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Development and validation of a supplementary e-learning module in biomolecules

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New normal;

Abstract

The "new normal", characterized by the exigencies of asynchronous learning, presents significant pedagogical challenges, particularly concerning student comprehension, sustained engagement, and academic achievement in environments with constrained direct instructional guidance. This context necessitates the development of robust self-directed learning resources. This mixed-methods study investigated the systematic development and pedagogical efficacy of a supplementary e-learning module focused on biomolecules. Employing the ADDIE Model as a foundational framework and meticulously aligned with K-12 curriculum standards, the learner-centered module garnered exemplary evaluations from a distinguished panel of subject matter experts. Quantitative analysis of post-intervention assessments revealed a profound enhancement in student performance: pre-intervention scores predominantly clustered within the Developing or Approaching Proficiency strata, whereas subsequent to module engagement, 69.5% of students attained an Advanced classification and 30.5% achieved Proficient status, signifying a demonstrable shift towards conceptual mastery. Statistical analysis confirmed a significant improvement in academic outcomes. Complementary qualitative data, derived from structured interviews, provided robust evidence of the module's instrumental role in fostering learner autonomy and cultivating profound conceptual understanding. The absence of reported negative feedback, while potentially influenced by contextual factors, suggests a generally favorable reception. These findings underscore the module's efficacy in addressing the complexities of asynchronous learning environments, positioning it as a valuable pedagogical tool for educators and a substantive contribution to the ongoing advancement of science education within flexible learning paradigms.

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Introduction

The COVID-19 pandemic has dramatically impacted the ongoing teaching-learning processes in the Philippine educational system brought on by the growth of the distance online class. Since learner study on their own, challenges arise with respect to the success of the distance education students in e-learning environments. As learners are now required to study independently, various challenges have emerged, particularly concerning the effectiveness and success of students engaged in e-learning environments. These challenges include limited access to reliable internet, lack of technological devices, reduced interaction with teachers and peers, and difficulties in maintaining motivation and self-discipline. Consequently, the shift to

online learning has raised serious concerns about educational equity, learning outcomes, and the overall quality of education during and after the pandemic.

There are different forms of online learning (Lowenthal, Wilson, & Parrish 2009; Moore, Dickson-Deane, & Galyen, 2011). Different methods are applied during distance learning delivered via cable TV or CD; however asynchronous web-based online instruction was reported as the most adopted delivery method for distance education (Parsad & Lewis, 2008). While distance education can be delivered via different methods such as cable TV or CD, asynchronous web-based online instruction was reported as the most adopted delivery method for distance education (Parsad & Lewis, 2008). Real-time participation of both the instructor and students are not required in asynchronous online communication for it can be supported through tools such as e-mails, discussion boards, blogs, wikis, or video/audio recordings.

The idea that learners are active participants in their learning journey is the basis of the constructivist theory since knowledge is constructed based on experiences. Each learning in their experience is incorporated to build new ideas with their prior knowledge. Schemas are developed by the learners to organize acquired knowledge. This model was entrenched in learning theories by Dewey, Piaget, Vygotsky, Gagne, and Bruner.

Constructivist theory is significant to understanding on how students learn. This theory posits that knowledge are constructed by the students and this idea is central to constructivism. Learners incorporate knowledge from their new experiences adding it to their current foundation of understanding. According to Woolfolk (1993) "learning is active mental work, not passive reception of teaching".

The success of a constructivist classroom hinges in these four key areas:

- The instructor takes on the role of a facilitator instead of a director.
- There are equal authority and responsibility between the students and the instructor.
- Learning occurs in small groups.
- Knowledge is shared between both the students and the instructor.

With the help of functional instructional materials to enhance innovative production in modern fields such as science and technology made the effective teaching possible, among others Idris, 2008. In learning every subject in the school curriculum, it is vital to have instructional materials. They allow the students to interact with words, symbols, and ideas in ways that develop their abilities in reading, listening, solving, viewing, thinking, speaking, writing, using media, and technology. According to Faize and Dahan (2011), instructional materials are print and non-print items designed to impart information to students in the educational process. Instructional materials include items such as prints, textbooks, magazines, newspapers, slides, pictures, workbooks, electronic media among others. With this, it is therefore important nowadays that supplementary e-learning modules be developed to aid student learning in the new normal which is why the present study is conducted.

