

# The impact of an interactive digital learning module on students' academic performance and memory retention

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## ABSTRACT

Our empirical research delved into how this interactive digital learning module affected students' learning outcomes and their ability to retain information. We explored three distinct scenarios: an e-learning environment with the interactive digital learning module, an electronic learning module without interactive video, and a traditional classroom environment with a text-based module. This study was conducted with a sample of 180 eleventh-grade students from a senior high school.

The results of the experiment revealed that students in the e-learning environment, which incorporated the interactive digital learning module, demonstrated significantly better learning outcomes and retention compared to those in the other settings. Conversely, students who utilized the electronic learning module featuring non-interactive video did not exhibit any notable improvements. These findings suggest that the integration of interactive modular teaching into the learning process enhances student retention, thereby positively influencing their overall learning performance.

**Keywords:** academic performance, interactive, learning module, memory retention

## INTRODUCTION

One of the most demanding responsibilities for educators is adjusting their teaching methods to cater to the individual variances among students. Acknowledging the diverse nature of students, as Newby et al. (2019) pointed out, many of the approaches teachers employ to provide tailored instruction have notable drawbacks. For instance, the practice of grouping students by ability, where they continue to study in mixed-ability classes, can be disadvantageous for both exceptionally advanced and struggling learners. In today's digital age, students are immersed in technology, including computers, chat platforms, email, and the internet. Consequently, they naturally anticipate that their coursework will incorporate similar technological standards.

Multimedia-based learning is becoming increasingly prevalent in higher education, whether it's in online courses, video conferencing setups, or traditional in-person classes. When we talk about multimedia in this context, it encompasses a wide range of elements such as animations, simulations, instructional tutorials, interactive drills and practice sessions, and modules centered around problem-solving. While there is ongoing debate about the educational advantages of multimedia in the learning process (Ayeni & Adelabu, 2012).

It is essential to recognize that the synergy between information and communication technologies and teaching methods, which opens up unique possibilities for multimedia to profoundly impact teaching and learning (Dang & Robertson, 2010). In the field of biological sciences, multimedia is becoming an indispensable tool for educators. This is particularly evident because the subject matter often involves intricate concepts and functional complexities that pose educational challenges not easily addressed through traditional teaching techniques, as pointed out by Khan (1997).

In the use of the interactive digital learning module, students are encouraged to be actively involved in the process of thinking, not only in understanding the lesson content, but also the students are stimulated to build a framework to determine the appropriate hypotheses and designing strategies to find the "root" problem they face (Mayer & Moreno, 2002). Based on the above, it can be presumed that interactive digital learning module provides better and positive effect in improving student learning outcomes.

Furthermore, multimedia-based modules enable students to engage in interactive learning experiences that would otherwise be unattainable due to the intricacies of certain subjects (Shahrory, 2012). When it comes to teaching biology, a distinct approach is necessary. The conventional teaching method, where the teacher imparts knowledge and students passively listen, tends to be

less effective in fostering a genuine interest in learning. The educational outcomes facilitated by interactive digital textbooks have proven to be particularly robust (Molenda et al., 2001).

Digital textbooks offer stimulation through various sensory channels, including text, images, audio, animations, and visuals. They often help students engage different sensory organs in the learning process, thereby achieving a diverse range of educational objectives (Hiemstra, 1994). Interactive learning media also contribute to long-term memory retention, making it easier for learners to recall and apply what they have learned over time.

Learning retention refers to the length of a learning material can be maintained in memory of students. Retention also refers to the percentage score of material that can be kept in the students' memories after a certain period of time. Meaningful learning can be obtained by utilizing an interactive digital learning module and learning will be more real with using video and interactive quizzes, which are available in interactive digital learning modules that affect student's learning retention (Chandra & Fisher, 2009). Hence, it is assumed that the utilization of interactive digital learning modules positively impacts students' capacity for retaining and recalling information (Zhang et al., 2006).

In this study, we outline the objectives, which were to gather both quantitative and qualitative data regarding the influence of implementing interactive digital learning modules on the academic performance and memory retention in the field of biology of 11<sup>th</sup> grade students. Furthermore, the study seeks to investigate whether the implementation of a modular approach in teaching biology yields more favorable outcomes compared to the traditional lecture-discussion method. The research hypotheses were formulated, as follows:

- The presence of an interactive digital learning module has a significant effect on students' learning achievements.
- The presence of an interactive digital learning module has a significant effect on students' memory retention.

## METHODOLOGY

### Instrument Tested

Instrument was tested to 180 student's in grade eleventh class at SMAN 2 Balige. The research instruments used for assessing the learning achievement and retention in this study were cognitive test, which consists of 30 questions in multiple choice.

