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The effectiveness of edutainment in teaching cell cycle and transport mechanisms

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ABSTRACT

Traditional lecture-based teaching methods prevalent in Philippine schools often lead to passive learning. By contrast, this study investigates the active engagement and enhanced conceptual comprehension facilitated by edutainment through Classcraft v.4.2.6, focusing on the least learned competencies of cell cycle and transport mechanisms. Expert evaluation of edutainment content affirmed its potential as a valuable educational tool. Students exposed to the edutainment method showed significantly improved learning outcomes compared to those taught via traditional lecture method, as validated by statistical analyses. However, challenges such as technological barriers and distractions were acknowledged. To optimize edutainment's benefits, strategic design considerations and support mechanisms are recommended, including purposeful design, progressive complexity, and educator training. This study significantly updates knowledge in educational practices by highlighting edutainment's efficacy. By challenging lecture-based teaching, it advocates for more engaging instructional approaches in Philippine secondary education, promising enhanced learning experiences and outcomes.

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1. INTRODUCTION

In the global setting, rapid technological progression and evolving educational paradigms transformed the landscape of science education. Traditional pedagogical approaches are increasingly being complemented, if not replaced, by innovative methods that harness the power of digital technology and entertainment, giving rise to the concept of edutainment [1]. This paradigm shift seeks to revolutionize the way science is taught and learned, with the goal of fostering greater engagement and deeper understanding among students [2].

The significance of science education lies in empowering students to make informed choices and enhance comprehension of critical scientific matters, such as climate change, vaccination, and genetic engineering, as integral components of general biology [3], aiming to cultivate the application of scientific understanding to real-world scenarios despite globally poor student performance [4]. The 2022 Program for International Student Assessment (PISA) results revealed that only eighteen out of eighty-one countries exceeded the Organization for Economic Co-operation and Development (OECD) average in mathematics, reading, and science [5], with a significant 15-point decline in math performance across OECD nations

between 2018 and 2022, marking a record drop, while over the past decade, there has been a downward trend in average reading and science scores despite mathematics maintaining stability from 2003 to 2018 [5]. In the Philippines, the PISA 2022 results showed scores approximately 120 points lower than the average across all participating countries: 355 for mathematics, 347 for reading, and 373 for science, indicating a deficit of one year in the annual pace of learning for 15-year-olds compared to the average scores, with every 20 points below the average representing one year of learning [6].

In 2019, the Department of Education (DepEd) reported a decline in science proficiency to 41.9% from 47.5%, varying across regions and socioeconomic classes, highlighting disparities and underscoring the need for targeted interventions to ensure equitable access to quality science education [7]. In Caraga Region, the 2019 national achievement test (NAT) showed a low average science score of 41.86%, with only 30.21% of students passing the Division Achievement Test in Agusan del Norte, indicating potential issues with science education quality or resources, necessitating targeted interventions for equitable access to high-quality science education [7]. Low student performance nationally and locally stems from factors such as student disinterest, resource inadequacy, and ineffective instructional methods [7], including a reliance on lecture-based teaching in general biology [8], which may hinder students' acquisition of essential competencies and lead to suboptimal academic outcomes [9].

In the prevailing instructional landscape of teaching general biology in high schools, lectures dominate as the primary method. This approach often fails to provide coherent learning experiences, potentially leading to suboptimal academic outcomes [9]. In the Philippines, secondary school teachers predominantly employ lecture-based teaching [10], resulting in passive learning among students who focus on rote memorization rather than engaging with the subject matter [11]. This traditional approach does not foster in-depth understanding or long-term retention, particularly in abstract topics [11]. Consequently, there's a pressing need for educators to adopt innovative instructional strategies, such as incorporating digital applications, to enhance student engagement and promote meaningful learning experiences that align with modern educational demands.

The primary aim of this study is to assess the effectiveness of employing the edutainment instructional technique in enhancing conceptual comprehension of the cell cycle and transport mechanisms among grade 11 science, technology, engineering, and mathematics (STEM) students at Agusan National High School–Senior High School. The decision to focus on this topic stems from the findings of the 2021 and 2022 MPS and item analysis conducted among grade 11 students at Agusan National High School–Senior High School. The results highlighted that the mastery level for the cell cycle is currently at 74.14%, and for transport mechanism, it stands at 73.61%. Based on the bureau of education assessment (BEA), these percentages fall below the accepted standard mastery level of 75% hence, the least learned competencies. Additionally, it seeks to identify and analyze the challenges and issues encountered by students during the implementation of this instructional approach.

