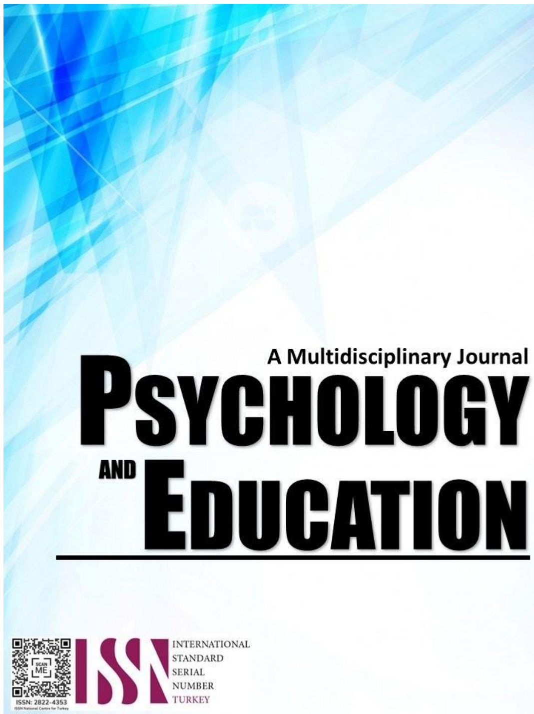
DEVELOPMENT, VALIDATION, AND ASSESSMENT OF ER-QUEST IN TEACHING ECOLOGICAL RELATIONSHIPS



PSYCHOLOGY AND EDUCATION: A MULTIDISCIPLINARY JOURNAL

Volume: 43
Issue 7
Pages: 896-907
Document ID: 2025PEMJ4203
DOI: 10.70838/pemj.430707
Manuscript Accepted: 06-18-2025

Psych Educ, 2025, **43**(7): 896-907, Document ID:2025PEMJ4203, doi:10.70838/pemj.430707, ISSN 2822-4353
Research Article

Development, Validation, and Assessment of ER-Quest in Teaching Ecological Relationships

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Abstract

Presence of technology can create or develop learning materials. This study developed ER-Quest, a computer-simulated educational resource for teaching science. It answered the mean responses of teacher-validators and student-participants in terms of objectives, usability, accuracy, clarity and appeal to the target user. It also described the proficiency level and significance between the control and experimental group. A quantitative approach and Research and Development (R&D) design were used in this study. For the validity and acceptability, the teacher-validators rated the content of the software as very high with an overall mean of 4.73, while the student participants rated it as high with a mean of 4.47. Findings revealed that there was no significant difference in the pretest scores of the control and experimental group as evidenced by a t-computed value of .825 and a p-value of .413. There was a significant difference in posttest scores between the two groups with t-computed value of 3.136 and a p-value of .003. It was observed that there was a significant difference in the pretest and posttest scores of the control group with t-computed value of 11.077 and a p-value of .000 and there was a significant difference in the pretest and posttest scores of the experimental group with a t-computed value of 12.835 and a p-value of .000. Also, there was a significant difference in the mean gain scores of both groups with a t-computed of 4.169 with p-value of .000. The use of ER-Quest can improve the proficiency of students in science than the use of conventional methods. Teachers were encouraged to incorporate the developed tool as supplementary learning material.

Keywords: *development and validation, ER-Quest, ecological relationships, science*

Introduction

The use of technology nowadays is wide and fast-changing. Everyone relies mainly on technology to make work easier. With the rapid advances in technology, it is now embedded in lessons that make it understandable, fun-filled and captures students' attention.

With the Philippines among the lowest-ranked countries in reading comprehension, mathematics, and science according to the 2018 Programme for International Student Assessment (PISA). The findings show that Filipino students' average scientific literacy score was 357 points, much lower than the 489-point average of the Organization for Economic Cooperation and Development (OECD) and shows that urban learners performed noticeably better on average than rural learners, as stated by Malaluan et al. (2019). It was mainly because rural learners were less exposed to technology.

It was emphasized by Li et al. (2024) that students' motivation to learn is positively impacted by digital educational games. Additionally, Fokides (2017) stated that by listing the names of high-achieving students, the digital gaming system honors exceptional achievement, creating a sense of success and motivating beneficial behaviors like paying attention in class.

As the use of technology was more prevalent in education, it allows teachers to encourage learners to participate actively in the teaching-learning process. Giving students recognition, points, and badges boosts student motivation, focus, and perseverance. Jackson et al. (2022) asserted that these games' interactive and

demanding features increase student engagement and motivate them to devote time and energy to solving problems and finishing tasks. Additionally, it allows kids to investigate potential outcomes and solutions related to events and circumstances from real life. Furthermore, the process of learning becomes more engaging and inspiring. Morgan et al. (2022) emphasized that it concerns how students engage critically, safely, and effectively with digital content. In addition to being adept with technology, students who possess high levels of digital literacy are also able to assess, evaluate, and produce digital content.

Herewith, the researchers aimed to develop engaging software called ER-Quest that applied technology in instructional material to increase students' curiosity about one of the least-taught science concepts: the different ecological relationships.

