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Research Article

Effects of the Technology-Enhanced Lessons in Optics (TELO) on the Academic Performance of Grade 10 Students

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ABSTRACT

This study investigated the effects of Technology-enhanced Lessons in Optics (TELO) on the academic performance of grade 10 students. A researcher-made Physics Achievement Test was used to measure student performance, and mean scores were utilized to describe the student's performance in both pretests and post-tests. The study employed statistical tests, including the t-test of difference between dependent samples and the t-test of difference between means of two independent samples, to analyze the data.

During the 2nd Quarter of the School Year 2022-2023, the Technology-enhanced Lessons in Optics (TELO) intervention was implemented for twenty meetings with grade 10 Science, Technology, and Engineering students. The control and experimental groups, consisting of two heterogeneous students, were randomly assigned. Pretest and post-test scores showed a significant improvement in both groups, indicating the acquisition of knowledge and skills. However, the experimental group achieved significantly higher scores in the post-test. TELO's interactive features and ICT-based instruction facilitated active learning and enhanced student performance. The study provides evidence for the effectiveness of TELO in improving the academic performance of grade 10 students, highlighting the value of interactive and ICT-based approaches grounded in constructivist principles and the SAMR model in enhancing Physics learning outcomes.

Keywords*: Academic performance, Constructivism, Effects, ICT-based, TELO.*

Introduction

Science is important and indispensable because of its links to technology and industry. This is evident with the appearance of its numerous contributions like that of the great scientific inventions and innovations that ultimately paved the way to modernization. Thus, it plays a big role in human and societal development and progress.

The K to 12 curriculum promotes technology for engaging, effective, and efficient instruction. The Science curriculum must be inquiry-based and Information and Communications Technology (ICT)–based. In the pursuit

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of ICT in education, Republic Act 10844 prioritizes the provision of Wi-Fi access at no charge in selected public places including parks, plazas, public libraries, schools, government hospitals, train stations, airports, and seaports. This ICT-supported education allows students to use learned skills in other academic content areas, motivates them to learn more, provides them opportunities to collaboratively learn with other learners, and helps them develop various intelligences (Bonifacio, 2013).

The use of e-learning is becoming a global issue now. In the educational field, many institutions already use it. The study is very important and aims to test the feasibility and effectiveness of developing instructional materials for e-learning based on blended learning. As to the performance of Filipino students in the international and national assessments, Paris (2019) reported that the Philippines was ranked 79th in reading in the 2019 Program for International Student Assessment (PISA), as indicated by its very low average of 340 compared to the international average of 487. In addition, Filipino learners scored poorly in Mathematics and Science, as indicated by the low averages of 353 and 357 points, respectively. For both areas, the score is significantly lower than the international average of 489. Furthermore, according to Albano (2021), the National Achievement Test (NAT) results for 2018 revealed that the national average mean percentage score (MPS) continued to decline, with the lowest performance in the history of the Department of Education's standardized examination.

With the adoption of the new curriculum, the same old problems in the education sector were not addressed. Still, there are shortages of classrooms, textbooks, seats, and toilets in public schools (Figueroa, 2016). The excessive teaching loads of teachers (Esguera, 2018), the difficulty in following the spiral progression approach in teaching (Dunton & Co, 2019), the scarcity of instructional materials (Mercado & Ching, 2016), the presence of big class sizes (Esguera, 2018), and the inadequate training for teachers (David, Albert & Vizmanos, 2019), are still there.

With the developed material by Calzada and Antonio (2018), this study aimed to determine the effects of the TELO on the academic performance of grade 10 students in learning electromagnetic spectrum and light concepts.

ICT Integration in Science Education

Technology-based learning is the prima donna today and is believed to be able to facilitate educators in transferring knowledge (). The K to 12 Basic Education Program of the Department of Education (DepEd) is aligned with curriculum standards set forth under R.A. 10533 otherwise known as Enhanced Basic Education Act of 2013. It radiates new features that will truly refit the present basic education system. The K to 12 program is aimed at making the curriculum relevant to the learners and easy to understand. Students acquire in-depth knowledge, skills, values, and attitudes through continuity and consistency across all levels and subjects. Likewise, Information & Communications Technology (ICT) is included in the enhanced curriculum (K to 12 Program Curriculum Guide, 2013).