2. METHOD

The study used an experimental approach to compare the effectiveness of an edutainment method versus traditional lectures in enhancing students' grasp of general biology course. This approach allows for a systematic investigation of the research question while controlling for potential confounding variables, strengthening the validity of the study's findings. The study provides robust evidence on the influence of teaching methods on student learning outcomes.

2.1. Material

There were two group of participants in the study, first group of participants are used for the pilot testing of the questionnaire to ensure its validity and reliability, the second group of participants are used for the administration of the edutainment method of teaching. For the pilot testing, the participants are the grade 11 STEM students of Timber City Academy currently enrolled in school year 2023-2024. A total of 30 students answered the researcher-made questionnaire. For the administration of the edutainment method of teaching, the participants of the study are the grade 11 STEM students of Agusan National High School–Senior High School currently enrolled in the school year 2023-2024 with a total of 57 students from two sections: 25 males and 32 females. Students were divided into two groups the controlled and experimental groups. The control group will be employed by the lecture method, while the experimental group will be using the edutainment method of teaching.

The instruments utilized in the study are test questionnaires and validated survey questionnaires. The validated test questionnaire comprised 30 multiple-choice items, utilized for assessing the pretest and posttest scores of each student. Additionally, an edutainment validation questionnaire was employed to evaluate the validity of the edutainment method of instruction, considering aspects such as its appropriateness, instructional feasibility, and linguistic suitability. The instrument was validated by three

expert science teachers assigned as content material validators; IT specialists from Agusan National High School to be assigned as media validators; and English teachers as language validators.

The Classcraft v.4.2.6 software was used in the development of edutainment in the topic cell cycle and transport mechanisms which can be used or run offline and online. The Classcraft v.4.2.6 can be freely downloaded from any smart devices or computers. To cater students who did not have access to smart devices, the researchers utilized the available 50 tablet computers in the school.

2.2. Data analyses

First, the collected data undergoes tests for normality and homogeneity. Subsequently, descriptive analysis and hypothesis testing are conducted. The study employs three statistical tests to evaluate the research hypothesis. Cronbach's alpha assessed the consistency and reliability of test items in both pretest and posttest for general biology knowledge. High alpha value of 0.00 suggest consistent measurement. With consistency confirmed, statistical tests compare pretest and posttest scores to evaluate knowledge level differences between lecture and edutainment methods.

Wilcoxon signed rank test was used to determine the significant differences between the level of the students' knowledge in general biology (pretest and posttest) given the lecture method and the developed edutainment method. Independent T-Test was utilized to quantitatively compare the mean post-test scores of the two instructional methods (lecture and edutainment). It provides a statistical measure of whether any observed difference is likely due to a real effect or if it could be attributed to random variability. By comparing post-test scores, the effectiveness of different teaching methods can be evaluated. If one method leads to significantly higher scores, it may suggest that the instructional approach is more effective in facilitating learning.

3. RESULTS AND DISCUSSION

3.1. Validation of edutainment

The first question in this study focuses on validating the characteristics that affect edutainment's effectiveness in improving students' conceptual grasp of the cell cycle and transport mechanisms. These characteristics include edutainment worthiness, which evaluates its engagement and educational value, instructional feasibility, which looks at its practicality in the classroom, and language eligibility, which ensures students' clarity and comprehensibility. Tables 1-3 provide a complete evaluation of edutainment as a teaching method.

Table 1. Edutainment worthiness validation

	Indicators	Mean score	Remarks
1.	The edutainment content contains accurate educational topics.	4.83	Strongly agree
2.	The educational content is appropriate for students at various learning stages and ability levels.	4.83	Strongly agree
3.	The interactive components in the educational content stimulate user engagement.	4.83	Strongly agree
4.	The user's interest is effectively drawn in and held throughout the educational content.	5.00	Strongly agree
5.	An engaging and intriguing experience is produced by the educational content.	5.00	Strongly agree
6.	The edutainment content's plot or narrative is interesting and well-developed.	5.00	Strongly agree
7.	The educational material is interesting enough to encourage repeated use.	5.00	Strongly agree
8.	The edutainment content's user interface (UI) is simple to use and offers straightforward navigation.	5.00	Strongly agree
9.	The educational content efficiently records the user's progress and offers feedback.	4.83	Strongly agree
10.	The educational material adjusts to the interests and demands of each user.	4.83	Strongly agree
	Mean	4.92	Strongly agree

Evaluation framework for digital learning resources (DFLR). Range of means: 1.00-1.80 (strongly disagree); 1.81-2.60 (disagree); 2.61-3.40 (uncertain); 3.41-4.20 (agree); 4.20-5.00 (strongly agree).