Research Questions

This study aimed to develop ER-Quest as an interactive teaching application for teaching Ecological Relationships, specifically Mutualism, Commensalism, Parasitism, Predation, and Competition, to further enhance the teaching-learning process and embrace the use of technology in teaching. Specifically, this study sought to answer the following sub-problems:

1. What are the mean responses of the teacher-validators to the content-validity of ER-Quest in terms of:
   1.1 objectives;
   1.2 usability;
   1.3 accuracy of the material;
   1.4 clarity of the material; and

   1.5 appeal to the target user?
2. What are the mean responses of the student-participants to the acceptability of ER-Quest in terms of:
   2.1 objectives;
   2.2 usability;
   2.3 accuracy of the material;
   2.4 clarity of the material; and
   2.5 appeal to the target user?
3. What is the proficiency level of the control and experimental group in the pre-test and post-test?
4. Is there a significant difference between the scores of the control and experimental groups in the pre-test?
5. Is there a significant difference between the scores of the control and experimental group in the post-test?
6. Is there a significant difference between the pre-test and post-test scores of the control group?
7. Is there a significant difference between the pre-test and post-test scores of the experimental group?
8. Is there a significant difference between the mean gain scores of the control and experimental groups?

Literature Review

Gamification in Education

Gamification is the process of motivating people through non-gaming activities by incorporating aspects of game design, game mechanics, and game thinking, as stressed by Al-Azawi et al. (2016). Pelegro (2022) defined it as the use of game features in non-gaming contexts, such as classrooms, to engage students and create a more playful, game-like environment.

Singh (2023) also emphasized that one of the key reasons gamification has gained such traction in education is its capacity to increase student motivation. Instructors can use students' innate desire for achievement and acknowledgment by incorporating leaderboards, badges, and points. Students are more focused and persistent during the learning process when they actively participate in their studies, which is encouraged by this natural motivation. Samosa et al. (2021) stressed that Gamification can be a powerful tool for encouraging and altering the norm to accomplish goals even when the work is tedious. Additionally, learning through games can have a big impact on the teaching of basic skills to kids or pupils who have trouble learning these abilities in different contexts. Therefore, educators need to evaluate the usability of these games to ensure they are suitable for this specific target audience.

The "gamification of education" technique involves introducing gaming aspects into a learning environment to boost student engagement, as affirmed by Smiderle et al. (2020). Mee (2020) also added that gamification in the classroom significantly impacts students' ability to think critically and creatively and their aptitude for fixing issues. The addition of fascinating and captivating exercises subconsciously piques students' curiosity about the acquisition of language. Further levels and Gamification exercises could reduce students' anxiety levels, and using compelling games and providing entertainment value could encourage students with low competence levels to participate in class instruction.

Based on the study of Colendra and Carada (2023), using Wordwall, Raptivity, and Classpoint as gamification tools to teach Filipino is quite acceptable. The study's findings also demonstrated how well gamification technologies helped students improve their critical, inferential, and literacy comprehension abilities. It was further emphasized by Regudon et al.(2022) that Students who play games feel like they belong, which allows them to adjust to a remote learning environment via the Internet. Relationships can be forged and strengthened through games over time. Conventional teaching approaches are formal and boring for pupils, making it difficult for them to understand the lessons.

With gamification techniques, students can study and enjoy themselves at the same time. Because activities are associated with happy memories, students' retention increases. When all is said and done, the term "flow state" refers to a situation in which students are fully present and involved in the task at hand. Pupils who enjoy and are passionate about their work are more likely to complete the assigned task.

As highlighted by Wang (2021), Gamification in the classroom will encourage independent and more productive learning from the pupils. One of the main reasons is that it fosters rivalry and cooperation among students, enabling academic community members to connect. Whether an instructor is teaching in-person or virtually, it is crucial to remember the social aspects of teaching and learning, and gamification is a great tool for accomplishing this. A gamified learning environment can help your students fully engage with the course material and develop a good study mindset. Learning is now an enjoyable and fulfilling endeavor rather than a tedious one.

A few popular instances of gamification in e-learning are interactive simulations, puzzles and quizzes, and progress monitoring tools. Teachers and trainers may give their students more interesting and productive learning experiences by gamifying their courses. Excellent outcomes can be achieved to guarantee that learners retain the newly taught material when the game is optimally integrated into the curriculum.

Educational game development aims to accomplish learning objectives and real-world learning. When players successfully complete objectives in the game, they can learn while having fun and accomplishing their goals. Alternatively, instructional games wrap up the lesson within the game, as asserted by Kim (2018).

Methodology

Research Design

This study employed Research and Development (R&D) and quantitative methods to achieve the intended outcomes. As highlighted by Gustiani (2019) that Research and Development (R&D) Method is one of the most outstanding model designs and widely used in educational research. This study was conducted in multiple stages, with the protocols under this kind of research design being closely adhered to guarantee the caliber of the intended outputs. The simulated instructional material was developed based on the contents of the competencies in science. The created educational content undergone validation to guarantee that it meets the requirements for the objectives, usability, accuracy, clarity, and attractiveness to the intended audience. To guarantee that the suggested instructional material was improved, the evaluations from both master and non-master teacher-evaluators was considered.

In particular, the researcher utilized the ADDIE (Analysis, Design, Development, Implement, Evaluate) Model in developing the ER-Quest for teaching Ecological Relationships, specifically Mutualism, Commensalism, Parasitism, Predation, and Competition. The used of this model as stated by Quigley (2019) can get a streamlined, targeted approach that offers feedback for ongoing progress.

In planning phase, the first step was analyzing of the curriculum guide and examining the desired learning competencies, scope, and sequence. The next step was checking references, textbooks and other instructional materials related to the study. Then, choosing of instructional settings as class section, schedule, etc and lastly, estimating the allocated budget for the study.

For the designing/development phase, the first step was determining the nature and design of the ER-Quest, then specifying the concepts and objectives of the lesson to be included in the instructional material. Third, conceptualize the flow and sequence of instructional material and lastly, determining and preparing the questions to be included in the pretest and posttest evaluation.

