8	64	2	4	
6	36	8	64	4	16	3	9	k= 4
6	36	6	36	5	25	4	16	n= 12
7	49	10	100	6	36	8	64	N= 48
7	49	6	36	7	49	5	25	G= 316
5	25	6	36	6	36	8	64	$\sum X^2$=2260
7	49	9	81	7	49	3	9	
10	100	10	100	9	81	7	49	
6	36	6	36	6	36	5	25	

6	36	5	25	9	81	3	9
7	49	6	36	10	100	8	64
81	565	86	656	85	637	64	402
6.75		7.1666666 67		7.0833333 33		5.3333333 33	
18.25		39.666666 67		34.916666 67			60.666666 67

Table 11 shows the scores of the four groups of students taking the second competency. The Flipped Classroom method has an average of 6.75 which is satisfactory.

Table 12 ANOVA Table of the Four Groups in the Second Competency

Source	SS	df	MS	F
Between treatments	26.16666667	3	8.722222222	2.557003
Within Treatments	153.5	45	3.411111	
Total	179.6666667	48		

Table 12 shows the ANOVA Table for the second competency with the f value of 2.557.

Table 13 Tabular F and Computed F in the Second Competency

Tabular F=	2.798
Compute f=	2.557003

Table 13 shows the computed F value of 2.557 and the tabular F of 2.798. Since the computed F is not greater than the tabular f, the null hypothesis is accepted for the second competency.

1. Mean Standard Deviation, ANOVA Table, and F table of all four groups for the third Competency.

Table 14 Mean Standard Deviation Table of the Four Groups in the Third Competency

X_1	X_1^2	X_2	X_2^2	X_3	X_3^2	X_4	X_4^2	
8	64	7	49	7	49	5	25	
9	81	7	49	9	81	6	36	
8	64	9	81	8	64	5	25	k= 4
6	36	5	25	7	49	5	25	n= 12
7	49	9	81	10	100	6	36	N= 48
8	64	7	49	7	49	5	25	G= 359
3	9	8	64	8	64	10	100	$\sum X^2$=2833
9	81	8	64	10	100	7	49	
10	100	7	49	10	100	8	64	
5	25	8	64	9	81	4	16	
6	36	9	81	6	36	7	49	
9	81	10	100	10	100	8	64	
88	690	94	756	101	873	76	514	
7.333333333		7.833333333		8.416666667		6.333333333		

44.66666667	19.66666667	22.91666667	32.66666667

Table 14 shows the scores of the four groups of students taking the third competency. The MCDOO Learning group has an average of 8.42 which is very satisfactory.

Table 15 ANOVA Table of the Four Groups for the Third Competency

Source	SS	df	MS	F
Between treatments	28.0625	3	9.354166667	3.510250
Within Treatments	119.9166667	45	2.664814	
Total	147.9791667	48		

Table 15 shows the ANOVA Table for the third competency with the f value of 3.51.

Table 16 Tabular F and Computed F in the Third Competency

Tabular F=	2.798
Compute f=	3.510250

Table 16 shows the computed F value of 3.510 and the tabular F of 2.798. Since the computed F is greater than the tabular f, the null hypothesis is rejected for the third competency. It means that the scores of the students between the four groups of teaching approaches: CT, FC, MCDOO, and FC+MCDOO have a significant difference between groups of teaching approaches in the third learning competency of EM waves.

Table 17 Tukey Post Hoc Test

Tukey Post-Hoc Test – Post test Score

		CT	FC	MCDOO	FC+MCDOO
CT	Mean difference	—	-1.00	-1.500	-2.083 *
	p-value	—	0.456	0.132	0.018
FC	Mean difference		—	-0.500	-1.083
	p-value		—	0.880	0.385
MCDOO	Mean difference			—	-0.583
	p-value			—	0.822
FC+MCDOO	Mean difference				—
	p-value				—

Note. * p < .05, ** p < .01, *** p < .001

Table 17 shows the Tukey Post Hoc Test results to determine where the groups differ significantly. It shows that Conventional Teaching (CT) and Flipped classrooms with MCDOO Learning differ significantly. Table 17 highlights the overall mathematical interpretation of the participant's scores in electromagnetism undergoing Conventional Teaching, Flipped classroom, MCDOO Learning, and Flipped Classroom with MCDOO Learning in explaining the effects of electromagnetic waves on living things and the environment. The data revealed the p-value between CT and FC is 0.456, CT and MCDOO is 0.132, FC and MCDOO is 0.880, FC and FC+MCDOO is 0.385, MCDOO and FC+MCDOO is 0.822, which are all greater than 0.05. Thus, there mean differences are not significant; however, between CT and FC+MCDOO, the results revealed that the p-value is 0.018, which is lower than 0.05. Thus, there is a significant difference between these two strategies: Conventional Teaching and FC+MCDOO learning.

Overall, in the first and second competencies, the null hypotheses are accepted; therefore, all four groups' differences are insignificant. However, in the third learning competency, the null hypothesis is rejected, so there is a need to undergo the Tukey Post Hoc test to point out where is/are the significant difference/s. It was revealed through the Tukey Post Hoc Test that Conventional and FC+MCDOO learning is statistically significantly different in teaching interventions to the understanding of Electromagnetism. This result means that FC+MCDOO learning boosts higher learning achievement than conventional teaching, FC alone, or MCDOO alone. This result also lends credence to the Combination Learning Model, which asserts that learners learn most effectively when given learning experience and instruction by way of a varied combination of two or more learning constituents. It is a procedure-based theory that emphasizes how students learn and personalize their learning path on a given topic. Yilmaz (2021) also found out that technology integration has a positive change in critical and creative thinking, multidimensional 21st-century learning skills as well as on academic performance.

CONCLUSION

It was revealed that using Flipped Classroom and ManyChat Delivering Online-Offline Learning is not significantly different from Conventional Teaching in Electromagnetic Waves in the first and second competencies. It means that the academic performance of the participants in FC, MCDOO, and FC+MCDOO is not that high compared to the scores of conventional teaching. However, in the third competency, explaining the effects of EM waves on living things and the environment, statistics revealed a significant difference. The scores of the students in the combined flipped classroom and MCDOO learning were significantly higher than the conventional teaching.

Analysis of the results simply means that after the conduct of the flipped classroom and MCDOO learning as teaching and learning strategies in analyzing the Physics performance in electromagnetism of Science, Technology & Engineering Curriculum students, a significant effect took place. A substantial change in the levels of Physics performance in electromagnetism is observable; a shift from satisfactory scores to high outstanding test results is evident. Thus, flipped classrooms and MCDOO learning positively affect students' struggling scientific literacy in electromagnetism and are good teaching strategies or methods when associated or combined, as revealed by the Post Hoc test, especially for higher-order thinking skills- based learning competencies like explaining the effects of EM waves. It also accounts for and is supported by Padak 2018.

Furthermore, the result showed that the participants in MCDOO and FC+MCDOO learning are consistently higher from the first to the third competencies in their physics performance in electromagnetism. From these, Most of them achieved an outstanding level of performance, while some achieved Very Satisfactory performance. It states that participants performed primarily in the flipped classrooms with MCDOO learning. Some were in the flipped classroom and MCDOO learning groups, however the majority were in both interventions. To sum up, flipped classrooms and MCDOO learning as technological interventions have a significant impact on Physics performance in electromagnetism of STEC learners compared to the traditional way of teaching EM waves.

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