Method

The study is conducted in an authentic e-learning utilizing Google Classroom and Google meet as the platform for learning delivery of MSU-IIT Integrated Developmental School (IDS), located in the province of Lanao Del Norte, Region 10. Grade 11 STEM students

of IDS taking up General Biology 1 subject for the school year 2021-2022 constitute this study. Only 59 entries were used, representing 47.2% of the total number of Grade 11 STEM students.

Weighted Means was used to measure the validity of the material from content experts as well as student's performance in the achievement test administered to measure effectiveness of the material. Qualitative analysis through clinical interview was also conducted to validate the quantitative data.

Results and Discussion

Development Process of the Supplementary E-learning Module on Biomolecules

The researcher used the ADDIE model in developing the supplementary e-learning module on Biomolecules. This creates better objective alignment, making sure to teach what to test. The five phases: Analysis, Design, Development, Implementation, and Evaluation were followed to produce effective lessons and activities that support 21st Century learning in line with DepEd learning goals stated in DepEd Order No. 21 series of 2019.

In the Analysis Phase, a baseline evaluation was done by conducting a Needs assessment to find out what makes the topic difficult to understand from the point of view of student and teachers. Resource assessment is also considered as it is essential particularly, in designing laboratory activities and experiments for student as they are in their homes. Availability of materials and prerequisite laboratory skills were considered for both students and teachers.

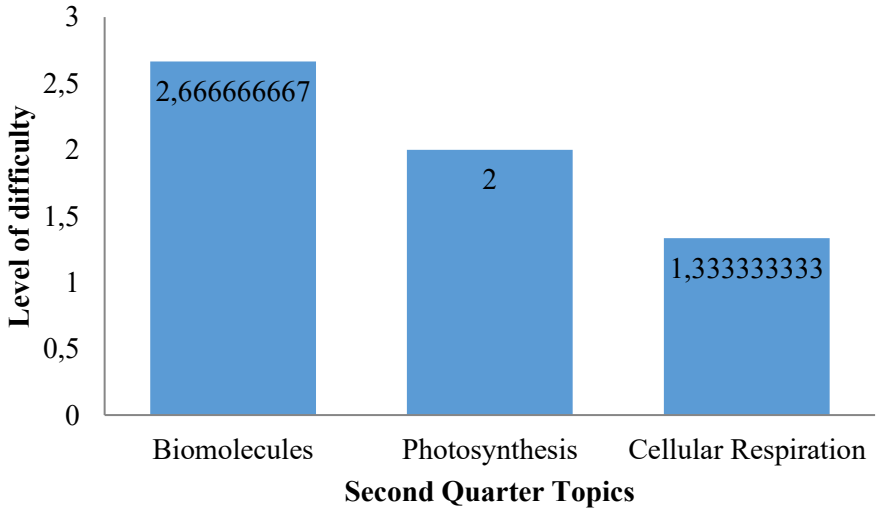


Figure 1. Students Level of Difficulty in Second Quarter Topics.

Based on the needs assessment interview conducted by the researcher, Biological Molecules ranked as the most difficult topic with an average of 2.76 due to the technicality of the topic as differences between biological molecules and their structures and functions can be confusing. Table 1 shows the elements or components of a supplementary e-learning module to be included based on the needs assessment interview conducted.

Table 1. Elements to Be Included in a Supplementary E-Learning Module on Biomolecules Based on The Needs Assessment

Elements or Components of A Module to be Included in A Biology Module	Reasons
Definition of Terms/Simplified Vocabulary:	Simplify the technical terms for it to be more understandable
Illustrations/Diagram	For better understanding
Trivia/Fun Facts	Memorable
	Lesson Self-Check with Key answers at the back
Video Clips/links	Supplement the discussion
Activity/Experimentation	Apply the concepts learned
Analogy/Examples	Relatable
Mnemonics	For it to be easily remembered

The Design Phase. Based on the curriculum guide and the needs of the end users (learners and teachers) in the new normal classroom environment, a supplementary e-learning module on Biomolecules was designed.