### Subjects

The research was carried out at SMAN 2 Balige, located on Kartini Soposurung Balige Street. The study population consisted of eleventh-grade students, totaling 180 individuals, at SMAN 2 Balige. The sample was chosen using a comprehensive total sampling method, which included six different classes.

### Research Design

This research desing was quasi-experimental, which employed to examine the impact of interactive digital learning modules on students' learning achievements and memory retention. In this study, the variables included different types of learning modules (text-based, electronic digital, and interactive digital learning modules) as independent variables. On the other hand, students' learning achievements and retention were considered the dependent variables. **Table 1** illustrates the variations in the treatments involving different learning modules utilized in this research.

### Data Analysis

Assessment of data analysis involves the utilization of tests for validity, reliability, normality, and homogeneity. The result of students' learning achievements counted by the one-way ANOVA. If the p-value exceeds 0.05, the null hypothesis ( $H_0$ ) is upheld, while the alternative hypothesis ( $H_a$ ) is discarded. Conversely, if the p-value is less than 0.05, the null hypothesis ( $H_0$ ) is rejected in favor of the alternative hypothesis ( $H_a$ ).

## RESULTS

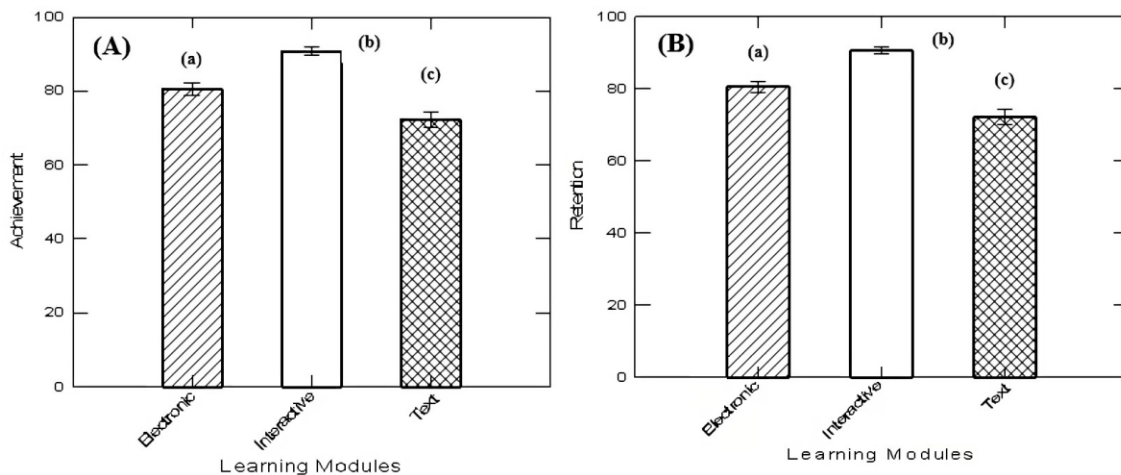
The research findings reveal that students who utilized the interactive digital learning module achieved an average learning achievement score of  $86.31 \pm 7.97$ . This outperformed the scores of students using the electronic learning module ( $81.47 \pm 7.6$ ) and the text-based learning module ( $78.30 \pm 7.84$ ). The type of learning module had a statistically significant impact on students' learning achievements, as indicated by an F-value of 16.48 and a p-value of 0.000. Consequently, we reject the null hypothesis ( $H_0$ ) and accept the alternative hypothesis ( $H_a$ ).

To provide a quantitative perspective, the average learning achievement of students using the interactive digital learning module was 5.94% higher than that of students using electronic learning modules. The interactive class also exhibited the highest percentage of learning completeness at 91.67%, surpassing other classes. In comparison, electronic learning modules resulted in a 4.04% improvement in learning achievement when compared to text-based learning modules. Furthermore, students who engaged with the interactive learning module demonstrated a 10.22% enhancement in learning achievement compared to those using the text-based learning module (see part A in **Figure 1** for graphical representation).

The retention rates among students who utilized different learning modules were as follows: interactive digital learning modules ( $92.10 \pm 8.57$ ), electronic learning modules ( $80.55 \pm 13.16$ ), and text-based learning modules ( $72.29 \pm 14.88$ ). The analysis