In validation and try-out phase, first, evaluating ER-Quest as interactive applications utilized as instructional material based on set criteria (12 panels of experts) then feedbacking and revision of ER-Quest. Next, orienting the student-participant on the conduct of the study and assessing the student's pre-knowledge of the lesson by taking a pre-test. Fourth, performing the class, conduct the lecture using ER-Quest. Fifth, assessing the student's post-knowledge of the lesson by taking a post-test and recording the pre-test and post-test. And lastly, administer the student evaluation.

For the evaluation and finalization phase, first, comparing the results of the pre-test and post-test of the student- participants. Second, interpreting the responses of the student participants based on set criteria on the evaluation checklist and recommending and suggesting the necessary revisions based on the result of the study.

Respondents

The two randomly selected groups (A) Control Group and (B) Experimental Group of students were subjected to a simple random sampling using the fishbowl method and focus on the topic ecological relationships.. The control group composed of 30 students undergone traditional teaching using the chalkboard method, while the experimental group composed of 30 students had utilized the ER-Quest. Both groups was given a pretest before the lesson and a posttest after the lesson to measure their proficiency in science and to test the effectiveness of the developed ER-Quest.

Instrument

In gathering the data relevant to the study, the researchers worked on the following: 1. Teacher-validators checklist of the proposed interactive application as instructional material; 2. Pretest and Posttest before and after exposure to the said instructional material; 3. Student-participant's evaluation checklist of the instructional material.

To obtain the validity of the developed instructional material in terms of objectives, usability, accuracy, clarity, and appeal to the target user, the dichotomous (Likert) scale was used with the categorical options of "Agree" and "Disagree," which indicates a favorable or unfavorable item, respectively. The evaluation checklist, a questionnaire, was adapted from Torrefranca (2017) studies. The level of validity was categorized into very highly valid, highly valid, valid, not so valid, and not valid. There was modifications to the item format to align it with the purpose of the study.

To gather a baseline of information, the researchers had administered a pretest that obtained the students' knowledge before their exposure to the proposed instructional material. After exposing them to the instructional material, a post test was administered to measure the student's learning and achievement. In developing the pretest and posttest, the researchers adhered to the standard procedures for developing and validating a test, starting with a table of specifications and ending with collecting evidence that had provided the validity and reliability of the test.

The student evaluation checklist was also a five-point Likert Scale adapted from the studies of Torrefranca (2017). This scale determined the acceptability of the instructional material in terms of objectives, usability, accuracy, clarity, and appeal to the target user. The level of acceptability was categorized into very highly acceptable, highly acceptable, acceptable, not so acceptable, and not acceptable.

By adhering to the standards, it ensures validity, acceptability, and reliability of the gathered data. It also ensures the quality of the developed ER-Quest that captures student's attention and interest and at the same time meets their needs.

Procedure

Following the ADDIE model, this study utilized Research and Development Design (R&D). ADDIE model was an instructional systems design framework consisting of five phases- the Analysis, Design, Development, Implementation, and Evaluation as highlighted by Molenda (2023). The used of this model as stated by Quigley (2019) can get a streamlined, targeted approach that offers feedback for ongoing progress.

Phase 1- Analysis/Planning phase

The first phase of this design was the planning stage, where the researchers had analyzed the Junior High School Curriculum Guide in Science 7 Biology. The researchers' goal was to examine the desired learning competencies, scope, and sequence of the topic that was included in the instructional material. The researcher checked the different references, textbooks, and other instructional materials related to the study.

Phase 2- Designing/Developing Phase

The second phase was the designing and developing stage. The researchers determined the nature and design of ER-Quest as an interactive application used as instructional material (IM). The researchers had consulted an IT expert specializing in programming to create the IM. Then, the researchers conceptualized the flow and sequence of instructional material. Afterwards, the researchers had determined and prepared the questions that was included in the pre-test and post-test evaluations. The researchers also prepared a table of specifications.

Phase 3- Validation and Try-Out Phase

In this phase, the researchers approached the Schools Division Superintendent to help contact non-master teachers and master teachers and ask for their expertise to validate ER-Quest. They had used the evaluator's checklist with the set criteria of objectives, usability, accuracy, clarity, and appeal to the target user of the instructional material. A total of 12 teacher-evaluators had participated in validating the ER-Quest. They were given ample time to scrutinize and systematically assess the IM using the adapted validation tool. The researchers had set two weeks for the questionnaire instrument to be retrieved and for the feedback of their comments and recommendations. After the experts had validated the material, revisions were made to the instructional material to ensure its validity and efficiency.

Likewise, the researchers guided the students who participated in the study. Using a simple random sampling technique, one section was part of the control group, and the other was part of the experimental group. The students took the pre-test to measure their knowledge before the lesson. The test was conducted using a paper-and-pen test. The students in the control group had regular class discussions using static pictures as instructional material and a chalkboard method. The students from the experimental group had their class discussion, but this time, the researchers utilized the interactive application as instructional material (ER-Quest). Similarly, all students took the post-test to assess the achievement and effectiveness of the IM. Then, the researcher gathered and recorded the pre-test and post-test results. The researchers administered the evaluation of the IM using the evaluation checklist to the student participants.

Phase 4- Evaluation and Finalization Phase

The last phase of this study was the evaluation and finalization phase. The researchers evaluated the developed ER-Quest as instructional material by obtaining the feedback responses of the student participants in terms of objectives, usability, accuracy, clarity, and appeal to the target user of the instructional material.

The researchers also obtained the results of comparing the student participants' performance in the pre-test and post-test between the control and experimental groups. Lastly, the researchers considered all recommendations and suggestions that was reflected during the evaluation and that are necessary to improve the instructional material.

Data Analysis

The following statistical tools was used in analyzing the data objectively. By using the following statistical tools, the researchers ensures the accuracy and reliability of the research and aligns with research standards.