Furthermore, a performance task which integrates 21st Century Skills such as Collaboration, Knowledge Construction, Real-world Problem Solving, ICT Integration and Self-Regulation was also developed and implemented. This is done to help learners apply their knowledge and subsequently implement the practice of 21st Century Skills which is aligned with the goals of the Enhanced Basic Education Program or K to 12 Basic Education Program. Performance-based assessment and formative assessment is designed in a way that will measure students' ability to apply the skills and knowledge learned from a unit of study at the same time will not require face-to-face contact with others.

Table 2 shows the mapping of the K-12 standards to the learning objectives and the list of science concepts and skills of the module to ensure alignment to the educational goals of the Department of Education.

Table 2. Task Analysis Table Based from K-12 Standards Curriculum Guide
Year Level: Grade 11

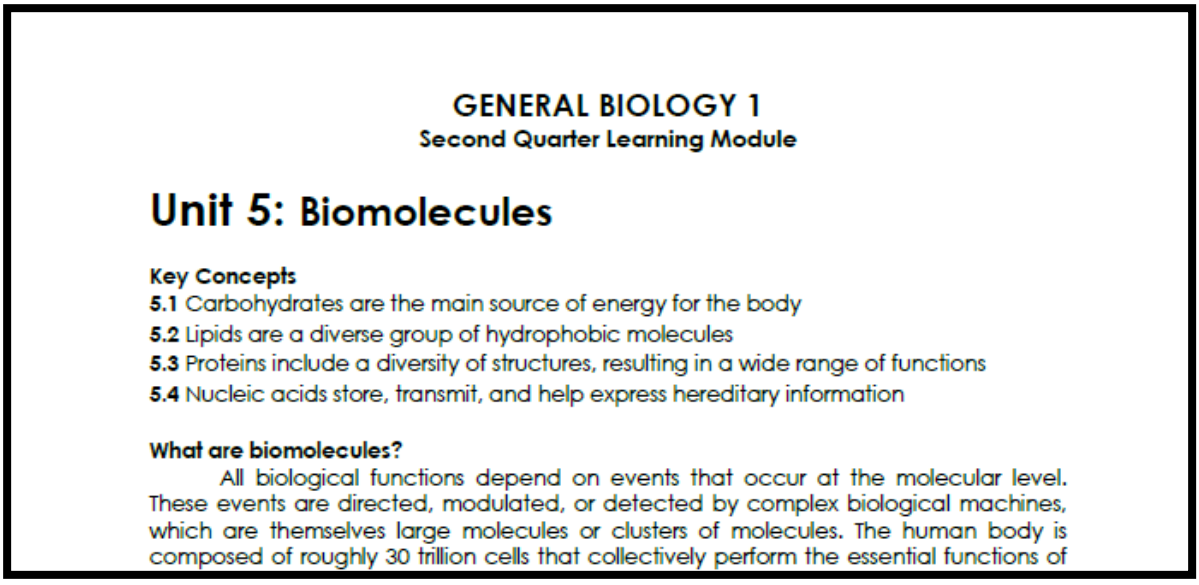
Objective	Concept	Skill	Value	Strategy
Categorize the biological molecules (lipids, carbohydrates, proteins, and nucleic acids) according to their structure and function	A biomolecule is a chemical compound found in living organisms. Biomolecules include lipids, carbohydrates, proteins, and nucleic acids.	Communicating Classifying Experimentation	Curiosity Honesty Critical thinking Collaboration Responsibility	Direct Instruction Experiment
Explain the role of each biological molecule in specific metabolic processes	Biomolecules are the building blocks of life and perform important functions in living organisms.	Communicating Classifying Experimentation	Curiosity Honesty Critical thinking Collaboration Responsibility	Direct Instruction Experiment
Describe the components of an enzyme	Enzymes are proteins that help speed up metabolism, or the chemical reactions in the human body.	Communicating Experimentation	Curiosity Honesty Critical thinking Collaboration Responsibility	Direct Instruction Experiment
Determine how factors such as pH, temperature, and substrate affect enzyme activity	Enzyme activity can be affected by a variety of factors, such as pH, temperature, and substrate concentration.	Communicating Experimentation	Curiosity Honesty Critical thinking Collaboration Responsibility	Direct Instruction Experiment

Based on the curricullum guide and the needs of the learners in the new normal classroom environment, a supplementary e-learning module on Biomolecules is designed.

