Publisher: Sapienza Grupo Editorial
R. Santa Cruz, 2187, Vila Mariana
São Paulo, Brazil
editor@sapienzaeditorial.com

Sapienza
International Journal of Interdisciplinary Studies
ISSN: 2675-9780

OPEN ACCESS

Signatory of DORA

Effectiveness of constructivist e-learning module in General Biology

Eficácia do módulo construtivista de e-learning em Biologia Geral

Eficacia del módulo de aprendizaje electrónico constructivista en biología general

Lucelle M. Maglinte
https://orcid.org/0009-0002-2083-8970
Professor at the University of the Immaculate Conception, Philippines. MAST-Biology from University of the Southeastern Philippines and PhD in Science Education major in Biology from Notre Dame of Dadiangas University.
lmaglinte@uic.edu.ph (correspondence)

Leizle B. Coronica
https://orcid.org/0009-0004-0850-4227
Professor at the Notre Dame of Dadiangas University-General Santos City. MS in Biology from Ateneo de Davao University and PhD in Science Education major in Biology from Notre Dame of Dadiangas University
lcoronica@nddu.edu.ph

ABSTRACT

With the need for improved learning materials for General Biology becoming increasingly evident, this study developed a constructivist e-learning module and evaluated its effectiveness for teaching senior high school STEM students. The module, anchored in the 5E Instructional Model (engage, explore, explain, elaborate, and evaluate), was implemented in a blended instruction setting for 81 senior high school STEM students. This module distinguishes itself from traditional e-learning modules by emphasizing student-centered learning and experiential engagement through hands-on activities, problem-solving, and peer collaboration. Pretest and posttest were used to assess content mastery and cognitive skills performance. Mean, standard deviation, and paired t-test were used to describe the scores and significant differences between the scores. The posttest scores revealed a significant increase in both content mastery and cognitive skills performance. The constructivist e-learning module effectively enhances student engagement, content mastery, and cognitive skills development while aligning with curriculum of Philippine Department of Education (DepEd) and can be seamlessly integrated into existing classrooms.

Keywords: Cognitive skills; Constructivist e-learning; Content mastery; General biology.

RESUMO

Com a necessidade de melhores materiais de aprendizagem para Biologia Geral II tornando-se cada vez mais evidente, este estudo desenvolveu um módulo construtivista de e-learning e avaliou sua eficácia para o ensino de alunos STEM do ensino médio. O módulo, ancorado no Modelo Instrucional 5E (envolver, explorar, explicar, elaborar e avaliar), foi implementado em um ambiente de ensino combinado para 81 alunos STEM do ensino médio. Este módulo se diferencia dos módulos tradicionais de e-learning, enfatizando a aprendizagem centrada no aluno e o envolvimento experiencial por meio de atividades práticas, resolução de problemas e colaboração entre pares. O pré-teste e o pós-teste foram utilizados para avaliar o domínio do conteúdo e o desempenho das habilidades cognitivas. Média, desvio padrão e teste t pareado foram utilizados para descrever os escores e diferenças significativas entre os escores. As pontuações do pós-teste revelaram um aumento significativo no domínio do conteúdo e no desempenho das habilidades cognitivas. O módulo construtivista de e-learning melhora efetivamente o envolvimento dos alunos, o domínio do conteúdo e o desenvolvimento de habilidades cognitivas, ao mesmo tempo que se alinha com o currículo do Departamento de Educação das Filipinas (DepEd) e pode ser perfeitamente integrado às salas de aula existentes.

Palavras-chave: habilidades cognitivas; e-learning construtivista; domínio de conteúdo; biologia geral.

RESUMEN

Dado que la necesidad de mejorar los materiales de aprendizaje para Biología General II se vuelve cada vez más evidente, este estudio desarrolló un módulo de aprendizaje electrónico constructivista y evaluó su efectividad para enseñar a estudiantes STEM de secundaria. El módulo, basado en el modelo de instrucción 5E (participar, explorar, explicar, elaborar y evaluar), se implementó en un entorno de instrucción combinada para 81 estudiantes STEM de secundaria. Este módulo se distingue de los módulos tradicionales de aprendizaje electrónico al enfatizar el aprendizaje centrado en el estudiante y la participación experiencial a través de actividades prácticas, resolución de problemas y colaboración entre pares. Se utilizaron pruebas previas y posteriores para evaluar el dominio del contenido y el desempeño de las habilidades cognitivas. Se utilizaron la media, la desviación estándar y la prueba t pareada para describir las puntuaciones y las diferencias significativas entre las puntuaciones. Las puntuaciones posteriores a la prueba revelaron un aumento significativo tanto en el dominio del contenido como en el desempeño de las habilidades cognitivas. El módulo de aprendizaje electrónico constructivista mejora eficazmente la participación de los estudiantes, el dominio del contenido y el desarrollo de habilidades cognitivas, al mismo tiempo que se alinea con el plan de estudios del Departamento de Educación de Filipinas (DepEd) y se puede integrar perfectamente en las aulas existentes.

Palabras clave: habilidades cognitivas; aprendizaje electrónico constructivista; dominio del contenido; biología general.

ARTICLE HISTORY

Received: 18-09-2023
Revised Version: 12-11-2023
Accepted: 16-11-2023
Published: 30-11-2023

Manuscript type: Article

ARTICLE INFORMATIONS

Science-Metrix Classification (Domain):
Economic & Social Sciences
Main topic:
Constructivist e-learning.
Main practical implications:
The constructivist e-learning module was found to be effective in enhancing student engagement, content mastery, and cognitive skills development. This module can be seamlessly integrated into existing classrooms and aligns with the curriculum of the Philippine Department of Education (DepEd).
Originality/value:
This study provides empirical evidence for the effectiveness of constructivist e-learning modules in teaching General Biology to senior high school STEM students. It also highlights the benefits of using these modules to promote student-centered learning and experiential engagement. The study's findings can inform the development of more effective e-learning materials for biology education.

INTRODUCTION

In today's education landscape, the COVID-19 pandemic has caused widespread disruptions, leading schools worldwide to turn to distance learning as a way to protect everyone's health. E-learning, which involves teaching digitally and remotely, has become a popular solution to these challenges (Li & Lalani, 2020). Lurvnik (2020), emphasized that keeping students engaged is a significant challenge, especially when students come from diverse backgrounds. Quickly converting teaching materials into digital formats has been a tough task. This is where e-learning comes in to support effective learning (Radha et al., 2020).

E-learning helps students gain confidence and encourages them to collaborate, share ideas, and think critically. It pushes them to explore different ways to solve problems, see issues from various angles, and develop their own ideas (Bauzon, 2022). In essence, it transforms students from passive recipients of knowledge to active learners. Learning strategies, like those used in learning modules, promote students' understanding of the world through hands-on experiences.

In the same vein, as the world transforms at an unprecedented pace, driven by the Fourth Industrial Revolution (4IR), traditional teaching methods are no longer sufficient to equip students with the skills and knowledge they need to thrive in the 21st-century workforce. The rapid advancements in artificial intelligence, digitalization, robotics, automation, and biotechnology demand a paradigm shift in education, particularly in STEM fields (Górriz et al., 2020). Innovative teaching methods that foster critical thinking, problem-solving, and adaptability are essential to prepare students for the challenges and opportunities of the 4IR (Seo & Park, 2018). By embracing these innovative approaches, STEM education can empower students to become not only skilled technicians but also creative innovators capable of shaping the future.

Learning materials, specifically learning modules, have gained importance as organized resources that cover content, teaching methods, and assessments, allowing students to learn independently (Evenddy et al., 2021). In response to current challenges, schools have embraced online education. The Most Essential Learning Competencies, as outlined by DepEd, play a central role in making education accessible, with a focus on constructivist teaching methods (DepEd, 2019). The 5E Instructional Model provides a structured framework for fostering constructivist learning in learning modules. It comprises five phases: Engage, Explore, Explain, Elaborate, and Evaluate. When effectively implemented within constructivist e-learning modules, the 5E Instructional Model promotes active learning, enhances student engagement, and fosters deep conceptual understanding. It empowers students to take ownership of their learning journey, becoming self-directed learners who can confidently apply their knowledge and skills to solve real-world problems.