Evaluators strongly endorsed the edutainment content with an average rating of 4.92, indicating alignment with predefined validity criteria. The design tailored to learners' needs and interests enhances its educational suitability [12]. This underscores the importance of procuring comprehensive educational content to elevate the learning experience [13].

Material worthiness in edutainment is integral for creating an inclusive, engaging, and effective learning environment that caters to the diverse needs of students [14]. It ensures that the educational content is not only entertaining but also purposeful, contributing significantly to the overall learning experience. Students who were matched with appropriate contents and activities had higher academic achievement, satisfaction, and motivation compared to those who were mismatched or not exposed to any appropriate contents [15]. This suggests that matching instructional materials to learners' characteristics is an important

aspect of material worthiness [16]. When selecting and incorporating worldwide web resources, one of the key features to consider is content, it must explicitly articulate its objectives or competencies [17]. This clarity is essential to accommodate various learning styles and intelligences among students. A well-defined set of objectives ensures that the instructional material caters to diverse ways of understanding and processing information [18].

Table 2. Instructional feasibility

	Indicators	Mean score	Remarks
1.	The instructional content is in line with the stated learning goals or outcomes.	5.00	Strongly agree
2.	The subjects covered in the material are pertinent to the needs of the curriculum.	4.83	Strongly agree
3.	The planned cognitive and skill development objectives are covered by the educational content.	4.83	Strongly agree
4.	The edutainment content is successfully incorporated into the learning process using instructional methodologies.	4.83	Strongly agree
5.	The edutainment material increases student involvement and interest during instruction.	4.83	Strongly agree
6.	The gadgets and technical facilities needed to access the educational content are easily accessible.	4.83	Strongly agree
7.	Learners can easily access the edutainment content.	5.00	Strongly agree
8.	The edutainment content's technological requirements are compatible with the platforms and devices that are currently in use.	5.00	Strongly agree
9.	The educational institution can provide the necessary technical support for using the edutainment content.	4.83	Strongly agree
10.	The edutainment content is scalable and can accommodate varying numbers of learners.	5.00	Strongly agree
	Average mean	4.90	Strongly agree

DFLR. Range of means: 1.00-1.80 (strongly disagree); 1.81-2.60(disagree); 2.61-3.40 (uncertain); 3.41-4.20 (agree); 4.20-5.00 (strongly agree).

In the evaluation of instructional feasibility, the evaluators expressed a resounding agreement, providing a strong confirmation with an average rating of 4.90. Their feedback emphasizes that the tool's credibility for potential teachers and institutions, emphasizing the need for perceived objectivity to be notably high. This attests that the instructional approach in the edutainment, where its practicality and viability is effectively executed to achieve desired learning outcomes within the given educational context [19].

Integrating practical elements like interactivity and visuals into edutainment positively impacts students' problem-solving ability and scientific literacy, enhancing their learning experiences and understanding of scientific concepts [20]. The importance of entertainment elements such as animation and music, play a crucial role in engaging students and enriching their learning [21]. The validators strongly agreed on the viability of the edutainment material, noting its ability to boost student engagement during instruction. The effectiveness of edutainment in improving knowledge [22] and comprehension across various subjects and asserts that edutainment is a valuable tool for enhancing learning outcomes [23] offering a potential alternative to traditional teaching methods by increasing student motivation and engagement.

Table 3. Language eligibility

	Indicators	Mean score	Remarks
1.	Language is appropriate for the level of the target user.	5.00	Strongly agree
2.	Vocabulary level is adapted to target reader's experienceand understanding.	5.00	Strongly agree
3.	Length of sentences is suited to the comprehension levelof target reader.	5.00	Strongly agree
4.	Sentences and paragraph structure are varied andinteresting to the target reader.	5.00	Strongly agree
5.	Vocabulary used is suitable to the target reader.	5.00	Strongly agree
6.	The material does not need special provisions to the extent that the student is uncomfortable to the unfamiliarwords	5.00	Strongly agree
7.	The material choice of words is free from ambiguity.	5.00	Strongly agree
8.	There is a little or no help or assistance needed form the teacher in terms of language confusion.	5.00	Strongly agree
9.	The material is free from red flags on possible copyright and plagiarism issues.	5.00	Strongly agree
10.	The material does not need language/word corrections.	5.00	Strongly agree
	Average mean	5.00	Strongly agree

Level 2 – DepEd evaluation rating sheet for general references and print materials. Range of means: 1.00-1.80 (strongly disagree); 1.81-2.60(disagree); 2.61-3.40 (uncertain); 3.41-4.20 (agree); 4.20-5.00 (strongly agree)

The language proficiency aspect continues to receive highly positive feedback, with evaluators expressing strong agreement, reflected in a rating of 5. This underscores that the language employed in the edutainment adheres to the principles of sound and accurate grammar usage. The significance of employing proper grammar is crucial for conveying accurate messages [24].