**Table 1.** Differences of learning modules

Differences	Learning modules		
	Text module	Electronic module	Interactive digital module
System provided	The system is not linked to the Internet servers or web-based platforms, and it does not involve the sharing of multimedia content.	The system is not designed to be interoperable with internet servers or web-based platforms, and it does not facilitate multimedia sharing.	The system is interoperable with internet servers and web-based platforms, enabling seamless integration with applications such as multimedia sharing.
Interactivity learning materials	Students' learning material typically refers to instructional materials used in classroom. Unfortunately, these materials often fail to maintain student engagement because there is absence of a feedback loop from module to students in their role as users. Students tend to passively consume these materials, similar to reading a traditional textbook.	Self-learning material typically denotes teaching materials used in classroom. However, these materials often do not actively engage learners because there is absence of a feedback loop from module to students in their role as users. Students tend to interact with these materials in a manner similar to reading a conventional textbook.	Self-learning material usually pertains to teaching materials used within the classroom. However, these materials are designed to keep learners actively engaged by providing feedback response from the module to the students as users, thus aiding in the enhancement of their cognitive skills.
Media provided	Learning module is predominantly text-based and includes figures but does not incorporate elements such as videos, interactive quizzes, or music.	The learning module is devoid of video content, interactive quizzes, and music. Its format and appearance are PDF documents.	Learning module is enriched with video content, interactive quizzes, & music. These interactive & flexible learning programs are designed to facilitate self-study approaches, offering students a dynamic & engaging learning experience.
Accessing	It can be accessed and read at any location and at any time, similar to carrying a physical textbook with you.	It can be read from anywhere and at any time without the need to carry a physical textbook.	It can be accessed from anywhere and at any time through the web or a weblog.
Convenience of learning	Enhance students' self-confidence while they are learning in the classroom.	Boosting the students' confidence levels and foster positive attitudes towards their own learning.	Enhance students' confidence levels & cultivate positive attitudes towards their own learning. Promote opportunities for collaborative online learning & meaningful conversations. Facilitate connections with real world & provide access to worldwide communities possessing expertise & many viewpoints to enhance educational experience.



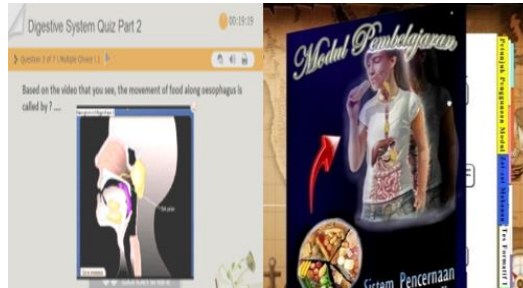
**Figure 1.** Impact of interactive, electronic, & text-based learning modules on student learning outcomes (A) & retention (B) within context of digestive system topic at grade 11 science major SMAN 2 Balige showed significant differences ( $df=2, p=0.000$ ). Error bars represent standard errors. Data was assessed using a one-way ANOVA test. Letters (a), (b), & (c) enclosed within graph box denote significant distinctions among three instructional modules (Data visualization, from authors' research documentation, 2023)

revealed a significant impact of the learning modules on student memory retention, with an F-statistic of 44.023, degrees of freedom ( $df$ ) equal to two, and a p-value of 0.000. This resulted in the rejection of the null hypothesis ( $H_0$ ) and the acceptance of the alternative hypothesis ( $H_a$ ).

Comparing the effects, students who learned using interactive digital learning modules showed a 14.37% improvement in retention compared to those using electronic learning modules (92.10: 80.55), while electronic learning modules exhibited an 11.47% increase in retention compared to text-based learning modules (80.55: 72.29). Notably, students who engaged with interactive learning modules demonstrated a significant 27.49% improvement in retention compared to those using text-based learning modules (see part B in **Figure 1** for graphical representation).



**Figure 2.** Interactive learning module class (Learning activity, from authors' research documentation, 2023)



**Figure 3.** Interactive digital book (Learning media, from authors' research documentation, 2023)



**Figure 4.** Text learning module class (Learning activity, from authors' research documentation, 2023)

## DISCUSSION

Classes that using interactive digital learning modules (**Figure 2**) taught by using digital books that consist of audio-visual media, the teacher gives a description of the material that is taught with helping of interactive digital book and developed with the video as a supporting media that could be seen in **Figure 3**.

On the other hand, groups that learning by using electronic and text module (**Figure 4**) were not developed by audio-visual media, so students only obtain information from the image displayed on the modules only. The main difference of the third module is an interactive digital and electronic module can be accessed and read by students anywhere via internet facilities, but for the students who study by using text learning modules does not require internet facilities or electronic equipment to read it.

Students listened to the teacher's explanation about the material discussed from the digital learning modules and electronic learning modules in front of the class with the help of a projector. After that, teachers guided students to solve the formative questions on the learning module. The learning process in interactive class used interactive digital learning modules assisted video and interactive quiz. Students did not just listen to the explanation from teacher, but they could hear back the explanation in the video while looking at the processes of the digestive system video in the modules.