However, the use of learning modules, especially in the K to 12 program, has received mixed feedback (Tan, 2019). While DepEd has made preparations for the K to 12 Basic Education Curriculum, educators have found the Biology Modules to be complex, and students have struggled to grasp biological concepts (Lopez et al., 2022). Challenges include unfamiliar terms and a lack of extra materials (Selvi & Çosan, 2018). A more scientific approach and attention to content and concept application are needed (Funa & Talaue, 2021).

Teaching Biology to STEM students using constructivist modules is a challenge, and it is crucial to create high-quality instructional materials to enhance the learning process (Bauzon, 2022). Incorporating e-learning modules can improve efficiency and effectiveness in education, potentially outperforming traditional resources (Hadianto et al., 2018).

Given the feedback and observations mentioned, it is clear that evaluating the effectiveness of a constructivist e-learning module in General Biology for STEM students is essential. The study aims to address several research questions, including developing an e-learning module in General Biology based on the existing curriculum guide for Senior High School (SHS). It also seeks to assess student performance in content standards and cognitive skills before and after using a constructivist e-learning module in both control and experimental groups. Additionally, the study aims to identify any significant differences in pretest and posttest scores between the two groups in terms of content mastery and cognitive skills. The ultimate goal is to design an improved e-learning module that empowers students to construct their own understanding and knowledge through practical experiences and problem-solving.

METHODS

Design, Sample and Location

The study employed a quasi-experimental research approach with a pretest-posttest design. This design allowed for a rigorous assessment of the e-learning module's effectiveness in enhancing content and cognitive skills among Grade 12 Senior High School students in an Academic Strand, specifically STEM, during the school year 2022-2023.

The pretest-posttest design was chosen to measure the immediate impact of the treatment, which involved using the researchers-developed e-learning module, on the outcome variables. A nonequivalent control group was utilized to compare the effects of the treatment with those not receiving it, as they continued to use the usual module provided by their institution. To minimize the potential for bias, this group was carefully selected to match the characteristics of the experimental group as closely as possible. This approach was chosen due to the practical constraints of implementing random assignment or matching in the context of this study. The control group consisted of students from a similar demographic background who were enrolled in the same institution and were using the usual module provided by the institution. Extensive data collection and analysis were conducted to ensure that the two groups were comparable in terms of relevant variables that could potentially influence the outcome of the study.

To determine the sample size, a sample size calculator by Raosoft online was employed, setting a 5% margin of error, 95% confidence level, and a 90% response distribution. For a population of 189, a sample size of 81 was computed for the experimental group. The same number of students participated in the control group. The sampling method used in this study was probability sampling, specifically cluster sampling. This approach was chosen as it facilitates the random selection of clusters (schools), followed by the inclusion of all individuals within those clusters. This multistage or clustering procedure ensured a representative sample. Respondents were chosen based on inclusion criteria, which included being Grade 12 STEM Senior High School students, currently enrolled, and part of heterogeneous classes in the selected schools.

The study excluded individuals who were not enrolled, did not belong to the specified grade level and academic track, and were not in heterogeneous classes. These criteria were established to ensure that the sample accurately represented the target population. The study was conducted in two selected private secondary education institutions situated in Davao City, Davao del Sur, Region XI, Philippines. These institutions were carefully chosen to ensure a representative sample of private secondary schools in the region, encompassing a diversity of student demographics, socioeconomic backgrounds, and academic performance levels. This selection process aimed to minimize potential biases and enhance the generalizability of the study findings.

Research Instrument

This study employed a constructivist e-learning module and a teacher-made pretest and posttest to evaluate content mastery and cognitive skills performance. The researchers developed a constructivist e-learning module that aligns with the 5E Instructional Model, incorporating engaging, exploratory, explanatory, elaborative, and evaluative elements. The module identifies core concepts and competencies essential for learners to master by the end of the subject.

To evaluate the effectiveness of the e-learning module, a modified instrument consisting of three parts was developed: usability (4 items), adequacy (4 items), quality of content (5 items), and potential effectiveness as a teaching tool (5 items). Three experts in the field of e-learning evaluated the module using the adopted module criteria.

The constructivist e-learning module was further evaluated by three biology experts to ensure alignment with the K to 12 Most Essential Learning Competencies (MELCs). A comprehensive review of the module's content was conducted, ensuring that the learning objectives, activities, and assessments were aligned with the specified MELCs. Multiple-choice questions were developed based on the learning competencies and aligned with the Table of Specifications (TOS). The TOS ensured that the test questions adequately covered the range of knowledge and skills expected of learners. Three expert validators evaluated the test items to check the competencies' alignment against the TOS, providing feedback on the clarity, relevance, and appropriateness of the questions.

Two pilot field tests were conducted to refine the test questions and ensure their reliability. The first pilot test involved 20 STEM graduates from the University, and the second pilot test involved 30 STEM students from a local high school. The outcome of the second pilot run was used to calculate the reliability coefficient of the developed test questions using the Kuder-Richardson Formula 20 (KR-20), yielding a value of 0.82, indicating high internal consistency.

Constructivist E-Learning Module

An e-learning module in General Biology was developed based on the identified content standard to be covered in alignment with the learning competencies reflected in the existing Senior High School (SHS) curriculum guide of the Department of Education. Adding on, the developed module is an instructional material for General Biology learners anchored on a constructivist pedagogical approach crafted in a way that learners have to be engaged in acquiring different knowledge and skills.

The General Biology e-learning module covers the five content standards: Plant and Animal Organ Systems and their Functions; like reproduction, development, nutrition, gas exchange, transport/ circulation, regulation of body fluids, chemical and nervous control, immune systems, and sensory and motor mechanisms. Feedback Mechanisms; Recombinant DNA; Relevance, Mechanisms, Evidence/Bases, and Theories of Evolution; discusses the geologic timeline, the mechanisms of evolution, the history of evolutionary thought, and the evidence of evolution. Basic Taxonomic Concepts and Principles, Description, Nomenclature, Identification, and Classification examine species diversity and cladistics to identify evolutionary links in addition to structural and developmental traits in classifying living things.

The cover page of the constructivist e-learning module as shown in Figure 1, contains the title of the module, the subject name as applied in the curriculum, the name of the school, the year level of the students who will use the instructional material, and the name of the developer.

The constructivist e-learning approach was implemented for the experimental group through an online learning management system (LMS), as depicted in Figure 2. This LMS enabled teachers to upload the designated learning materials for each lesson, which were incorporated into the module. The experimental group was instructed to access the online platform via the provided link and complete the activities for each module.

Figure 3 illustrates the description of the instructional material for the third quarter. The third quarter was divided into three areas: the transfer goal, which emphasized the long-term, practical applications of understanding, knowledge, and skill; the essential understanding, which consisted of statements summarizing key concepts and fundamental procedures that are central to a discipline and have value beyond the classroom; and the essential question, which was an important, vital, and core question that captured the essence of the matter.

As shown in Figure 4, the introduction provides an overview of the module's objectives and content, serving as the starting point for students. It aims to engage learners, pique their curiosity about the subject, and prepare them for the learning process. This Learning Module Guide is intended to orient Senior High School students of the University to the different components of the Learning Module and the expectations that students are required to fulfill. The Learning Module encompasses lessons for Quarter 3 and Quarter 4 for one semester, based on competencies and standards aligned with the school's vision, mission, and goal.