Weighted Mean. It is an average computed by giving different weights to some individual values. It was used to answer problems 1 and 2. This was employed to get consolidated results per group of the two validators, the teacher-validators and student participants. With the computed mean of at least 3.0, the computer-mediated instructional material was considered adequate, usable, and appropriate.

Independent sample t-test. This tool compares the means of the two independent groups (control and experimental) to determine if statistical evidence associated with the population means is significantly different. It was employed to determine the significant difference in the students' pretest and posttest scores and answered problems 3, 4, 5, and 8.

Paired sample t-test. This statistical tool defines whether the mean difference between two sets of observations is zero. It was used to examine whether the means of the two paired measurements, such as posttest and pretest scores, differ significantly. As such, this tool was used to answer problems 6 and 7.

Ethical Considerations

The researchers keep the records for this study confidential as far as permitted by law. Any identifiable information obtained in connection with this study will remain confidential, except if necessary to protect the rights or welfare of the respondents.

A consent form was given to all participants of this study informing the purpose, procedure, potential risk, benefits, confidentiality of data and rights of the research participants.

Results and Discussion

This section presents the results, analyses, and interpretations of the data gathered to provide answers on the problems of the study.

Table 2. *Mean Responses of the Teacher-Validators to the Content-Validity of the ER-Quest*

Indicator	*Weighted Mean*	*Description*	*Interpretation*
Objectives			
1. Relevant to the topics covered in Grade 7 Science	4.83	Strongly Agree	Very Highly Valid
2. Objectives are clearly stated and specific	4.75	Strongly Agree	Very Highly Valid
3. Objectives are measurable	4.67	Strongly Agree	Very Highly Valid
4. Objectives are attainable	4.83	Strongly Agree	Very Highly Valid
5. Objectives are result-oriented	4.83	Strongly Agree	Very Highly Valid
Mean	4.78	Strongly Agree	Very Highly Valid
Usability			
1. The concepts and problems are logically presented from the simplest to the most complex.	4.58	Strongly Agree	Very Highly Valid
2. The tool will develop the analytical thinking and reasoning skills of the students in learning Ecological Relationships.	4.58	Strongly Agree	Very Highly Valid
3. The tool will allow the students to learn Ecological Relationships at their own pace.	4.75	Strongly Agree	Very Highly Valid
4. The tool is fitted for individuals and groups of students.	4.83	Strongly Agree	Very Highly Valid
5. The tool will serve as supplementary material that can cater to the needs of the students.	4.83	Strongly Agree	Very Highly Valid
Mean	4.72	Strongly Agree	Very Highly Valid
Accuracy of Material			
1. The topics are well-arranged to provide a clear sequence of understanding.	4.58	Strongly Agree	Very Highly Valid
2. The tool provides sufficient repetition of learning through an example to easily understand the concept.	4.58	Strongly Agree	Very Highly Valid
3. The tool is appropriate to the age, maturity, and experience of the user.	4.58	Strongly Agree	Very Highly Valid
4. The ideas and concepts are well-expressed in the E-Quest.	4.83	Strongly Agree	Very Highly Valid
5. The tool relates to the present learning on the content in Ecological Relationships.	4.83	Strongly Agree	Very Highly Valid
Mean	4.68	Strongly Agree	Very Highly Valid
Clarity of Material			
1. The concepts of the E-Quest are clear and easy to understand.	4.92	Strongly Agree	Very Highly Valid
2. The font style, size, and color are readable.	4.33	Agree	Highly Valid
3. The layouts and graphics in the E-Quest are attractive	4.50	Strongly Agree	Very Highly Valid
4. The Problems presented are easy to understand.	4.83	Strongly Agree	Very Highly Valid
Mean	4.65	Strongly Agree	Very Highly Valid
Appeal to the Target User			
1. The problems and graphics used in the tool capture the interest of the user.	4.58	Strongly Agree	Very Highly Valid
2. The tool is presented at a pace that allows for reflection and review.	4.75	Strongly Agree	Very Highly Valid
3. The tool stimulates the user to have an interest in Ecological Relationships.	4.83	Strongly Agree	Very Highly Valid
4. The tool is worth the time, effort, and experience.	4.92	Strongly Agree	Very Highly Valid
5. The tool enables the user to develop his/her thinking and problem-solving skills.	4.92	Strongly Agree	Very Highly Valid
Mean	4.80	Strongly Agree	Very Highly Valid
Over-all Mean	4.73	Strongly Agree	Very Highly Valid

Legend: 4.5-5.0 , Very Highly Valid; 3.5-4.49, Highly Valid; 2.5-3.49, Valid; 1.5-2.49, Not So Valid; 1.0-1.49, Not Valid

As shown in table 2, in terms of objectives, the computed mean of 4.78 indicates that the content-validity was very high. Rating also showed very highly valid with the objectives are result-oriented (M=4.83), attainable (M=4.83), and relevant to the topics covered in Grade 7 Science (M=4.83), the objectives were also clearly stated and specific (M=4.75) and it was measurable (M=4.67).

Relative to usability, the computed mean of 4.72 suggests that the content-validity in terms of usability was very highly valid. Results also showed very highly valid with the tool fitted for individuals and groups of students (M=4.83) and the tool serves as supplementary material that can cater to the needs of the students (M=4.83). Also, very highly valid with the tool allows the students to learn Ecological Relationships at their own pace (M=4.75), the tool develops the analytical thinking and reasoning skills of the students in learning Ecological Relationships (M=4.58), and the concepts and problems are logically presented from the simplest to the most complex (M=4.58). This further implies that the tool demonstrates very high usability.