Integrating ICT in the teaching-learning process has become a great concern for many educators in K to 12 schools in the Philippines. In the pursuit of ICT in education, Republic Act 10844 prioritizes the provision of Wi-Fi access at no charge in selected public places including parks, plazas, public libraries, schools, government hospitals, train stations, airports, and seaports. This ICT-supported education will allow students to use learned skills in other academic content areas, motivate them to learn more, provide them opportunities to collaboratively learn with other learners, and help them develop various intelligences (Bonifacio, 2013). Technology integration in education has opened up new opportunities for interactive learning experiences. Hence, teachers must identify appropriate technological tools and resources to effectively incorporate educational technology to support their teaching objectives and engage students in meaningful learning experiences. Teachers must also assess students' technical skills and design activities appropriate for their technological competency level (Mariscal et al, 2023). In sum, the above citations imply that constant evaluation of teacher competence and high-quality instructional materials are required to ensure excellent delivery of instruction in the field. This assessment determines weaknesses and strengths in the system and identifies relevant challenges that can solve the ailing condition of a country's education system.

Technology-Enhanced Lessons

The use of technology in the classroom is increasingly prevalent for good reasons, including students' familiarity with this medium and its flexibility, which enables students to actively engage as manipulators rather than passive spectators. Technology-enhanced Physics teaching includes computer-simulated instruction, interactive games, video clips, and slideshow presentations.

Ubiña (2002) stressed that computer simulation of physical phenomena is one of the most practical and realistic uses of computers in tracking and learning Physics. Learners can observe, explore, recreate, and receive immediate feedback about real objects, phenomena, and processes that would otherwise be too complex, time-consuming, or dangerous.

Teachers can focus students' attention on learning objectives when real-world environments are simplified, the causality of events is clearly explained, and unnecessary cognitive tasks are reduced through a simulation (Bell & Smetana, 2010).

In the study of Wieman (2001), it was found that the computer simulation technique used in Physics experiments has changed the traditional model of experiment teaching. It solves the problem of the shortage of teaching resources, and it is helpful for the students to carry out the opening study. Ubiña (2002) further mentioned that the use of animation and simulation in combination with demonstration could improve the teaching of Physics.

Adams (2010) also pointed out that careful analysis revealed that simulations showing the invisible with the use of analogy help students build a conceptual understanding of Science concepts. Hence, appropriate scaffolding of the material is needed to help students build a mental framework for the concept (Batuyong, 2017).

Research indicates that interaction with computer simulations results in significant achievement gains. Studies consistently show that simulations are at least as effective, if not more so, than traditional instructional methods.

Additionally, the use of interactive games, video clips, slideshow presentations, and other multimedia materials has been proven to be effective instructional tools for teaching Physics.

Teaching and learning are inseparable, and they occur at the same time. A teacher to be effective in his role in the learning process, must realize that the student must be the center of the educative process and devise a learning method that suits his learners' needs as stressed by the theory of constructivism coupled with the appropriate integration of ICT that enhances and transforms learning, thus creating lifelong learners.

Methods

Design

This descriptive study followed the true-experimental design to determine the effectiveness of the TELO in improving the academic performance of grade 10 students.

Sample and Data Collection

The tryout of the developed and validated TELO to the 37 Grade 10 Science Technology and Engineering (STE) Program students of Sarrat National High School, Sarrat, Ilocos Norte for twenty (20) meetings. Another equivalent class was taken as a control group by random assignment. The TELO was used as instructional material in teaching Physics concepts, particularly Optics in addition to the traditional chalk-talk and laboratory method.

The following steps, modeled after Tumaneng (2010), guided the researchers during the tryout phase: (a) Setting the students' mood. The teacher explained to the students that participation in the activities is fundamental to the success of the study. (b) Conducting the pretest. The 50-item test on Physics concepts was administered as a pretest to the experimental and control classes to determine their prior knowledge of the lessons. (c) Administering the lessons using TELO. The experimental group was provided with the TELO and experiences designed to help them understand and acquire Physics concepts. Every time they finished a lesson, they were instructed to write at most five (5) sentences as feedback on what they did. The control group was taught the same topic using the usual lecture or traditional method wherein the researchers used graphic organizers and pictures to discuss the concepts. (d) Conducting the post-test. After exposing the experimental class to the lessons found in the TELO and the control class to the same lessons but via the lecture or traditional method, the same test on Physics concepts was administered to both groups as post-tests to determine the knowledge and skills gained by them and the effectiveness of the TELO.