Figure 5 outlines the instructions for the pretest of the instructional materials. Before embarking on the learning journey, students are required to assess their current knowledge and understanding of the subject. This pretest helps students gauge their existing skills and tailor their needed lessons. To access the pretest, they need to click the provided link to navigate to the pre-assessment page. Once they reach the pretest page, they must carefully read the instructions. They are required to answer all questions to the best of their ability. It is important to remember that this assessment is meant to evaluate their current understanding and honest responses are encouraged. After completing the pre-assessment, they should click the submit button to record their answers.

The instructional material was designed with a cover page for every lesson of the module, as shown in Figure 6. This cover page included the topic, competency, and objectives. The developed instructional material was anchored in constructivism and incorporated the 5E Instructional Model (Bybee & Landes, 1990). which emphasizes the following qualities: engage, explore, explain, elaborate, and evaluate.

The first step of the student's activities is presented in Figure 7. This engage phase captures students' interest and curiosity by creating a context or posing a question that stimulates their thinking and activates prior knowledge. It helps to generate interest and set the stage for the upcoming learning experience. The teacher can decide whether the students complete the tasks individually or in groups.

Figure 8 depicts a sample sheet for the constructivist model's second step. Students actively investigate the idea or phenomenon during this phase through investigations. They gather information, make notes, and develop hypotheses, which enables them to gain understanding through first-hand encounters. The teacher allowed students to engage in conversation and provided enough time to complete the tasks given to them.

The explain phase involves students explaining or articulating their understanding of the concept or phenomenon. They communicate their findings, discuss their observations, and construct explanations based on the evidence they have gathered. Teachers may also provide explanations and clarify any misconceptions. The teacher continued the conversation, which helped the students conceptualize the discussed subject, and utilized student participation through interactive explanations and conversations. This phase confirmed the student's knowledge acquisition.

The fourth step of the constructivist model is displayed in Figure 10. In this phase, students delve deeper into the topic, expand their understanding, and apply their knowledge in new contexts. They engage in more complex activities, connect to real-world examples, and further develop their conceptual understanding.

The last phase of the constructivist module is illustrated in Figure 11. The final phase involves assessing students' learning and understanding to gauge students' progress and achievement of learning objectives. Teachers use various assessment methods, such as quizzes, projects, presentations, or discussions, to evaluate student learning. The 5Es model promotes active participation, critical thinking, and student-centered learning. It offers educators a framework to guide the learning process and encourage a more profound comprehension of scientific concepts.

Figure 12 shows the instructions for the posttest of the instructional materials. After a learning experience, a posttest is carried out to assess the effectiveness of the learning and gauge the accomplishment of particular learning outcomes or objectives. Posttests allow teachers to evaluate the efficiency of their instructional strategies and materials. They can evaluate the efficacy of their instructional strategies and, if necessary, make improvements by comparing pretest and posttest results.

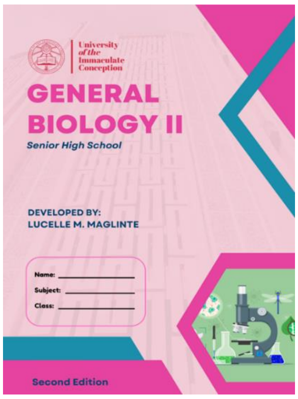

Figure 1. Cover page of a constructivist e-learning module in General Biology.

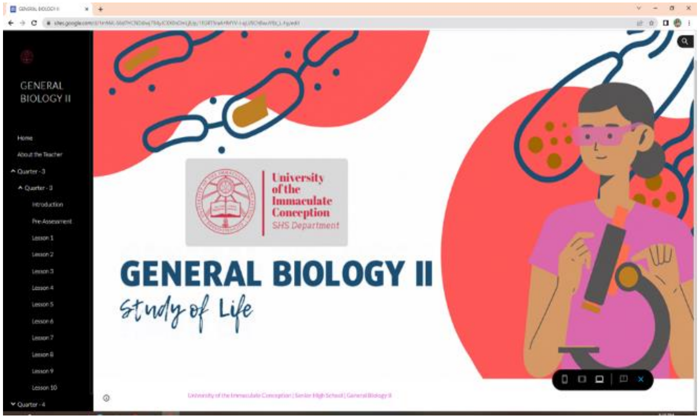

Figure 2. Sample sheet on learning management system.

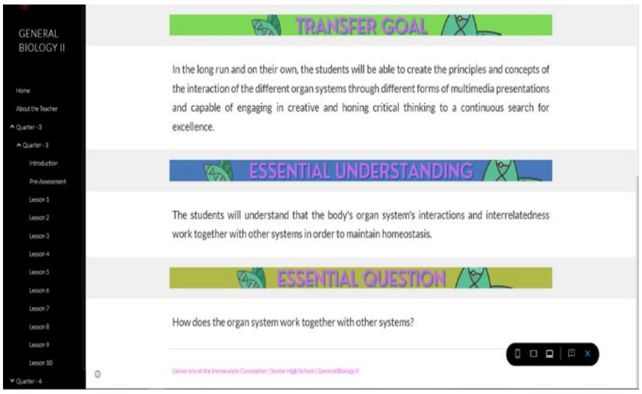

Figure 3. Sample sheet quarter three description.

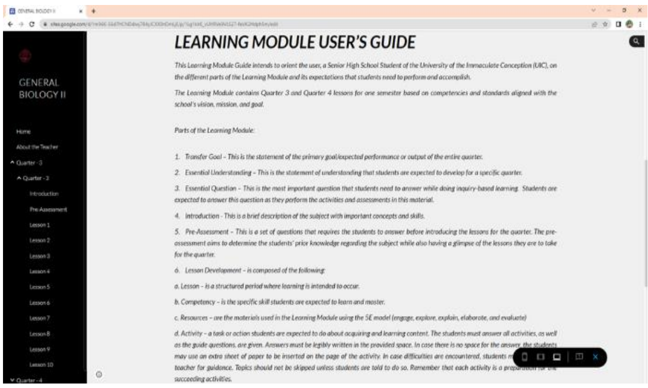

Figure 4. Sample sheet for module user's guide.

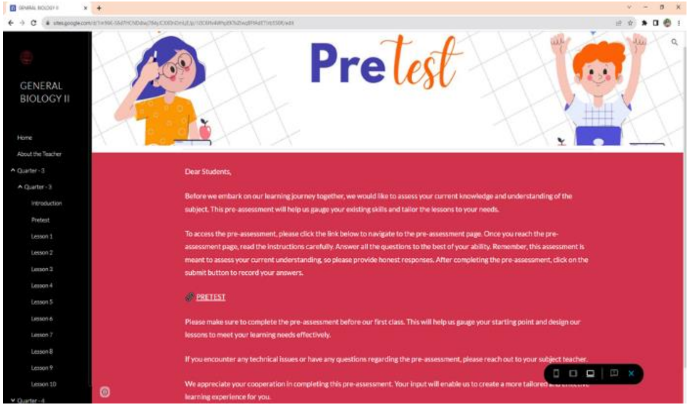

Figure 5. Sample sheet for pretest.

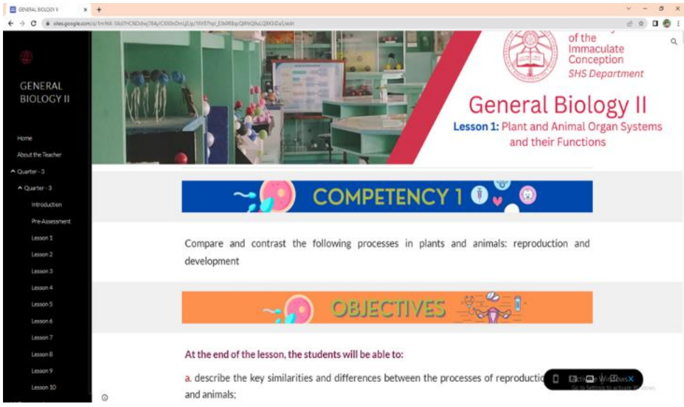

Figure 6. Sample sheet for module cover page.