The *Development Phase* is when the researcher creates and assemble the content assets that were considered in the *Analyze* and *Design* phases. Based on the standards and objectives, the researcher outlined and developed the supplementary e-learning module in Biomolecules.

The developed e-learning module includes the following elements:

- **Lesson Content**
  - ✓ Key Concepts
  - ✓ DepEd Standards
  - ✓ Introduction
  - ✓ Unlocking of terms
  - ✓ Diagram/Illustration
  - ✓ Concept Highlights
  - ✓ Interesting Facts
  - ✓ Value Focus
- **Home Laboratory Activity**
  - ✓ Introduction
  - ✓ Materials
  - ✓ Procedure
  - ✓ Observations
  - ✓ Questions
- **Biology Update (BioUP)**
- **Unit Review**
- **Unit Assessment**
  - ✓ Level 1: Knowledge/Comprehension
  - ✓ Level 2: Application/Analysis
  - ✓ Level 3: Synthesis



GENERAL BIOLOGY 1

Second Quarter Learning Module

Unit 5: Biomolecules

Key Concepts

5.1 Carbohydrates are the main source of energy for the body

5.2 Lipids are a diverse group of hydrophobic molecules

5.3 Proteins include a diversity of structures, resulting in a wide range of functions

5.4 Nucleic acids store, transmit, and help express hereditary information

What are biomolecules?

All biological functions depend on events that occur at the molecular level. These events are directed, modulated, or detected by complex biological machines, which are themselves large molecules or clusters of molecules. The human body is composed of roughly 30 trillion cells that collectively perform the essential functions of

Figure 2. Screenshot of The Developed Supplementary E-Learning Module on Biomolecules

During the *Implementation Phase,* the teacher-researcher ensures that the module was posted in the Google classroom. The teacher-researcher made sure that the students are given the ability to learn and explore on their own at their own pacing. The performance task, which is a group activity with ICT integration, ensures learner participation in the learning process.

The *Evaluation Phase* measures the effectiveness of the instruction and developed activities. This actually occurs throughout the entire instructional design phases- within phases,

between phases, and after implementation. A panel of evaluators composed of three (3) content experts helped in ensuring the quality of the module. A Module Evaluation instrument was adopted using a 5-point Likert scale where 1 is poor and 5 is excellent.

Table 3. Evaluation of the Developed Supplementary E-learning module

Criteria	Validator 1	Validator 2	Validator 3	Mean
Attainment of Objectives	4.00	4.00	4.33	4.11
Accuracy of content	4.20	4.40	4.42	4.33
Originality	4.20	4.20	4.22	4.22
Clarity	4.00	4.25	4.25	4.16
Appeal	4.33	4.00	4.33	4.22
Mean	4.14	4.17	4.30	4.20

The content evaluators helped with the improvement of the e-learning module based on the following parameters: attainment of objectives, accuracy of content, originality, clarity, and appeal.

Table 4. Summary of The Validators' General Comments on The Developed Supplementary E-Learning Module

	Validator 1	Validator 2	Validator 3
General Comments/ Suggestions	Add supplemental reading	You may play with font and sizes to emphasize new topic or important words	N/A
Recommendation	Minor revision	Minor revision	For field validation

Based on the recommendations of the evaluators, some parts were added in the activty (ie specifying the different roles the learners take in the advertisement, specific instructions on collaboration amidst the pandemic and reflecion) to apply the knowledge they learned and promote 21st century skills.