In terms of accuracy of material, teacher-validators' rating with computed mean of 4.68 suggests that it's content-validity was very highly valid. It also showed very highly valid with the ideas and concepts were well-expressed in the ER-Quest (M=4.83) and the tool relates to the present learning on the content in Ecological Relationships (M=4.83). They also rated very highly valid with the topics were well-arranged to provide a clear sequence of understanding (M=4.58), the tool provides sufficient repetition of learning through an example to easily understand the concept (M=4.58), and the tool was appropriate to the age, maturity, and experience of the user (M=4.58). This means that the material shows high accuracy in content.

As to the clarity of material, teacher-validators rating with the computed mean of 4.65 implies that it is very highly valid. It also showed very highly valid with the concepts of the ER-Quest were clear and easy to understand (M=4.92), layouts and graphics in the ER-Quest are attractive (M=4.50), and the problems presented were easy to understand (M=4.83). Highly valid with the font style, size, and color are readable (M=4.33).

On the appeal to the target user, the computed mean of 4.80 was described as very highly valid by the teacher-validators. It showed very high validity with the tool was worth the time, effort, and experience (M=4.92), and the tool enables the user to develop his/her thinking and problem-solving skills (M=4.92). Additionally, very highly valid with the problems and graphics used in the tool capture the interest of the user (M=4.58), the tool is presented at a pace that allows for reflection and review (M=4.75), and stimulates the user to have an interest in Ecological Relationship (M=4.83).

The overall mean of 4.73, described as strongly agree, indicates that the ER-Quest had a very high level of content validity. The high ratings across all five dimensions—objectives, usability, accuracy of material, clarity of material, and appeal to target users—demonstrate that the ER-Quest was a valid and potentially effective supplementary learning material for science. It also suggests that it can be a useful tool in aiding student's learning that is aligned with educational standards. This tool may also address learner's difficulties in learning science concepts. By using this education tool, learners can relate to real-life situations, capture their interest and make learning more fun and enjoyable.

As presented in table 3, for the objectives, results indicated that the acceptability of the ER-Quest was very high as rated by the student-participants. They showed very highly acceptable with the objectives were relevant to the topics covered in Grade 7 Science (M=4.68), objectives are clearly stated and specific (M=4.52), and the objectives are result-oriented (M=4.53). Highly Acceptable with the objectives are measurable (M=4.37), and attainable (M=4.47). The computed mean of 4.51 was described as strongly agree. This high level of agreement suggests that the ER-Quest possesses a very high degree of acceptability regarding objectives..

On usability, the computed mean of 4.45 indicates that the acceptability of the ER-Quest in terms of usability was high as rated by the student-participants. Very highly acceptable with the tool develops the analytical thinking and reasoning skills of the students in learning Ecological Relationships (M=4.62) and the concepts and problems were logically presented from the simplest to the most complex (M=4.57). Highly Acceptable with the tool allows the students to learn Ecological Relationships at their own pace (M=4.62), the tool is fitted for individuals and groups of students (M=4.38), and the tool serves as supplementary material that can cater to the needs of the students (M=4.37).

For the accuracy of material, the computed mean of 4.46 indicates that the acceptability of the ER-Quest was high. The student-participants' ratings showed very highly acceptable with the topics were well-arranged to provide a clear sequence of understanding (M=4.63). Highly Acceptable with the tool relates to the present learning on the content in Ecological Relationships (M=4.47), the tool provides sufficient repetition of learning through an example to easily understand the concept (M=4.47), and the tool was appropriate to the age, maturity, and experience of the user (M=4.30).

With the clarity of material, the computed mean of 4.45 indicates that the acceptability was high. It also shows very high acceptability with the font style, size, and color are readable (M=4.53). Highly Acceptable with the problems presented are easy to understand (M=4.28), the concepts of the ER-Quest are clear and easy to understand (M=4.48), and the layouts and graphics are attractive (M=4.48).

To its appeal to the target user, results showed that the problems and graphics used in the tool capture the interest of the user (M=4.62) and the tool enables the user to develop his/her thinking and problem-solving skills (M=4.58) were very highly acceptable. And highly acceptable with the tool stimulates the user to have an interest in Ecological Relationships (M=4.33), the tool is presented at a pace that allows for reflection and review (M=4.47), and the tool is worth the time, effort and experience (M=4.45). The computed mean of 4.49 is described as agree.

Table 3. *Mean Responses of the Student-Participants to the Acceptability of the ER-Quest*