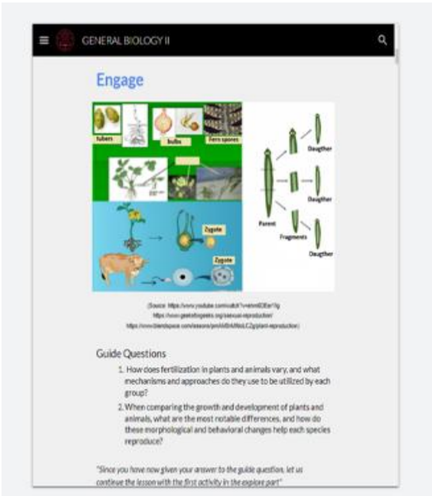

Figure 7. Sample sheet on the first step of the constructivist model

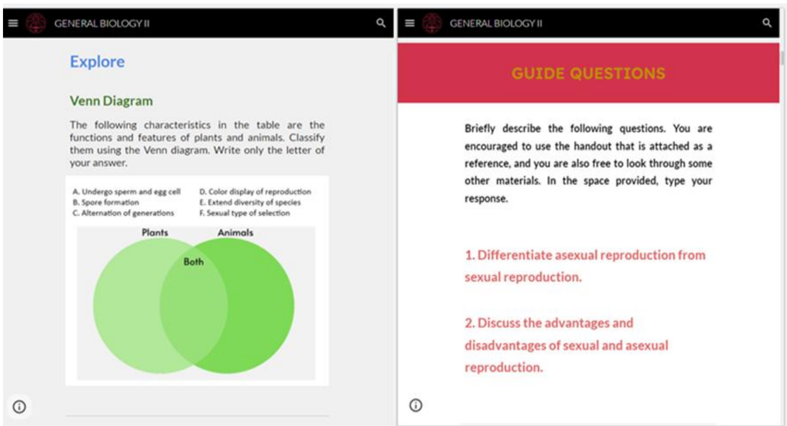

Figure 8. Sample sheet on the second step of the constructivist model.

Figure 9. Sample sheet on the third step of the constructivist model.

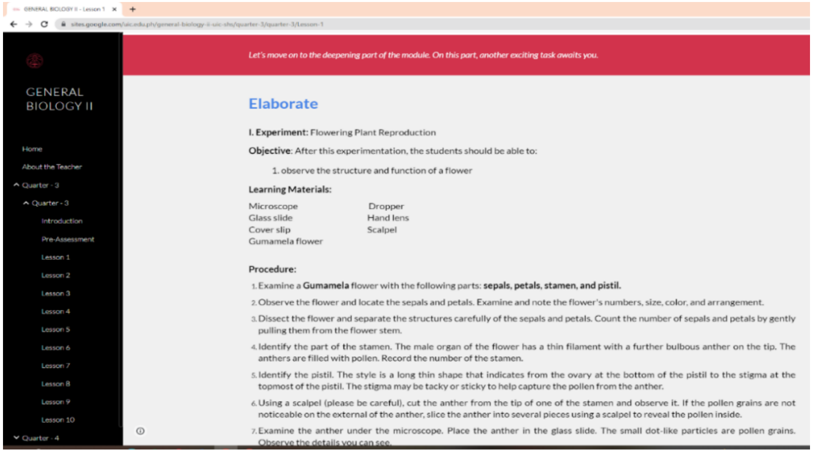

Figure 10. Sample sheet on the fourth step of the constructivist model.

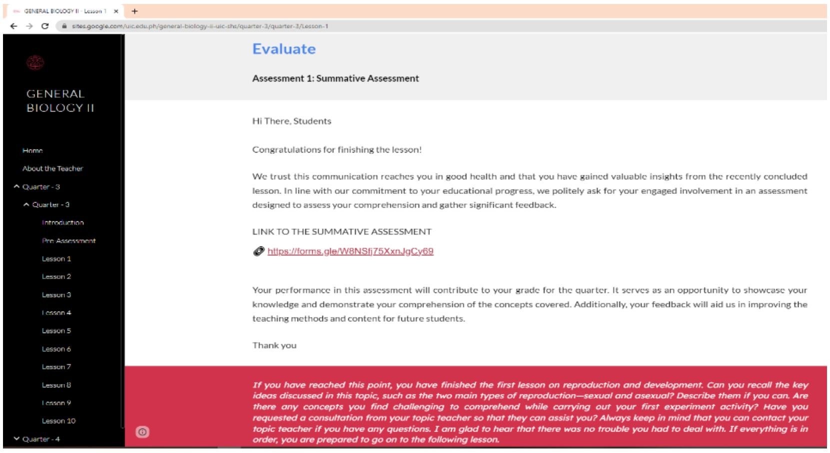

Figure 11. Sample sheet on the fifth step of the constructivist model.

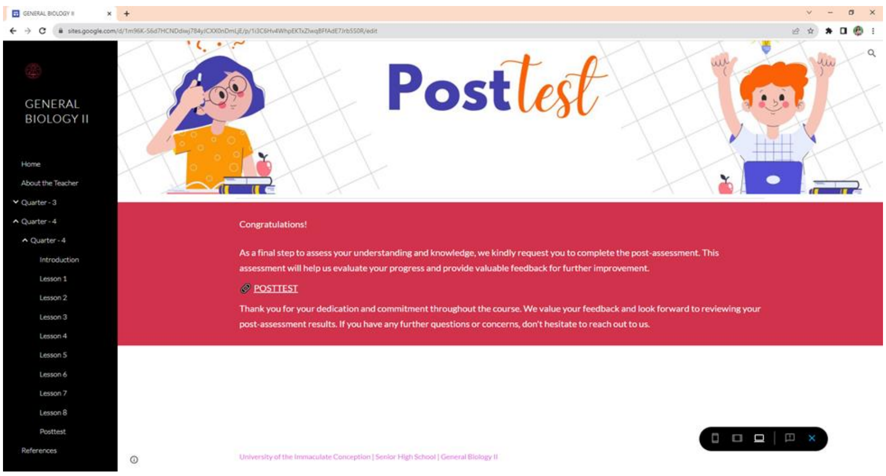

Figure 12. Sample sheet for posttest.

Usual E-Learning Module

The usual e-learning module is a learning module or curriculum that follows the MELCs as prescribed by the DepEd. It represents the typical educational content and approach that students in the control group would receive in their institution. This module is designed to cover the necessary learning competencies and is considered the standard curriculum that students in the control group are exposed to. It serves as a baseline for comparison with the experimental group that received the e-learning module developed by the researchers.

This e-learning module was created following a rigorous development process to ensure its reliability and validity. The development of the usual e-module began with a careful alignment with the K to 12 Most Essential Learning Competencies (MELCs) curriculum established by the Department of Education (DepEd) in the Philippines. The content and learning objectives of the module were derived directly from the MELCs to ensure that it covered the essential competencies required at the specific grade level. Subject matter experts, experienced educators, and curriculum specialists were consulted to review and validate the content. Their expertise was crucial in ensuring that the module effectively addressed the learning objectives and was pedagogically sound. The module underwent pilot testing with a sample group of students who were not part of the main study. This phase helped identify any issues related to clarity, appropriateness, and usability of the module content and materials.

The content of the usual e-module was subjected to content validation, which involved a panel of experts assessing the module's alignment with the MELCs and the appropriateness of its learning objectives. Any discrepancies or issues were addressed through revisions. To establish the module's reliability, the same pretest and posttest were administered to the control group. The reliability of the assessment instruments was assessed through statistical measures, such as Cronbach's alpha for test items, to ensure that the test was consistent in measuring what it intended to measure.