Data Analysis

The t-test of difference between dependent samples was used to find out if there was a significant gain in the test scores within each of the experimental group and control group and the t-test of difference between means of two independent samples to compare the two groups. The level of significance was set at the 0.05 probability level.

Result and Discussion

Effectiveness of the Technology-Enhanced Lessons in Optics (TELO)

The frequency and percentage distribution of the pretest scores of the experimental and control groups are shown in Table 1. Results show that in the experimental group, 36 (97.30%) of the students got scores within the score range of 11-20 with a descriptive interpretation of fair, while one (2.70%) got scores within the range of 21-30 with a descriptive interpretation of satisfactory.

Table 1. Distribution of pretest scores of the experimental group and the control group.

Scores	Descriptive Interpretation	Experimental Group		Control Group	
		f	%	f	%
41-50	Outstanding	0	0	0	0
31-40	Very Satisfactory	0	0	0	0
21-30	Satisfactory	1	2.70	0	0
11-20	Fair	36	97.30	34	91.89
0-10	Poor	0	0	3	8.11
Total		37		37	
Mean		14.78 (Fair)		14.76 (Fair)	
SD		2.47		2.52	

In the control group, 34 (91.89%) of the students got scores in the score range of 11-20 with a descriptive interpretation of *fair*, and 3 (8.11%) scored in a range of 0-10 with a descriptive interpretation of *poor.* The mean scores of the experimental and control groups which are 14.78 and 14.76, respectively, indicate that the students are not yet fully aware of the Physics concepts, particularly in Electromagnetic Spectrum and Light.

Table 2. Results of the t-test of difference between the pretest mean scores of the students from the experimental and control groups.

Group	n	Pretest Mean Score	Diff	t-value	p
Exp	37	14.78	0.02	0.047^{ns}	0.963
Control	37	14.76			

$p>0.05$

Comparing the pretest mean scores of the two groups, the results of the t-test displayed in Table 2 below show that the pretest mean score of the students in the experimental group (14.78) is not significantly different from the pretest mean score of the students in the control group (14.76) as indicated by t-value of .047, the probability value of 0.963 which is greater than 0.05 probability value.

This indicates that the experimental and control groups have the same entry-level knowledge of the topics covered by the TELO, hence the two groups are equivalent.

Level of Performance of the Experimental and Control Groups in the Post-test

Table 3 below shows the distribution of the post-test scores of the experimental group and the control group. In the experimental group, 36 (97.30%) of the students had an outstanding performance as they got scores within the score range of 41-50 while one (2.70%) got a score within the score range of 31-40 which is described as very satisfactory.

Table 3. Distribution of post-test scores of the experimental group and the control group.

Scores	Descriptive Interpretation	Experimental Group		Control Group	
		f	%	f	%
41-50	Outstanding	36	97.30	1	2.70
31-40	Very Satisfactory	1	2.70	2	5.41
21-30	Satisfactory	0	0	29	78.38
11-20	Fair	0	0	5	13.51
0-10	Poor	0	0	0	0
Total		37		37	
Mean		45.46 (Outstanding)		24.16 (Satisfactory)	
SD		2.08		5.41	

In the control group, 29 (78.38%) of the students got scores within the score range of 21-30 in the satisfactory level, 5 (13.51%) were within the range of 11-20 in the fair level, 2 (5.41%) were within the score range of 31-40 in the very satisfactory level and one (2.70%) was within the range of 41-50 in the outstanding level.

The mean score of the experimental group is 45.46 with a descriptive interpretation of outstanding while the control group has a mean score of 24.16 with a descriptive interpretation of satisfactory. This means that both groups were able to increase their post-test scores after teaching them Electromagnetic Spectrum and Light concepts using the TELO for the experimental group and the traditional lecture-discussion method for the control group.

Table 4 below shows the results of the t-test between the pretest and post-test mean scores of the students from the experimental and control groups.

It can be deduced from Table 4 that the pretest mean score of the experimental group (14.78) is significantly lower than its post-test mean score (45.46) as evidenced by the mean difference of 30.68 with a computed t-value of 57.778 that has a probability of 0.000 which is less than the 0.05 probability value. Also, in the control group, the pretest mean score (14.76) of the students is significantly lower than their post-test mean score (24.16) as evidenced by the mean difference (9.40) with a computed t-value of 9.588 with a probability of 0.000 which is less than the 0.05 probability value.

Table 4. Results of the t-test of difference between the pretest and post-test mean scores of the students from the experimental and control groups.