Indicator	*Weighted Mean*	*Description*	*Interpretation*
Objectives			
Relevant to the topics covered in Grade 7 Science	4.68	Strongly Agree	Very Highly Acceptable
Objectives are clearly stated and specific	4.52	Strongly Agree	Very Highly Acceptable
Objectives are measurable	4.37	Agree	Highly Acceptable
Objectives are attainable	4.47	Agree	Highly Acceptable
Objectives are result-oriented	4.53	Strongly Agree	Very Highly Acceptable
Mean	4.51	Strongly Agree	Very Highly Acceptable
Usability			
The concepts and problems are logically presented from the simplest to the most complex.	4.57	Strongly Agree	Very Highly Acceptable
The tool will develop the analytical thinking and reasoning skills of the students in learning Ecological Relationships.	4.62	Strongly Agree	Very Highly Acceptable
The tool will allow the students to learn Ecological Relationships at their own pace.	4.38	Agree	Highly Acceptable
The tool is fitted for individuals and groups of students.	4.38	Agree	Highly Acceptable
The tool will serve as supplementary material that can cater to the needs of the students.	4.28	Agree	Highly Acceptable
Mean	4.45	Agree	Highly Acceptable
Accuracy of Material			
The topics are well-arranged to provide a clear sequence of understanding.	4.63	Strongly Agree	Very Highly Acceptable
The tool provides sufficient repetition of learning through an example to easily understand the concept.	4.47	Agree	Highly Acceptable
The tool is appropriate to the age, maturity, and experience of the user.	4.30	Agree	Highly Acceptable
The ideas and concepts are well-expressed in the ER-Quest.	4.43	Agree	Highly Acceptable
The tool relates to the present learning on the content in Ecological Relationships.	4.47	Agree	Highly Acceptable
Mean	4.46	Agree	Highly Acceptable
Clarity of Material			
The concepts of the ER-Quest are clear and easy to understand.	4.48	Agree	Highly Acceptable
The font style, size, and color are readable.	4.53	Strongly Agree	Very Highly Acceptable
The layouts and graphics in the ER-Quest are attractive	4.48	Agree	Highly Acceptable
The Problems presented are easy to understand.	4.28	Agree	Highly Acceptable
Mean	4.45	Agree	Highly Acceptable
Appeal to the Target User			
The problems and graphics used in the tool capture the interest of the user.	4.62	Strongly Agree	Very Highly Acceptable
The tool is presented at a pace that allows for reflection and review.	4.47	Agree	Highly Acceptable
The tool stimulates the user to have an interest in Ecological Relationships.	4.33	Agree	Highly Acceptable
The tool is worth the time, effort, and experience.	4.45	Agree	Highly Acceptable
The tool enables the user to develop his/her thinking and problem-solving skills.	4.58	Strongly Agree	Very Highly Acceptable
Mean	4.49	Agree	Highly Acceptable
Over-all Mean	4.47	Agree	Highly Acceptable

Legend: 4.5-5.0 , Very Highly Acceptable ; 3.5-4.49, Highly Acceptable; 2.5-3.49, Acceptable; 1.5-2.49, Not So Acceptable; 1.0-1.49, Not Acceptable

The over-all computed mean was 4.47 described as agree. This means that the student-participants had high level of acceptability. They had very high level of acceptability in terms of objectives, and they have high acceptability relative to appeal to the target user, accuracy of material, usability, and clarity of material.

It was important to note that developing an interactive application such as the ER-Quest must adhere to educational standards and must meet learners' needs and interest. The high rating of student-participants in the acceptability of ER-Quest suggested that the tool captures their interest. This implies that science topics that were interesting and appealing can easily be understood by the learners. High retention rate and better understanding of science concepts were expected when using game-based activities.

As presented in table 4, the control group during pretest was categorized as Developing and during posttest, the computed mean increased slightly but remained within Developing Proficiency level. While the experimental group during pretest was categorized as

Developing but on the posttest they improved to Approaching Proficiency level.

Table 4. *Proficiency Level of the Control and Experimental Group in the Pretest and Posttest*

		No. of Items (20)	0-4	5-8	9-12	13-16	17-20	Mean	Description
Control	Pretest	F	12	16	2	0	0	5.00	Developing
		%	40.00	53.33	6.67	0.00	0.00		
	Posttest	F	1	22	7	0	0	7.23	Developing
		%	3.33	73.33	23.33	0.00	0.00		
Experimental	Pretest	F	11	16	3	0	0	5.50	Developing
		%	36.67	53.33	10.00	0.00	0.00		
	Posttest	F	0	16	9	5	0	9.20	Approaching Proficiency
		%	0.00	53.33	30.00	16.67	0.00		

Legend: 0-4, Beginning; 5-8, Developing; 9-12, Approaching Proficiency; 13-16, Proficient; 17-20, Advanced

On the pretest of the control group, the mean was 5.00 which was categorized as developing. This indicates that, prior to any intervention, students had a relatively low proficiency level in science. The distribution of proficiency levels shows that 53.33% of the students are at the Developing level, 40.00% are at the Beginning level, and only 6.67% are at the Approaching Proficiency level. These results suggest that majority of the students had limited mastery of the concepts assessed, consistent with earlier findings by Soprano (2015), who noted that students often demonstrate lower baseline performance in science subjects due to challenges in conceptual understanding and retention of scientific processes.

In the posttest of the control group, the computed mean increased slightly to 7.23, but it remained within the Developing proficiency category. Despite the increase in the mean score, the students' proficiency still reflected limited mastery. Specifically, 73.33% of the students were at the Developing Proficiency level, 23.33% reached the Approaching Proficiency level, and 3.33% remained at the Beginning Proficiency level. These results suggest some degree of improvement, although the overall proficiency of the group remained relatively low.

The minimal improvement from pretest to posttest suggests that traditional methods of instruction may have limitations in significantly elevating students' understanding of scientific concepts. According to Garcia and Peña (2020), interventions that utilize interactive, gamified, or inquiry-based learning approaches have been shown to more effectively promote deep conceptual learning and critical thinking skills compared to traditional lecture-based methods.

Moreover, the research by Jitpranee et al. (2022) emphasized that low pretest scores, followed by only slight posttest gains, are typical in classrooms where students experience passive learning environments. These findings support the present results, suggesting that alternative pedagogical approaches, such as digital games or experiential learning activities, could be essential to achieve higher proficiency levels in science education

The results of this study show that although there was a slight increase in mean scores from pretest to posttest, the control group remained at a developing proficiency level. This indicates the need for more engaging, student-centered interventions to significantly enhance science learning outcomes.

On the hand, the pretest of the experimental group, the mean was 5.50 which was categorized as developing. This indicates that, prior to any intervention, students had a relatively low proficiency level in science. The distribution of proficiency levels shows that 53.33% of the students were at the Developing level, 36.67% were at the Beginning level, and only 10.00% were at the Approaching Proficiency level. These results suggest that majority of the students had limited mastery of the concepts assessed, consistent with earlier findings by Soprano (2015), who noted that students often demonstrate lower baseline performance in science subjects due to challenges in conceptual understanding and retention of scientific processes.