Data Gathering Procedure

Prior to conducting the study, the researchers obtained ethical clearance from the Research Ethics Committee (REC) to ensure that the study adhered to ethical guidelines and respected the rights and well-being of the student participants. The REC certificate of compliance served as formal authorization to proceed with the research.

Following the REC approval, the researchers sent a letter of intent to the school principal seeking permission to conduct the study within the school premises. Once the principal granted consent, the approval letter was shared with the teacher(s) responsible for teaching General Biology, the subject relevant to the research. Next, a pool of potential participants was identified based on specific criteria, and informed consent forms were distributed to each STEM student. These forms provided detailed information about the study's purpose, procedures, risks, and benefits, allowing students to make an informed decision about their participation. Students were assured that their participation was voluntary and that they could withdraw from the study at any time without penalty. To gather data, the researchers employed a pre-test and post-test multiple-choice question format, administered through a hybrid modality to both the control and experimental groups. The test questions were aligned with the learning competencies outlined in the curriculum and were developed by experienced teachers, ensuring their validity and relevance.

During the pre-test and post-test administration, a designated teacher served as the proctor to maintain a controlled and fair assessment environment. The proctor's responsibilities included monitoring the test administration, ensuring that students adhered to the test instructions, and preventing any instances of academic dishonesty. Before commencing the test, the proctor reminded the students of the importance of integrity and ethical conduct during the assessment. The pre-test and post-test assessments were designed to be completed within one hour. A timer was used to monitor the allotted time and ensure consistency across both groups. The collected data was treated with utmost confidentiality and was subjected to rigorous statistical analysis and interpretation to ensure its accuracy and validity.

Data Analysis

To understand the level of student mastery based on their mean scores, the criteria outlined in DepEd Order No. 31, s. 2020 were used. Scores in the range of 90-100 indicate outstanding mastery, while scores below 75 indicate that students did not meet expectations. Scores between 85-89 indicate very satisfactory performance, 80-84 indicate satisfactory performance, and 75-79 indicate fairly satisfactory performance.

A paired t-test was employed to determine if there was a statistically significant difference between the pre-test and post-test scores for both the control and experimental groups. This statistical test was chosen because it compares the performance of the same group of participants on two different occasions, in this case, before and after the implementation of the instructional intervention. The paired t-test allowed the researchers to assess whether the intervention had a significant impact on student learning outcomes. A p-value less than 0.05 is considered significant.

To ensure that the modified instrument was both reliable and effective as a teaching tool, criteria were developed based on four components: usability, adequacy, quality of content, and potential effectiveness as a teaching tool. The instrument should be easy to use and administer for both teachers and students (usability), adequately cover the content area being assessed (adequacy), feature clear, concise, and curriculum-aligned items (quality of content), and provide valuable feedback to teachers and students that can be used to inform instruction and improve student learning (potential effectiveness as a teaching tool).

RESULTS

Content Mastery Performance Level

This study developed a constructivist e-learning module for General Biology, covering five content standards: Topic 1 (plant and animal organ systems and their functions), topic 2 (feedback mechanisms), topic 3 (recombinant DNA), topic 4 (relevance, mechanisms, evidence/bases, and theories of evolution), and Topic 5 (basic taxonomic concepts and principles, description, nomenclature, identification, and classification).

Table 1 presents the content mastery performance in the five content standards in General Biology of the control group and experimental group. In the pretest, the control group did not meet expectations in any of the five content standards. Their mean ratings ranged from 66.77 to 74.23, with topic 3 (recombinant DNA) reflecting the lowest mean rating of 66.77 and topic 1 (plant and animal organ systems and their functions) garnering the highest mean of 74.23. The control group's posttest performance level in four of the five content standards still did not meet expectations. The experimental group also did not meet expectations in their pretest, with a mean rating of 65.74 on topic 2 (feedback mechanism) and the highest being 75.57 on topic 1 (plant and animal organ systems and their functions). However, their posttest performance showed an improvement in the content mastery performance level in all five content standards, with mean ratings ranging from 84.95 to 92.80.

Cognitive Skills Performance Level

The control group's pretest results showed that their mean ratings for all cognitive skills ranged from 64.07 to 74.26, which are all below 75, indicating a level of performance below expectations (Table 2). Their posttest results showed a decrease in cognitive skills, knowledge, and comprehension, while application and analysis skills showed an increase. The experimental group's pretest results showed mean ratings ranging from 64.73 to 75.57 for cognitive skills, with cognitive knowledge skill having the lowest mean (64.37) and being described as below expectations, while cognitive analysis skill having the highest mean (75.57) and being described as fairly satisfactory. The experimental group's posttest results showed mean ratings ranging from 84.95 to 91.75 for cognitive skills. Cognitive analysis skills had the lowest mean (84.95) and were described as satisfactory, while cognitive comprehension skills had the highest mean score (91.75).

Table 3 shows that a significant difference was observed between the pretest and posttest scores for the content area of plant and animal organ systems and their functions, with t (2, 80) = -2.28 and a p-value of .02, which is lower than the ∝ set at the .05 level of significance. No significant difference was observed between the average pretest and posttest scores for the other content areas in the control group, as indicated by p-values greater than the ∝ set at the .05 level of significance. The experimental group showed a significant difference between the pretest and posttest scores for all content areas, with p-values of .00, which is less than the ∝ set at the .05 level of significance.

Table 1. Content mastery performance level in General Biology (control and experimental).

Content standards	Control group			Experimental group		
	Mean	SD	Description	Mean	SD	Description
Plant and Animal Organ and their functions						
Pretest	74.23	7.52	Did not meet expectations	75.57	8.52	Fairly satisfactory
Posttest	76.07	6.93	Fairly satisfactory	84.95	7.77	Satisfactory
Feedback mechanism						
Pretest	73.15	17.13	Did not meet expectations	65.74	16.51	Did not meet expectations
Posttest	70.99	17.88	Did not meet expectations	85.49	16.71	Very satisfactory
Recombinant DNA						
Pretest	66.77	12.55	Did not meet expectations	66.95	14.48	Did not meet expectations
Posttest	68.14	14.61	Did not meet expectations	91.09	13.21	Outstanding
Relevance, mechanisms, evidence/bases, and theories of evolution						
Pretest	68.47	8.40	Did not meet expectations	67.90	13.21	Did not meet expectations
Posttest	67.73	8.72	Did not meet expectations	92.80	9.57	Outstanding
Basic, taxonomic concepts and principles, description, nomenclature, identification, and classification						
Pretest	69.06	14.68	Did not meet expectations	71.73	14.99	Did not meet expectations
Posttest	68.94	12.09	Did not meet expectations	91.95	11.28	Outstanding
Over-all						
Pretest	70.34		Did not meet expectations	69.58		Did not meet expectations
Posttest	70.37		Did not meet expectations	89.26		Very satisfactory

Table 2. Cognitive skills performance level in General Biology (control and experimental).

Content standards	Control group			Experimental group		
	Mean	SD	Description	Mean	SD	Description
Knowledge						
Pretest	64.07	12.70	Did not meet expectations	64.73	12.42	Did not meet expectations
Posttest	62.63	12.18	Did not meet expectations	89.90	15.02	Very satisfactory
Comprehension						
Pretest	70.12	8.19	Did not meet expectations	69.26	8.80	Did not meet expectations
Posttest	69.36	8.01	Did not meet expectations	91.75	7.76	Outstanding
Application						
Pretest	66.77	12.55	Did not meet expectations	66.95	14.48	Did not meet expectations
Posttest	68.14	14.61	Did not meet expectations	91.09	13.21	Outstanding
Analysis						
Pretest	74.26	7.30	Did not meet expectations	75.57	8.52	Fairly satisfactory
Posttest	76.07	6.93	Fairly satisfactory	84.95	7.77	Satisfactory

Table 3. Significant difference between the pretest and posttest scores of the content mastery in General Biology (control and experimental).