Academic performance level of the students in using the developed supplementary reading material

Five levels of proficiency were identified, namely: Beginning, Developing, Approaching Proficiency, Proficient, and Advanced. The Beginning (B) level will be given to students who obtained a score of 0.00 to 6.00 in the 30-item test; Developing (D) level for those

who obtained 6.01 to 12.00; Approaching Proficiency (AP) for those who obtained a score of 12.01 to 18.00; Proficient (P) for those who obtained a score of 18.01 to 24.00; and Advanced (A) for those who obtained a score of 24.01 to 30.00 in the 30-item test.

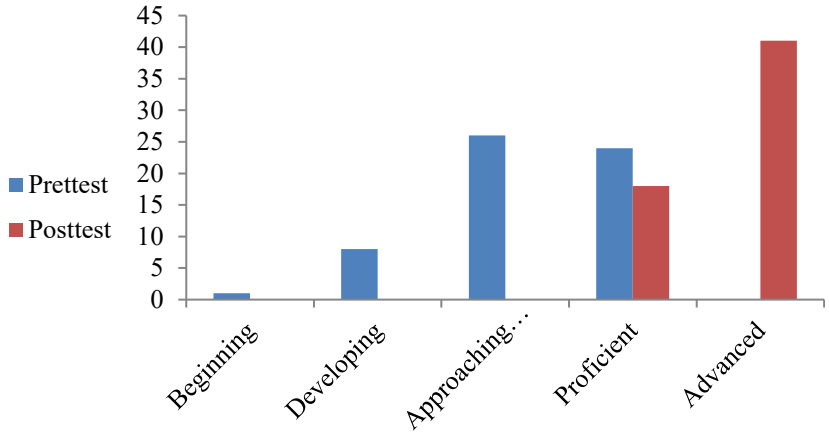


Figure 3. Students Level of Academic Performance After Using The E-Learning Module

Based on the results of their post-test as compared with the pre-test (Figure 1) there is a significant difference of the scores of the students before and after the lesson was given. The scores improved considerably in the post-test with 69.5% of the students belonging to the advanced group and 30.5% are proficient. The findings reveal that students perform statistically better in science over time utilizing the supplementary reading material developed in this study.

Student comments

A clinical interview was conducted to support the quantitative data. Students who used the material felt that they were motivating. Questions regarding whether students thought the supplementary e-learning module was useful for learning the content covered in the course were probed. Most respondents indicated that they found the material useful. The extracts below are illustrative of the type of feedback received:

Extract 1: The supplementary e-learning module was useful

Student 1:

The module is useful especially after synchronous time since I can read some stuff later that will supplement my learning.

Student 2:

The highlights for me of the module are the practice exercises, unit review and unit assessment as I can self-check conceptual understanding of the lesson. That's really something I find useful.

Student 3:

The supplementary e-learning module given to us by the teacher sure aids in my learning as it provides more content and other outside the class activities that I can do for myself.

Student 4:

Home laboratory activities were good and I can do it even by myself with the readily available materials. That's kind of convenient especially this online thing now.

Student 5:

I find the material interesting with all the fun facts and value focus. Also there are other elements that catch my attention like the update at the end of the module which for me is a thumbs up.

What we can see from these qualitative quotes is an apparent growth in students' motivation to engage in learning. Most felt that they benefitted from the material and that it helped them to learn more, because they could use it outside the classroom. No negative feedback was given by the students. Therefor the e-learning module is capable of mediating learning in this context.

Conclusion

The module was developed using the ADDIE Model and gained high rating from the panel of evaluators. The developed supplementary e-module on Biomolecules could be used as reference by educators as an effective learning tool in the transfer of learning in the new normal setting. The development of e-learning module (ADDIE model and K-12 standards-based) provides learners the chance to learn independently and collaboratively with their classmates and develop their skills in problem-solving through experimentation. Findings indicate that 1) those that used the supplementary reading material performed statistically significantly better over time, and 2) that students who used the material felt that they were motivating. Therefore the module is capable of mediating learning in this context. Moreover it could be of use to other educators and could be used as basis for further improvement of the science education in an asynchronous learning environment especially that the present health crisis is yet unsolved.

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