For the posttest of the experimental group, the computed mean increased to 9.20, and it improved to Approaching Proficiency category. This shows that following the implementation of the ER-Quest intervention, the posttest results of the experimental group showed a remarkable improvement. Specifically, 53.33% of the students were at the Developing Proficiency level, 30.00% reached the Approaching Proficiency level, 16.67% reached the Proficient level.

This implies a significant increase in students' understanding and application of science concepts after their exposure to the game-based learning tool. A substantial proportion of students transitioned from Developing to higher proficiency levels, demonstrating the effectiveness of the intervention. This was supported by the study of Garcia and Peña (2020), who found that gamified learning environments enhance student engagement, critical thinking, and mastery of scientific content more effectively than traditional instruction.

The notable rise from a mean of 5.50 (Developing) to 9.20 (Approaching Proficiency) indicates that the ER-Quest positively impacted the students' learning outcomes. The findings align with those of Jitpranee et al. (2022), who reported that inquiry-driven, game-based learning strategies significantly promote students' higher-order thinking skills and conceptual understanding. The use of interactive tools such as the ER-Quest may have provided opportunities for meaningful practice, immediate feedback, and motivational support, which contributed to the students' improved posttest scores.

It can be gleaned from the results that the experimental group exhibited a substantial improvement in proficiency from the pretest to the posttest. The ER-Quest intervention appears to have been highly effective in enhancing the science proficiency levels of the students, demonstrating the potential of game-based learning as a powerful instructional tool in the Science classroom.

Table 5. *Difference Between the Means of the Pretest Scores in the Students' Proficiency in Science of the Control and Experimental Groups*

Group	*Mean*	*SD*	*t computed*	*p- value*	*Remark*
Experimental	5.50	2.474	.825	.413	Not Significant
Control	5.00	2.213			
Mean Difference	.500				

Legend: A p value of greater than .05 (p=.413 > .05) indicates that there was no significant difference between the two groups

As presented in table 5, results revealed that there was no significant difference between the means of the experimental and control groups as evidenced by a t-computed value of .825 and a p-value of .413. A p value of greater than .05 (p=.413 > .05) indicates that there was no significant difference between the two groups. This implies that the results of the test at the start of the experiment were not significantly different. These two groups of students have almost the same mean scores at the start of the experiment and the groups are homogenous as shown by the small value of the standard deviation of the scores in the experimental and control groups.

The result of the pretest of the control and experimental groups shows that at the beginning of the study, learners had little idea of science concepts and that learners had little retention of the lesson thought in lower grade level. This implies an immediate need to improve the learning process and strategies to address these problems facing the educational system. And by using ER-Quest, it may enhance learner's capacity in learning science concepts. This was supported by Colendra and Carada (2023), that gamification technologies helped students improve their critical, inferential, and literacy comprehension abilities. It was also added by Mee (2020) that gamification in the classroom significantly impacts students' ability to think critically and creatively and their aptitude for fixing issues.

Table 6. *Difference Between the Means of the Posttest Scores in the Students' Proficiency in Science of the Control and Experimental Groups*

Group	*Mean*	*SD*	*t computed*	*p- value*	*Remark*
Experimental	9.20	2.833	3.136	.003	Significant
Control	7.23	1.942			
Mean Difference	1.967				

Legend: A p value of greater than .05 (p=.413 > .05) indicates that there was no significant difference between the two groups.

In table 6, results show a significant difference as evidenced by a t-computed value of 3.136 and a p-value of .003 as shown in table 5. This implies that the use of ER-Quest of the students had increased their proficiency level in science and better than the conventional or traditional method in teaching science. This was in line with the study of Kim et al. (2018) that gamified courses allow students to focus on their studies, they do better than other classes. Students who took a gamified course did better than those who took a lecture-based course.

With the developed intervention, learners better understand the science concepts, actively participated during class discussion, captured their interest and met their needs. This was strengthened by the study of Bangcaya et al. (2021) that the educational game-based learning approach produced positive outcomes. Those who engaged in game-based learning activities outperformed the traditional group in terms of score and regarding attention, confidence, and contentment, the experimental group members also exhibit higher motivation levels. Kabigting (2021) also supports the use of computer simulation as a teaching tool because it improves students' academic achievement.

Table 7. *Difference between the Means of the Pretest and Posttest Scores in Students' Proficiency in Science of the Control Group*

Control Group	*Mean*	*SD*	*t computed*	*p- value*	*Remark*
Posttest	7.23	1.942	11.077	.000	Significant
Pretest	5.00	2.213			

Legend: A p value of greater than .05 (p=.413 > .05) indicates that there was no significant difference between the two groups.

As shown in table 7, there was a significant difference as supported by a t-computed value of 11.077 and a p-value of .000. Results revealed that the use of conventional or traditional methods had also increased the students' proficiency in science. Although an increase of more than 2 points in the mean score of the posttest was noted in the control group, this was much lower compared to the results shown by the experimental group. Although it may increase students' proficiency in science, the learning retention was lower, and teachers are having difficulty in capturing students' attention and in classroom management. It was further demonstrated in the research of Öztürk and Korkmaz (2020) that the experimental group's students were more engaged with the gamification in teaching. In contrast, the students in the control group appeared disinterested and bored and desired to skip the course. It was asserted by Wouters et al. (2015) that serious games outperform traditional instruction in terms of learning and retention. Samortin (2023) suggested that innovative teaching techniques were needed as the current pedagogical approaches were less successful. With the integration of the developed software as intervention in the lesson of the experimental group shows significant difference in the results as shown in table

7. This implies that gamification using ER-Quest in learning was effective in teaching science than the conventional teaching method as supported by Bangcaya et al. (2021) that students engaged in game-based learning activities outperformed the traditional group in terms of score. Prieto-Andreu et al. (2022) further discussed that gamification not only helps teachers apply the law and essence of teaching, but it also helps students learn more effectively.