Content standards	Mean	SD	df	T	p-value	Remarks
Topic 1						
Control group			80	-2.28	.02	Significant
Pretest scores	74.23	7.52				
Posttest scores	76.07	6.93				
Experimental group			80	-9.31	.00	Significant
Pretest scores	75.57	8.52				
Posttest scores	84.95	7.77				
Topic 2						
Control group			80	.75	.46	Not Significant
Pretest scores	73.15	17.13				
Posttest scores	70.99	17.88				
Experimental group			80	-7.53	.00	Significant
Pretest scores	65.74	16.51				
Posttest scores	85.49	16.71				
Topic 3						
Control group			80	.69	.49	Not Significant
Pretest scores	66.77	12.55				
Posttest scores	68.14	14.61				
Experimental group			80	-12.04	.00	Significant
Pretest scores	66.95	14.48				
Posttest scores	91.09	13.21				
Topic 4						
Control group			80	.62	.54	Not Significant
Pretest scores	68.47	8.40				
Posttest scores	67.73	8.74				
Experimental group			80	-16.68	.00	Significant
Pretest scores	67.90	10.01				
Posttest scores	92.80	9.57				
Topic 5						
Control group			80	.07	.94	Not Significant
Pretest scores	69.06	14.68				
Posttest scores	68.94	12.09				
Experimental group			80	-16.43	.00	Significant
Pretest scores	71.73	14.99				
Posttest scores	91.95	11.28				

Table 4. Significant difference between the pretest and posttest scores of cognitive skills in General Biology (control and experimental).

Content standards	Mean	SD	df	T	p-value	Remarks
Knowledge						
Control Group			80	.76	.45	Not Significant
Pretest Scores	64.07	12.70				
Posttest Scores	62.63	12.18				
Experimental Group			80	-11.70	.00	Significant
Pretest Scores	64.73	12.42				
Posttest Scores	89.90	15.02				
Comprehension			80	.80	.42	Not Significant
Control Group						
Pretest Scores	70.12	8.19				
Posttest Scores	69.36	8.01				
Experimental Group			80	-17.81	.00	Significant
Pretest Scores	69.26	8.80				
Posttest Scores	91.75	7.76				
Application						
Control Group			80	-.69	.49	Not Significant
Pretest Scores	66.77	12.55				
Posttest Scores	68.14	14.61				
Experimental Group			80	-12.04	.00	Significant
Pretest Scores	66.95	14.48				
Posttest Scores	91.09	13.21				
Analysis						
Control Group			80	-2.32	.02	Significant
Pretest Scores	74.26	7.30				
Posttest Scores	76.07	6.93				
Experimental Group			80	-9.31	.00	Significant
Pretest Scores	75.57	8.52				
Posttest Scores	84.95	7.77				

Table 5. Features of old and improved module

Module features	Old module	Improved module
Additional reading	No additional reading resources provided.	Web links provided for each lesson as additional reading.
Guide questions	Students are not being engaged due to a lack of guide questions.	Guide questions were included to stimulate student interaction.
Engage phase enhancement	Insufficient attention-grabbing connections or relevance to the real world.	Enhanced with real-world examples and scenarios during the engage phase.
Explain phase enhancement	Delivery based on lectures with little interaction with students that fails to interest students.	The use of student participation through interactive explanations and conversations.

Based on the results, the experimental group, which was exposed to the constructivist e-learning module in General Biology, showed outstanding performance in the posttest evaluation for topics 3, 4, and 5, satisfactory performance for topic 1, and very satisfactory performance for topic 2. For the enhancement of the e-learning module, the focus will be on raising the performance levels for topics 1 and 2 to a higher level.

In the cognitive skills performance level, no significant difference was observed in the control group in all areas except for analysis (Table 4). This trend is not similar in the experimental group as pretest and posttest scores of the students were significantly different from each other across all cognitive skill areas. Features of the improved module compared to the old module were described in Table 5.

DISCUSSION

This research developed a constructivist e-learning module for SHS General Biology based on the existing curriculum guide and the 5E Model, focusing on the five content standards. The module divides the learning material into lessons with specific competency and learning objectives. Each lesson employs the 5E Model, providing a framework for a constructivist, guided-inquiry approach where students gather and analyze evidence, communicate their ideas, and think and work scientifically. The phases of the Primary Connections 5E teaching and learning model, based on the 5Es instructional model (Bybee & Landes, 1990), are engage, explore, explain, elaborate, and evaluate. The engage phase is the first phase, where learning activities elicit students' prior knowledge, stimulate interest, and gather diagnostic data. Each unit begins with a lesson that mentally engages students with an activity or question to capture interest, provide an opportunity for them to express their knowledge, and help them connect new ideas to existing knowledge. The explore phase involves learners working in collaborative teams to complete activities to generate ideas, questions, answers, designs, and inquiries.

During the explain phase, hands-on investigations are incorporated into the module, allowing students to tackle the problem or phenomenon and articulate their understanding in their own words. This phase also provides students with opportunities to acquire shared experiences that serve as a reference point for collaborative understanding of new concepts or skills. Multiple opportunities are integrated into this phase to foster hands-on learning and representation of thinking, including presentations, group discussions, reviews, and comparisons, all of which contribute to students' enhanced comprehension of the learned material.

The elaborate phase further reinforces learning by providing opportunities for students to apply their acquired knowledge to novel situations, deepening their grasp of the concept and enhancing their science inquiry skills. This phase encourages students to engage in discussions and compare their ideas, cultivating their ability to apply science inquiry skills in meaningful contexts.

The evaluation phase, the concluding stage of the module, provides an opportunity for students to review and reflect on their learning, solidifying their understanding and newly acquired skills. This phase also serves as a representation of students' evolving understanding, beliefs, and skills. Additionally, assessments of learning are integrated into this phase, allowing students to evaluate their progress towards the lesson's objectives.

The constructed e-learning module offers flexibility and self-paced learning, allowing students to access the module anytime, anywhere through e-learning platforms. This approach enhances students' knowledge, experimental and practical skills, and autonomy, as supported by Sautière et al., (2019). Buli and Blaevi (2020) also highlight that using e-learning for science and biology is equally motivating as using modern, active classroom methods.

The implementation of the 5E Model in the development of the constructivist e-learning module in General Biology enables teachers to effectively monitor students' mastery of the material and their cognitive abilities related to the essential topics covered in the module. This aligns with Ramadhani et al. (2020) assertion that constructivist modules promote the reconstruction of students' concepts. Additionally, it addresses by Rannikmäe et al., (2020) call for the adoption of constructivist pedagogy, recognizing its value in science education teaching and learning.

The performance level of students in the control group for content mastery in the five content standards: Plant and Animal Organ Systems and their Functions; Feedback Mechanisms; Recombinant DNA; Relevance, Mechanisms, Evidence/Bases, and Theories of Evolution; and Basic Taxonomic Concepts and Principles, Description, Nomenclature, Identification, and Classification revealed mean percentage scores below 75% in the pretest, indicating expectations not met. Only in topic 1 of content standard did the control group achieve a passing mean percentage score of 76.04% in the posttest, which is described as fairly satisfactory. Conversely, the experimental group demonstrated a passing score in topic 1 with a mean percentage score of 75.57% in the pretest, while the remaining topics scored below 75%. Notably, the experimental group's content mastery performance level significantly improved, achieving very satisfactory to outstanding posttest mean percentage scores of approximately 85 and above.

These findings align with the study of Bizimana et al. (2021) where biology students exhibited poor performance, with 49% failing the course. The significant improvement in content mastery performance observed in the experimental group using the constructivist e-learning module validates the findings of Ramadhani et al. (2020) which state that learning through constructivism-based modules influences concept reconstruction. This confirms that incorporating STEM-based applications and activities, like the constructivist e-learning module, enhances academic achievement (Kagnici & Sadi, 2021). Furthermore, these results corroborate the findings of Tiryaki and Adigüzel (2021) that STEM-based applications positively impact students' achievement performance.