Group	n	Pretest Mean Score	Post-test Mean Score	Diff	t-value	p
Exp	37	14.78	45.46	30.68	57.778**	0.000
Control	37	14.76	24.16	9.40	9.588**	0.000

**p<0.01

Results of the t-tests of difference between the pretest and post-test mean scores of the students from the experimental and control groups indicate a significant difference in the increase of the mean post-test scores of both groups. This further implies that the students in both groups have gained significantly and had a clearer understanding of the Optics concepts presented to them.

Comparing the post-test mean scores of the experimental and control groups, it can be gleaned from the results of the t-test presented in Table 5 that the post-test mean score of the students in the experimental group (45.46) is significantly higher than the post-test mean score of the control group (24.16) as indicated by the computed t-value of 22.362 with a probability of 0.000 which is less than the 0.01 level of significance.

Table 5. Results of the t-test of difference between the post-test mean scores of the students from the experimental and control groups.

Group	n	Post-test Mean Score	Diff	t-value	P
Exp	37	45.46	21.30	22.362**	0.000
Control	37	24.16			

**p<0.01

This implies that the students in the experimental group, having obtained the higher post-test mean score, were able to develop a better and clearer understanding of the Electromagnetic Spectrum and Light concepts covered in the study than their counterparts.

This implies that the use of the Technology-Enhanced Lessons in Optics (TELO) is more effective in teaching Electromagnetic Spectrum and Light concepts than the use of the traditional lecture-discussion method.

In support of the presented results above, students' journal entries were analyzed. It was noted that the usually inattentive students were listening intently and doing their tasks religiously. When interviewed, the students said that they learned a lot answering the activities and assessment exercises. The warm-up activities were very exciting; it was a must to be alert and remain focused on clicking the spaceships. The video clips were informative and educational. The video clips, interactive games, and simulations enhanced their understanding of lessons that are often difficult to grasp during regular discussions. Their quiz scores were even higher. These observations are evident in the following journal entries of the students:

> Student F: The TELO is a user-friendly material; it requires me to be independent of my learning.

> Student G: With the help of the video clips and simulations, my retention of the concepts is high.

> Student H: The videos and games are very educational, and my quiz scores are even higher this time.

> Student I: The graphics are very pleasing, and the animations are enticing.

The findings from the students' statements provide valuable insights into the use of Technology-Enhanced Lessons in Optics (TELO) for teaching Electromagnetic Spectrum and Light concepts. The students unanimously agree that TELO is a user-friendly material that fosters independent learning. They appreciate the convenience and ease of navigating through TELO, enabling them to take charge of their own learning experiences.

Furthermore, the students recognize the effectiveness of TELO's visual elements, such as video clips, simulations, and interactive games. These visual components not only enhance their comprehension but also contribute to better retention of the concepts covered. The students find the visual media engaging and educational, acknowledging the positive impact on their understanding and ability to recall information.

The use of TELO positively affects the students' academic performance. Their quiz scores are reported to be higher after using TELO, indicating improved learning outcomes. The students attribute this improvement to the educational value embedded in TELO's videos, games, and interactive elements. By providing additional learning opportunities beyond traditional lectures, TELO has proven to be a valuable tool for reinforcing understanding and facilitating knowledge application.

Additionally, the students express appreciation for the aesthetic appeal of TELO. The visually pleasing graphics and enticing animations enhance their overall learning experience. These elements capture their attention and contribute to sustained engagement with the material.

The students' statements collectively emphasize the effectiveness and positive impact of TELO in teaching Electromagnetic Spectrum and Light concepts. TELO's user-friendly nature, complemented by engaging visual elements, promotes independent learning and facilitates a deeper understanding of the subject matter. The educational value embedded in TELO's resources is evident in the students' improved quiz scores. Furthermore, the aesthetic appeal of TELO enhances student engagement and enjoyment of the learning process. Overall, these findings support the value of integrating technology-enhanced materials like TELO to enhance student learning outcomes and foster an enriched educational experience.

The results show that the TELO provides audio, visual, and aesthetic designs that could arouse, motivate, and enhance learners' interest. The TELO is composed of graphics, illustrations, motion pictures, animations, and simulations that further discuss the content of the lessons. These characteristics of the TELO made the students more interested and focused on their lessons.