Grammatical errors can lead to misunderstandings and ambiguity in the conveyed meanings [25]. Effective communication relies heavily on the clarity and precision provided by grammatically correct language, as errors may introduce confusion and compromise the intended message. Therefore, ensuring language eligibility is not just a matter of adherence to rules but is essential for fostering accurate and unambiguous communication in educational contexts [26].

The role of grammar in edutainment is critical, highlighting its positive impact on learner engagement and comprehension [27]. Proper grammar usage ensures clarity and precision in the content, making it easier for learners to understand and retain information. When language follows grammatical rules, learners are more likely to comprehend the content accurately, leading to enhanced understanding and retention of information [27].

Moreover, the emphasis on grammar extends beyond mere correctness; it taps into the broader implications for the learning process [28]. In edutainment, where the fusion of entertainment and education is paramount, clear and grammatically sound language serves as a foundation for effective communication [29]. It ensures that educational content is not only presented accurately but also in a manner that captivates and sustains the attention of learners [30], fostering a more immersive and fruitful learning environment [31]. Therefore, the careful attention to grammar in edutainment carries implications not only for conveying accurate messages but also for optimizing learner engagement and comprehension [21].

3.2. The pretest and posttest scores using lecture method and edutainment method

Table 4 displays the outcomes of the Wilcoxon signed rank test, which compares post-test and pre-test scores for two instructional methods: lecture method and edutainment method. The asymptotic significance (2-tailed) values for both lecture method (p=0.00) and edutainment method (p=0.00) are below the conventional significance level of 0.05. This indicates that the observed differences are statistically significant, leading to the rejection of the null hypothesis that posits no difference between post-test and pre-test scores for both instructional methods.

Table 4. Wilcoxon signed rank test of the post-test and pre-test scores of the students using lecture method and edutainment method

Parameter	Lecture method post-test – pre-test	Edutainment method post-test – pre-test
Z	-4.58[b]	-4.81[b]
Asymp. Sig. (2-tailed)	0.00	0.00

The Wilcoxon signed rank test indicates significant improvement in post-test scores for both lecture and edutainment methods, echoing findings from. While both methods enhanced student scores [20], edutainment showed a statistically significant improvement over traditional lectures [32], affirming its potential to boost engagement and achievement in science education [33]. To further analyze the effectiveness of each instructional method, a comparative examination of the posttest results was conducted using the independent t-test. This statistical analysis helps discern whether the differences in mean scores between the lecture method and edutainment method are statistically significant or merely due to random variation. The results in Table 5 shed light on the effectiveness of each instructional method in enhancing student learning and performance.

Table 5. Independent samples test on the post-test scores of the students using lecture method and edutainment method

Variable	Assumption	T-test for equality of means			Remarks
		Sig. (2-tailed)	95% confidence interval of the difference		
			Lower	Upper	
Post-test (lecture and edutainment)	Equal variances assumed	0.00	-6.22	-4.01	Highly significant
	Equal variances not assumed	0.00	-6.21	-4.01	Highly significant

Table 5 shows a p-value of α=0.00, indicating a significant difference between posttest scores of students using the edutainment method compared to the lecture method. This suggests that students exposed to edutainment have notably improved understanding of cell cycle and transport mechanisms compared to those taught through traditional lectures. The superiority of educational games, particularly edutainment is effective in enhancing student performance across subjects like science [33]. Edutainment has been found to

be consistently more effective than traditional lectures in improving student learning outcomes across various subjects, including science. This suggests that incorporating edutainment into educational settings may be a more effective approach to enhance student performance compared to conventional lecture-based methods.

Edutainment has been shown to be an effective tool in promoting science literacy and sparking interest in young learners. The use of animations in edutainment programs helped to simplify complex concepts and increase student engagement and motivation [34]. Integrating edutainment programs into science education has been found to have positive effects on student achievement and engagement, with interactive and game-like features contributing to increased motivation and participation. These findings suggest that edutainment can serve as a valuable tool in fostering science literacy and generating interest among young learners.