The cognitive skills performance level of students in the control group, as measured by their mean percentage scores in knowledge, comprehension, application, and analysis skills, fell below 75% in both the pretest and posttest. This indicates that their performance did not meet expectations. In contrast, the experimental group's performance in the analysis skill improved from a passing mean percentage score of 75.57% in the pretest to a satisfactory mean percentage score above 85% in the posttest. However, their performance in the other three cognitive skills remained below 75% in the posttest.

These findings are consistent with the argument of Paidi et al. (2020) that many students' cognitive knowledge and skills in Biology are not satisfactory. Additionally, the poor performance of students in Biology in the National Exam, as discussed by Taculod and Arcilla (2020), may explain why the control group did not meet expectations even in the posttest. They suggest that the practice of requiring students to memorize facts for school exams, which they quickly forget, may be a contributing factor.

Conversely, the experimental group's improved cognitive skills performance levels in the posttest provide evidence that effective utilization of constructivism can facilitate positive outcomes (Chen et al., 2023). The constructivist e-learning module used in this study provided learner-centered activities and collaborative environments that supported reflective and experiential processes for the students. These activities helped the experimental group develop their 21st-century skills, especially problem-solving, critical thinking, communication, collaboration, and creativity, which Achzab et al., (2018) identified as advantages of adopting constructivism as a pedagogy.

A comparison of the pretest and posttest scores of the control group revealed no significant difference in their content mastery performance levels in four out of five content areas: Feedback Mechanisms, Recombinant DNA, Relevance, Mechanisms, Evidence/Bases, and Theories of Evolution; and Basic Taxonomic Concepts and Principles, Description, Nomenclature, Identification, and Classification. However, a significant difference was observed in topic 1, Plant and Animal Organ Systems and their Function. In contrast, the experimental group exhibited significant differences in the content mastery performance levels of the students in all five content standards in General Biology, with p-values less than .05.

These findings suggest that the teaching and learning strategy and the resources available may not be sufficiently supportive for some students to adequately grasp the concepts being taught, resulting in no significant increases in the posttest scores of the control group. This aligns with the proposition of Harris et al. (2020) that difficulties with learning in Biology can stem from both internal (within the student) and external (from outside the student) factors. It is important to note that the influence of the learning environment, learning resources, and the influence of the teacher are examples of external factors that were not covered in this study and may have a possible effect on the differences between the posttest outcomes of the two groups.

This implies that the experimental group, which utilized the constructivist e-learning module, outperformed the students in the control group in terms of content mastery in the five content standards in General Biology. This finding corroborates the results of Gautam (2018), which revealed that students taught using the constructivist-based instructional model (CBIM) performed better on a researchers-made biology test than those taught using the traditional lecture method.

Moreover, teachers' factors, schools' factors, students' factors, and parents' factors, in that order, were in charge of differentiating academic performances in the schools and may have an impact on the variations in posttest results between the experimental and control groups (Jacob, 2020). Importantly, the finding corroborates with the study of Adonu et al., (2021) that performance and retention in biology classes of students in several senior secondary schools have been affected by constructivist teaching methods. The outcome of their study revealed that the treatment had a significant main effect on the achievement and retention of students in the experimental group.

While the control group showed no significant difference in their cognitive performance levels in knowledge, comprehension, and application cognitive skills (p-values > .05), a significant difference was observed in comprehension and analysis cognitive skills (p-values < .05). Conversely, the experimental group exhibited a significant difference in their cognitive performance levels in knowledge, comprehension, application, and analysis skills when pretest and posttest scores were compared (p-values < .05).

The unfavorable trend observed in the control group may be attributed to factors beyond the scope of this study. This finding aligns with the study of Harapap et al., (2019) who emphasized the impact of instructional strategies on enhancing knowledge and application cognitive skills. Their study revealed a significant difference in mean gain between the control group (7.51 for boys' classes, 7.69 for girls' classes, and 7.07 for mixed classes) and the experimental group (9.30 for boys' classes, 40.13 for girls' classes, and 23.30 for mixed classes), indicating the positive impact of the constructivist instructional approach on learner cognitive skills.

Consistent with the findings of this study, Chuang (2021) posited that constructivist learning strategies, compared to conventional methods, are more likely to enhance the learning performance of learners. Additionally, Santos et al. (2021) recommended that science instructors incorporate inquiry-based and hands-on learning activities to help students learn biology more proficiently and overcome their difficulties.

The improved e-learning module in General Biology should continue to adhere to the constructivist pedagogical approach and the 5E Model in its design. However, further enhancements and updates are necessary to address the identified areas for improvement. To enhance content mastery performance levels in topic 1 (plant and animal organ systems and their functions) and topic 2 (feedback mechanism), the module will incorporate additional learning activities. These activities will target the knowledge and analysis cognitive skills performance levels of students. Weblinks to relevant supplementary reading materials and more formative assessments will be provided to support enrichment activities and offer quick feedback on student understanding. Additionally, to enhance the development of the knowledge and analysis cognitive skills of students, the module will include a summary of important historical events and preeminent ideas in the period, accompanied by thought-provoking questions to facilitate deeper understanding. Moreover, by providing weblinks to additional reading materials in each lesson and posing focus questions, students can improve their interaction during the engage and explain phases of the 5E Model.

This study is subject to several limitations. First, the absence of tables comparing the content mastery and cognitive skills performance levels of the experimental and control groups for both the pre-test and post-test hinders a direct comparison of test scores between the two groups, making it challenging to conclusively evaluate the effectiveness of the e-learning module. To address this limitation, future studies should incorporate tables to present this data more clearly. Second, external factors that could affect the results of the study, particularly the differences between the control and experimental groups, should be noted. These factors may include prior academic performance, socioeconomic status, individual learning styles, and access to technology resources. Recognizing these external factors provides a more nuanced understanding of the study's findings and helps to control for potential confounding variables. Third, the quasi-experimental design used in this study has certain limitations. This design is less rigorous than a randomized controlled trial, which would have allowed for a more causal interpretation of the findings. Fourth, the cluster sampling procedure used in this study may have introduced some bias, as it is possible that the clusters selected were not representative of all private secondary education institutions in Davao City. Random selection from a list of all such institutions could have improved the sampling procedure. Finally, while the pretest and posttest instruments were designed to measure students' content mastery and cognitive skills, the specific content and cognitive skills assessed by these instruments were not specified. This makes it difficult to interpret the results of the study in detail. Future research directions include integrating the engage and explain phases of learning activities, evaluating the module in diverse contexts, conducting qualitative research, and comparative studies.

CONCLUSIONS

The developed constructivist e-learning module in General Biology proved to be an effective instructional tool, significantly enhancing students' content mastery and cognitive skills performance levels. The experimental group, which utilized the module, demonstrated a substantial improvement in content mastery, with average posttest scores exceeding expectations by a significant margin. Similarly, the experimental group's cognitive skills performance levels exhibited a remarkable improvement, with posttest scores indicating a significant shift towards satisfactory, very satisfactory, and outstanding levels. This marked improvement in both content mastery and cognitive skills underscores the efficacy of the constructivist e-learning module in fostering effective learning outcomes.

The module's effectiveness can be attributed to its alignment with DepEd's Most Essential Learning Competencies for the SHS, specifically targeting the five content standards outlined in the curriculum guide. The module's engagement and exploration phases effectively capture students' attention and pique their curiosity, while the explanation and elaboration phases provide clear explanations and opportunities for practice. The incorporation of constructivist principles further enhances the learning experience, encouraging active participation and self-directed learning.

The practical implications of these findings are significant. The constructivist e-learning module offers a valuable tool for educators seeking to enhance student engagement, improve content mastery, and promote cognitive skills development. The module's alignment with DepEd's curriculum guidelines facilitates its seamless integration into existing classroom settings. While potential challenges may exist in implementing the module, such as limited access to technology or insufficient training for teachers, these can be addressed through proper planning, resource allocation, and professional development opportunities.