Listening to the explanation from the teacher, assisted by moving images from video helped students in understanding the mechanisms and concepts involved in the digestive system, described the sequence of dynamic processes and abstract concepts. For example, to show concretely every stage of digestion in humans and ruminants.

These findings are relevant to the research Wu et al. (2014), which states that biology is a visual subject that often contains a sequence of complex dynamic processes and abstract concepts so that visualization is important for studying dynamic processes and abstract concepts in biology. Material digestive system has a lot of abstract concepts and dynamic process that must be understood by students. For example, when explaining about the mechanisms of ruminant digestion become more concrete when delivered using the video.

Other advantages of digital interactive learning modules are helping students to improve their biology learning comprehension and allow the meaningful learning. Students who study with interactive digital learning modules experience heightened engagement, as the presented videos have the ability to pique their curiosity, resulting in a lack of boredom during the learning process.

According to Hughes and Roblyer (2023), the incorporation of animated media has a substantial impact on students' motivation for learning and significantly influences their academic performance and demonstrate student learning outcomes that learned using animation media is higher than the students that learned without using the animation. Utilization of instructional media such as video is needed for studying digestive system material. Digestive system is one of abstract concept and has a lot of dynamic process. Utilization video to students at class help them to more understand about concrete concepts and create the attractive learning activities.

Learning that using an electronic module is capable of improving student learning activities in obtaining the information. Learning, which emphasizes self-learning could encourage students to learn better. It is proved by Mayer and Anderson (1992) states that students wish to have a more substantial offer concerning reviews such courses and, consequently, the participation could be greater. The increase is of the technology will contribute to the technological competence of the student. Students may demand the implementation of more sophisticated technological equipment in the educational environment.

Innovative learning approaches with incorporation of technology as a learning tool has become a crucial aspect in the field of education. Educators can harness the potential of this technological avenue to facilitate effective learning.

The result of a questionnaire and interviews with some students can be concluded they were interested learning by using this interactive digital learning module. Some of them assume that learning in the classroom without the use of learning media was boring and sleepy.

Utilization of video media on interactive digital learning modules in teaching materials digestive system is very precise. Because the material has a lot of complex dynamic process sequences and abstract concepts, so that visualization tools such as video will help students understand the subject matter (Brown et al., 1999).

Videos in interactive digital learning module increase students' retention in recall available learning materials. Some of the subject matter discussed in the digestive system of human and ruminant digestive mechanisms had a sequence of processes and steps that must be understood by the students. So that students are able to distinguish the characteristics of each stage there. Through the video in interactive digital module, every process that occurs from one stage to the next stage becomes evident and real. However, O'Day (2007) states that the animation is more effective than animation narrated without narration to deliver quality learning.

Retention of students is determined by teaching media used. Many studies explain that the level of student retention against biological material needed a strategy or learning method that is able to actively involve students during the learning process or student-centered learning.

Proverb of Copernicus stated "I hear I forget, I see I remember, I do I understand", has strengthened the assumption that the rate of retention of the material will be high, if students are given the opportunity to explore. This proverb is also reinforced by Steinkamp and Maehr (1983), which states that we remember 10% of what is read, 20% of which are heard, 30% of the visits, 50% of which are heard and seen, 70% of what is said, and 90% of what is said and done.

Retention of student learning as measured in this study is a long-term memory so that the measurement time is set after 21 days (three weeks) learning is completed. Such determination refers to research O'Day (2007), which states that students still remember about 21% of the material that has been learned in one to four weeks ago (long-term memory retention).

Retention of student that learned with electronic learning modules without applying videos is different with students that learned using text learning module. This is due to the learning activities of students who use electronic learning module is higher when compared to the learning activities of students who use the text learning module. Students can access the electronic modules anytime and anywhere. Increased student learning activities provide a positive influence on student learning outcomes.

## CONCLUSIONS

The utilization of learning modules has a significant positive impact on both students' learning achievements and retention rates. Among these modules, interactive learning stands out as the superior choice. This finding has led the researcher to conclude that employing modular instruction in biology yields better student performance compared to the traditional lecture-discussion method.

Modular instruction allows students to learn at their own pace, tailored to their individual abilities. Modular instruction proves to be a more effective teaching and learning approach for biology courses when compared to the lecture-discussion method. This approach provides students with the flexibility to learn at their own pace, aligning with their skill level and specific needs. However, it's important to note that students' performance may still be influenced by factors such as their prior knowledge of the subject

## Recommendations

This innovative teaching and learning approach is expected to inspire educators in creating instructional modules that foster the development of high-caliber graduates in both education and technology disciplines. Additionally, the knowledge gained by students through this experience can contribute to a heightened awareness and comprehension of the learning journey.

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**Declaration of interest:** No conflict of interest is declared by authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

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