3.3. The challenges and issues faced by the students in the implementation of the edutainment instructional technique

Edutainment, as an innovative approach that merges education with entertainment, holds great promise for enhancing the learning experience. However, the analysis reveals several challenges faced by students engaging with edutainment and these were categorized and collated into distinct themes, shedding light on the complexities associated with this educational method. Overall, there are two major themes arose out from the experiences of the students and these are technological barriers and distraction and overstimulation which are presented in Table 6.

As outlined in Table 6, a key obstacle linked to the implementation of edutainment in education revolves around guaranteeing equitable access to technology for all students. In the contemporary digital era, technology plays a crucial role in delivering edutainment content. Nevertheless, a digital divide arises, as not all students have uniform access to devices and the internet. Unequal access to technology is a significant issue with some students having limited or no access to computers and the internet at home [35]. This implies that there is a notable issue of unequal access to technology in schools [36]. Students face challenges due to limited or no access to computers and the internet at home. This digital divide can result in disparities in educational opportunities, potentially affecting students' ability to fully engage in modern learning methods and resources that require technology [36]. Addressing this issue is crucial to ensure equal access and opportunities for all students in the educational system.

Using edutainment in education can risk distracting students from the learning process if entertainment overshadows educational content. While interactive elements can increase engagement, excessive use can lead to distraction and decreased comprehension [37] as too much multimedia can cause cognitive overload. To address this, educators must balance entertainment with educational value, carefully selecting edutainment content and adjusting it to maintain student engagement without overwhelming them.

Table 6. Challenges and issues faced by the students in the implementation of the edutainment instructional technique

Issues/challenges	Responses	Mean	Percentage (%)
Technological barriers	"*Dili kaayo ko batid sa teknolohiya, ug naproblema ko sa paghunahuna kon unsaon paggamit ang mga interactive nga bahin sa edutainment platform.*" (in Filipino) (I'm not very tech-savvy, and I'm having trouble figuring out how to use the interactive features of the edutainment platform.)	13	43.33
	"*Wala koy access sa usa ka personal nga gadyet o device aron makiglambigit sa mga materyales sa edutainment gawas sa eskwelahan.*" (in Filipino) (I don't have access to a personal gadget or device to engage with the edutainment materials outside of school.)	9	30.00
Distraction and overstimulation	"*Lisud ang pag-focus sa pagkat-on kung adunay daghang mga interactive nga elemento nga nag-indigay alang sa akong atensyon.*" (in Filipino) (It is hard to focus on learning when there are so many interactive elements vying for my attention.)	14	46.67
	"*Samtang ang mga materyal sa edutainment makalingaw, kanunay nakong makit-an ang akong kaugalingon nga nawala sa immersive nga kasinatian ug nawala ang oras.*" (in Filipino) (While the edutainment materials are engaging, I often find myself getting lost in the immersive experience and losing track of time.)	16	53.33

4. CONCLUSION

This study aims to determine the effectiveness of using edutainment to enhance grade 11 STEM students' understanding of the cell cycle and transport mechanisms in comparison to the traditional lecture

method. As a conclusion based on the findings, the edutainment method surpasses the traditional lecture method in improving students' comprehension of the cell cycle and transport mechanisms. The positive results affirm the efficiency of edutainment as an innovative instructional approach. Despite its efficiency, challenges such as technological barriers and distractions were noted, highlighting the need for careful implementation. Future researchers should explore strategies to mitigate these challenges and further investigate the long-term impact of edutainment on various educational contexts. Additionally, it is suggested for future research to examine the role of different types of edutainment content in enhancing specific scientific concepts since not all edutainment content is equally effective in teaching scientific concepts. Studying different types (e.g., games, simulations, interactive videos) helps identify which formats best support learning specific scientific concepts. Also, there is a need to assess the cost-effectiveness of integrating edutainment into the curriculum to ensure scalability and sustainability. This helps ensure that educational institutions can adopt and maintain edutainment initiatives over the long term.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
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CONFLICT OF INTEREST STATEMENT

The authors declare no potential conflicts of interest regarding the research, authorship, or publication of this article.

INFORMED CONSENT

Informed consent was obtained from all individuals who participated in this study. Participants were fully informed about the purpose, procedures, and their rights before providing consent.

ETHICAL APPROVAL

This research was approved by Caraga State University, Graduate School and adhered to all relevant institutional policies and national regulations.

DATA AVAILABILITY

The authors confirm that all data supporting the findings of this study are included within the article. Data supporting this study's findings can be obtained from the corresponding author [EAL], upon reasonable request.

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