Table 8. *Difference between the Means of the Pretest and Posttest Scores in Students' Proficiency in Science of the Experimental Group*

Experimental Group	*Mean*	*SD*	*t computed*	*p- value*	*Remark*
Posttest	9.20	2.833	12.835	.000	Significant
Pretest	5.50	2.474			

Legend: A p value of greater than .05 (p=.413 > .05) indicates that there was no significant difference between the two groups.

Results revealed in table 8 that there was a significant difference as shown in table 7. This was supported by a t-computed value of 12.835 and a p-value of .000. The utilization of ER-Quest had increased the students' proficiency in science. An increase of more than 4 points in the mean score of the posttest was noted. Hence, the intervention was effective in increasing the achievement of students in science. It also implies that ER-Quest was effective in capturing learners' interest, encouraged active participation in class discussion, and increased student engagement and exploration of science concepts. Learners were not just learning science concepts but also developed their curiosity, enhanced creative thinking skills, strengthen collaboration with peers and having fun while learning. It was consistent with the study of Cabellero et al. (2022) that implementing gamification supported students' critical thinking skills development, active learning, and identification of the advantages and disadvantages of their subjects.

Table 9. *Difference Between the Mean Gain Scores in the Students' Proficiency in Science of the Control and Experimental Groups*

Group	*Mean*	*SD*	*t computed*	*p- value*	*Remark*
Experimental	3.70	1.579	4.169	000	Significant
Control	2.23	1.104			
Mean Difference	1.967				

Legend: A p value of greater than .05 (p=.413 > .05) indicates that there was no significant difference between the two groups.

As evident in the results in table 9, it was revealed that there was a significant difference as supported by a t-computed value of 4.169 with p-value of .000. This proves that the use of the developed intervention improved proficiency and enhanced learners' understanding of science concepts than the use of the conventional method. Wang (2021) also emphasized that a gamified learning environment can help the students fully engage with the course material and develop a good study mindset. This makes learning an enjoyable and fulfilling endeavor rather than a tedious one.

Conclusions

The teacher-validators rated the content-validity of the ER-Quest as very high and had a very high level of validity in terms of appeal to the target user, objectives, usability, accuracy of material, and clarity of material. The high ratings across all five dimensions demonstrate that the ER-Quest was a valid and potentially effective supplementary learning material for science. It also suggests that it can be a useful tool in aiding student's learning that is aligned with educational standards. This tool may also address learner's difficulties in learning science concepts. By using this education tool, learners can relate to real-life situations, capture their interest and make learning more fun and enjoyable.

The student-participants rated the same material as a very high level of acceptability in terms of objectives, and they have high acceptability relative to appeal to the target user, accuracy of material, usability, and clarity of material. The high rating of student-participants in the acceptability of ER-Quest suggested that the tool captures their interest. This implies that science topics that were interesting and appealing can easily be understood by the learners. High retention rate and better understanding of science concepts were expected when using game-based activities.

The students in the control group have a slight increase in mean scores from pretest to posttest, however, they remained at a Developing Proficiency level. These results suggest that majority of the students had limited mastery of the concepts assessed and needs some degree of improvement. The minimal improvement from pretest to posttest suggests that traditional methods of instruction may have limitations in significantly elevating students' understanding of scientific concepts. This indicates the need for more engaging, student-centered interventions to significantly enhance science learning outcomes

The results of the experimental group exhibited a substantial improvement in proficiency from the pretest to the posttest. The ER-Quest intervention appears to have been highly effective in enhancing the science proficiency levels of the students, demonstrating the potential of game-based learning as a powerful instructional tool in the science classroom.

There was no significant difference between the means of the pretest of the experimental and control groups. The two groups of students have almost the same mean scores at the start of the experiment and the groups were homogenous as shown by the small value of the standard deviation of the scores in the experimental and control groups. This implies an immediate need to improve the learning process and strategies to address these problems facing the educational system. And by using ER-Quest, it may enhance learner's capacity in learning science concepts.

There was a significant difference between the means of the posttest scores of the experimental and control groups. The use of ER-Quest of the students had increased their proficiency level in science and better than the conventional or traditional method in teaching science. With the developed intervention, learners better understand the science concepts, actively participated during class discussion, captured their interest and met their needs.

There was a significant difference between the means of the pretest scores and posttest scores in the proficiency of students in science of the control group. The application of conventional or traditional methods also increased the students' proficiency in science. An increase of more than 2 points in the mean score of the posttest was noted. Although it may increase students' proficiency in science, the learning retention was lower, and teachers are having difficulty in capturing students' attention and in classroom management. This implies that gamification using ER-Quest in learning was effective in teaching science than the conventional teaching method

There was a significant difference between the means of pretest scores and posttest scores in the proficiency of students in science of the experimental group. The application of ER-Quest can improve the students' proficiency in science. It also implies that ER-Quest was effective in capturing learners' interest, encouraged active participation in class discussion, and increased student engagement and exploration of science concepts. Learners were not just learning science concepts but also developed their curiosity, enhanced creative thinking skills, strengthen collaboration with peers and having fun while learning.

There was a significant difference between the mean gain scores of the experimental and the control groups. The use of ER-Quest can improve the proficiency of students in science than the use of the conventional method. The use of technology aided materials was more effective in teaching the students compared to traditional way of teaching. This can make teaching and learning process easy, innovative and fun filled.

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