REFERENCES

Achzab, A., Budiyanto, C., & Budianto, A. (2018, September). Analysis of the 21st century skills achievement using constructivist learning with Arduino based driverless vehicle technology. In *International Conference on Teacher Training and Education 2018 (ICTTE 2018)* (pp. 201-205). Atlantis Press.

Adonu, C. J., Nwagbo, C. R., Ugwuanyi, C. S., & Okeke, I. O. (2021). Improving students' achievement and retention in biology using flipped classroom and powerpoint instructional approaches: implication for physics teaching. *International Journal of Psychosocial Rehabilitation*, *25*(2), 234-247.

Bauzon, P. T. (2022). *Fundamental philosophies of education*. National Book Store.

Bizimana, E., Mutangana, D., & Mwesigye, A. (2021). Performance analysis of biology education under the implementation of lower secondary school biology-competence-based curriculum: Policy implications. *Interdisciplinary Journal of Environmental and Science Education*, *18*(1), e2259.

Bulić, M., & Blažević, I. (2020). The impact of online learning on student motivation in science and biology classes. Journal of Elementary Education, 13(1), 73-87.

Bybee, R., & Landes, N. M. (1990). Science for life and living: An elementary school science program from Biological Sciences Improvement Study (BSCS). *The American Biology Teacher*, *52*(2), 92-98.

Chen, C. J., Tsai, H. J., Lee, M. Y., Chen, Y. C., & Huang, S. M. (2023). Effects of a Moodle-based E-learning environment on E-collaborative learning, perceived satisfaction, and study achievement among nursing students: A cross-sectional study. *Nurse Education Today*, *130*, 105921.

Chuang, S. (2021). The applications of constructivist learning theory and social learning theory on adult continuous development. *Performance Improvement*, *60*(3), 6-14.

Department of Education. (2019). *Policy Guidelines on K-12 Basic Education Program.* [PDF]. https://www.deped.gov.ph/wp-content/uploads/2019/08/DO_s2019_021.pdf

Evenddy, S. S., Hamer, W., Pujiastuti, H., & Haryadi, R. (2021, February). The Development of 3D Flipbook E-Learning Module of English Mathematics Profession. In *Journal of Physics: Conference Series* (Vol. 1796, No. 1, p. 012017). IOP Publishing.

Funa, A., & Talaue, F. (2021). Constructivist learning amid the COVID-19 pandemic: Investigating students' perceptions of biology self-learning modules. *International Journal of Learning, Teaching and Educational Research*, *20*(3), 250-264.

Gautam, A. (2018). Effectiveness of constructivist approach based instructional material on reaction achievement and retention of secondary level Students.

Górriz, J. M., Ramírez, J., Ortíz, A., Martinez-Murcia, F. J., Segovia, F., Suckling, J., ... & Ferrandez, J. M. (2020). Artificial intelligence within the interplay between natural and artificial computation: Advances in data science, trends and applications. *Neurocomputing*, *410*, 237-270.

Hadianto, H., Mudakir, I., & AISYAH, I. (2018). Effectiveness of the module with scientific approach to the study of biology in senior high school. *International Journal of Advanced Engineering Research and Science*, *5*(7), 126-129.

Harahap, F., Nasution, N. E. A., & Manurung, B. (2019). The Effect of Blended Learning on Student's Learning Achievement and Science Process Skills in Plant Tissue Culture Course. *International Journal of Instruction*, *12*(1), 521-538.

Harris, B. N., McCarthy, P. C., Wright, A. M., Schutz, H., Boersma, K. S., Shepherd, S. L., ... & Ellington, R. M. (2020). From panic to pedagogy: Using online active learning to promote inclusive instruction in ecology and evolutionary biology courses and beyond. *Ecology and evolution*, *10*(22), 12581-12612.

Jacob, F. I. L. G. O. N. A., John, S. A. K. I. Y. O., & Gwany, D. M. (2020). Teachers' pedagogical content knowledge and students' academic achievement: A theoretical overview. *Journal of Global Research in Education and Social Science*, *14*(2), 14-44.

Kagnici, A., & Sadi, Ö. (2021). Students' Conceptions of Learning Biology and Achievement after STEM Activity Enriched Instruction. *ie: inquiry in education*, *13*(1), 7.

Li, C., & Lalani, F. (2020). The Covid-19 pandemic has changed education forever. this is how. 2020. *URL: https://www. weforum. org/agenda/2020/04/coronavirus-educationglobal-covid19-online-digital-learning*.

Lopez, E. N. B., Maraño, C. M. B., Origenes, R. W., Pizaña, A. D., Salmo, J. M., & Picardal, J. P. (2022). Content analysis of cell division concepts in Senior High School Biology textbooks. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *8*(2), 159-177.

Lurvnik, R. (2020). COVID-19 webinar: A new world for teachers, education's frontline workers.

Paidi, P., Mercuriani, I. S., & Subali, B. (2020). Students' Competence in Cognitive Process and Knowledge in Biology Based on Curriculum Used in Indonesia. *International Journal of Instruction*, *13*(3), 491-510.

Radha, R., Mahalakshmi, K., Kumar, V. S., & Saravanakumar, A. R. (2020). E-Learning during lockdown of Covid-19 pandemic: A global perspective. *International journal of control and automation*, *13*(4), 1088-1099.

Ramadhani, R., Abdullah, A., Hasanuddin, H., & Khairil, K. (2020, February). The implementation of constructivist modules to correct misconceptions on the human reproductive system concept. In *Journal of Physics: Conference Series* (Vol. 1460, No. 1, p. 012062). IOP Publishing.

Rannikmäe, M., Holbrook, J., & Soobard, R. (2020). Social Constructivism—Jerome Bruner. *Science education in theory and practice: An introductory guide to learning theory*, 259-275.

Santos, J. T. D., Lim, R., & Danilo Jr, V. (2021). Least mastered competencies in biology: Basis for instructional intervention. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *7*(3), 208-221.

Sautière, P. E., Blervacq, A. S., & Vizioli, J. (2019). Production and uses of e-learning tools for animal biology education at university. *The European Zoological Journal*, *86*(1), 63-78.

Selvi, M., & Çosan, A. Ö. (2018). The Effect of Using Educational Games in Teaching Kingdoms of Living Things. *Universal Journal of Educational Research*, *6*(9), 2019-2028.

Seo, E. J., & Park, J. W. (2018). A study on the effects of social media marketing activities on brand equity and customer response in the airline industry. *Journal of Air Transport Management*, *66*, 36-41.

Taculod, N. J. O., & Arcilla Jr, F. E. (2020). Enhancing the Academic Performance and Learning Interest in Biology of Grade 10 Students Using Expanded PowerPoint Instruction. *SMCC Higher Education Research Journal (Teacher Education Journal)*, *2*(1).

Tan, M. L. G. (2019). An evaluation of department of education produced grade 7 biology modules by biology experts and science teachers. *International Journal of Innovation in Science and Mathematics Education*, *27*(5).

Tiryaki, A., & Adigüzel, S. (2021). The Effect of STEM-Based Robotic Applications on the Creativity and Attitude of Students. *Journal of science learning*, *4*(3), 288-297.

Contribution of each author to the manuscript:

	% of contribution of each author	
Task	**A1**	**A2**
A. theoretical and conceptual foundations and problematization:	50%	50%
B. data research and statistical analysis:	50%	50%
C. elaboration of figures and tables:	50%	50%
D. drafting, reviewing and writing of the text:	50%	50%
E. selection of bibliographical references	50%	50%
F. Other (please indicate)	-	-

Indication of conflict of interest:

There is no conflict of interest

Source of funding

There is no source of funding

Acknowledgments

There is no acknowledgments.