The study's results are consistent with Tutaan's (2014) findings, which highlight the practicality and usefulness of e-learning materials for instructional purposes. Students are satisfied with the active learning model and the students are also provided more opportunities to learn by themselves which results in their higher learning achievement.

The results of the study indicate that the use of Technology-Enhanced Lessons in Optics (TELO) was more effective in teaching Electromagnetic Spectrum and Light concepts compared to the traditional lecture-discussion method. The t-test revealed that the experimental group, which utilized TELO, obtained a higher post-test mean score, suggesting that they developed a better and clearer understanding of the concepts covered in the study.

The students' journal entries further supported these findings. Typically, inattentive students were observed to be listening intently and actively engaging with the tasks assigned through TELO. In interviews, the students expressed that they learned a lot through the activities and assessment exercises. They found the warm-up activities exciting and felt the need to remain focused while interacting with the interactive elements, such as clicking spaceships. The video clips provided valuable information and contributed to their understanding of the lessons, which may have been challenging to grasp through traditional discussions alone. Notably, their quiz scores were also higher, indicating an improvement in learning outcomes.

These results align with previous research conducted by Tutaan (2014), which supports the practicality and usefulness of e-learning materials for instructional purposes. The active learning model facilitated by TELO allowed students to take a more self-directed approach to learning, resulting in higher achievement levels.

In summary, the study provides evidence that the use of TELO in teaching Electromagnetic Spectrum and Light concepts surpasses the effectiveness of traditional lecture-discussion methods. The students' positive experiences, increased engagement, and improved learning outcomes highlight the benefits of incorporating e-learning materials and active learning strategies in the classroom.

Conclusion

The use of e-learning materials, such as Technology-enhanced Lessons in Optics (TELO), has been shown to have a positive impact on student academic performance. One of the key benefits of TELO is its interactive features, which actively engage students in the learning process. When students are actively involved and participating in their learning, they tend to become more motivated and invested in the subject matter, leading to increased effort and a deeper understanding of the material.

By incorporating interactive elements, TELO helps to enhance student engagement. This increased engagement encourages students to explore and delve deeper into the assigned tasks and activities. As a result, their perception of Physics as a difficult subject may shift, and they may view it as interesting and exciting instead.

TELO aligns with the principles of constructivism and the SAMR model, further contributing to its effectiveness. Constructivism emphasizes the importance of hands-on experiences and active involvement in learning, which TELO facilitates through its interactive nature. The SAMR model, which stands for Substitution, Augmentation, Modification, and Redefinition, provides a framework for integrating technology into education. By applying the SAMR model, TELO stimulates multiple senses and allows learners to construct their ideas by integrating existing knowledge with new concepts.

Overall, the interactive features of TELO, coupled with its alignment with constructivist principles and the SAMR model, create an engaging and effective learning experience for students. By actively participating and integrating their knowledge, students are more likely to develop a deeper understanding of Physics and find the subject more interesting and exciting.

Based on the findings of the study, the researchers highly recommend the use of Technology-enhanced Lessons in Optics (TELO) in classroom teaching to enhance students' performance. The study showed that the TELO intervention had a significant positive impact on the academic performance of grade 10 students. Therefore, it suggests that implementing TELO in other areas of Physics instruction could yield similar benefits.

To further support the effective integration of technology in education, the study recommends that ICT experts should design more computer-based tools that can be utilized for classroom instruction. By developing interactive software, simulations, and other computer-based tools, teachers can create engaging learning experiences for students. It is also crucial for ICT developers to actively seek feedback from users to continuously improve these tools and meet the evolving needs of educators and learners.

To equip teachers with the necessary knowledge and skills to effectively use technology in the teaching and learning process, the study suggests conducting seminars and workshops on constructing materials like TELO. These events would provide opportunities for teachers to learn and exchange ideas about integrating technology into their instructional practices. Additionally, administrators should play a supportive role by encouraging teachers to produce instructional materials and updating existing ones, while providing the necessary resources and support.

Lastly, the study recommends conducting similar or related studies to investigate the use of TELO in other topics within Physics or other scientific disciplines. This would contribute to a broader understanding of the impact of technology-enhanced interventions on student learning outcomes and help identify additional areas where technology can be effectively utilized.

Overall, the study's recommendations emphasize the importance of leveraging technology, particularly ICT-based tools, in education. By implementing these recommendations, teachers can enhance their instructional practices, administrators can provide a supportive environment, and further research can expand our understanding of the benefits of technology-enhanced learning experiences.

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