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Development of A Digital Escape Room-Assisted E-book in Environmental Science Course

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Abstract

The use of advanced instructional technologies is essential for creating engaging and interactive learning experiences, especially in environmental science. Digital escape room games, combined with e-books, provide an innovative approach to supporting learning and improving instructional effectiveness in higher education settings. The research aimed to develop a digital escape room-assisted e-book for the environmental science course at UIN KHAS Jember in a manner that is valid and practical. Using the ADDIE development model by Branch in 2009, the research assessed content validity and practicality through expert validation and trials. Content experts rated the e-book at 93.6% (very valid), while design experts rated it at 94.7% (very valid) for instructional media quality. In the individual trial, the e-book received a 91.9% score (very appealing), followed by a 94.1% score in the small group trial, and a 95.8% score in the field trial, both also categorized as very appealing. To conclude, these results indicate that the digital escape room-assisted e-book is both highly valid and practical for use in environmental science course. Therefore, it should be implemented in the learning process to enhance students' thinking skills.

Keywords: digital escape room, e-book, environmental science course, technology

INTRODUCTION

TSkill development is crucial for students, as stipulated by the Law of the Republic of Indonesia No. 20 of 2003, Article 1, Clause 1. In the 21st century, heightened competition necessitates a focus on diverse skills, particularly for students preparing to be future educators, in the 21st century (Jirana et al., 2016; Kiswari et al., 2024; Sandika & Fitrihidajati, 2018). Quality education serves as a solution to mitigate environmental challenges (Rosyid, 2019). Students can comprehend the significance of prudent natural resource management, implement conservation practices, and utilise their knowledge when they assume roles as educators or interact with communities (USDA, 2021). Environmental education enables students to acquire a profound comprehension of ecological concerns, hence augmenting the capacity for critical thinking (USDA, 2021).

Prior research indicates that the critical thinking skills of Indonesian students are generally deficient (Amrullah & Suwarjo, 2018; Kirana & Kusairi, 2019; Listiani, 2018). Comparable outcomes were also

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noted among biology education students at other universities in Indonesia (Syahfitri et al., 2019). A preliminary investigation conducted by Nasution et al. (2023) at IAIN Jember, utilising Greenstein (2012) critical thinking markers, indicated that biology education students achieved an average critical thinking score of 52.25. The score signifies that biology education students at IAIN Jember, now UIN Kiai Haji Achmad Siddiq Jember, require further enhancement of their critical thinking abilities to adequately confront the issues of the 21st century. Given that Nasution et al. (2023) found students' learning outcomes with an average score of 52.57, it can be simply concluded that there is a relationship between critical thinking skills and concept mastery. This suggests that students' concept mastery also needs to be empowered to ensure they achieve better learning outcomes. Understanding concepts is one of the core of learning; students should not merely memorize them (Putri & Izzati, 2023; Sihombing et al., 2023; Sofianto, 2019).

The inadequate skills in critical thinking and conceptual understanding of biology education students may be affected by multiple factors, including the functions of students and lecturers, the curriculum, learning resources, governmental support, and societal influences. The lack of media is a limiting factor that hinders the student learning process (Putri et al., 2024; Ratna Kartika Irawati, 2019). Moreover, inadequate learning limitations that fail to achieve an appropriate level, particularly in the application of cognitive skills, may significantly exacerbate these difficulties (Wiyoko, 2019).

Learning media can serve as a powerful tool that can either effectively support the achievement of learning objectives for students (Chen & Ramadhanti, 2024). This study is distinguished from previous studies by its novel incorporation of e-books with a digital escape room game specifically designed for environmental science teaching. While earlier studies have demonstrated the effectiveness of e-books in improving learning outcomes (Azhari & Armanda, 2018; Damayanti et al., 2019) and digital escape rooms in fostering student engagement (Ananda et al., 2024; Buchner et al., 2022), this research uniquely combines these two tools to address the dual challenge of enhancing instructional quality and accessibility. Contrasting earlier approaches, this study uses the interactive and problem-solving character of digital escape rooms to enhance the e-book format, therefore generating a complete and interesting learning environment. This combination is particularly novel in the context of environmental science, where fostering active participation and contextual understanding is crucial for future educators.

A form of educational media that can mitigate these challenges is an electronic book (e-book) available on student devices. An effectively designed e-book that addresses educational requirements can be created to support students in their studies. Comprehensively designed e-books have demonstrated efficacy

in improving critical thinking abilities (Larassati & Rachmadiarti, 2021; Sofa & Indana, 2021) and mastery of concepts (Azhari & Armanda, 2018; Damayanti et al., 2019).

E-books provide convenient accessibility as they eliminate the need for a physical copy, are more cost-effective, and can accommodate greater content without the spatial constraints of printed books. Readers may swiftly search, bookmark, and save particular pages, offering a more engaging reading experience than printed books. The sustainability aspect of e-books is advantageous, as they diminish the use of paper and printed resources, thereby contributing to environmental protection and serving as a beneficial illustration in environmental science education.

One benefit of digital learning media, such as e-books, is their capacity to integrate diverse electronic characteristics, including hyperlinks, multimedia, and interactivity (Harahap et al., 2019; Liliana et al., 2020). A form of electronic integration is the capacity to amalgamate diverse media, including digital photos, videos, animations, audio, and digital games. A digital escape room game is a sort of integration that can augment the efficacy of e-books.

A digital escape room game is an interactive digital experience in which participants uncover clues, resolve riddles, and accomplish tasks within one or more rooms, aiming to achieve a certain objective (often to depart the area) within a constrained time frame (Buchner et al., 2022; Nicholson, 2015). The problem-solving tasks undertaken by students in a digital escape room game can facilitate the e-book's objective of enhancing students' critical thinking skills and comprehension of concepts in environmental science. Moreover, students demonstrate greater engagement and participation in the learning process when interactive multimedia is used (Ananda et al., 2024). The digital escape room-assisted e-book provides an opportunity for distance learning, enabling learners to study actively and responsibly (Fikriyah et al., 2020).

This study will design an e-book integrated with a digital escape room game in the environmental science course to boost students' critical thinking skills and comprehension of concepts. This research seeks to (1) evaluate the validity of an e-book enriched by a digital escape room game in the environmental science course to enhance critical thinking skills and conceptual mastery among UIN KHAS Jember students; and (2) assess the practicality of the e-book enriched by a digital escape room game in the environmental science course to enhance critical thinking skills and conceptual mastery among UIN KHAS Jember students.

METHOD

This developmental research utilized the ADDIE development model (Branch, 2009). The research aimed to develop a digital escape room-assisted e-book for the environmental science course in a manner that is valid and practical. The stages in the

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ADDIE model include Analyze, Design, Develop, Implement, and Evaluate (Figure 1).

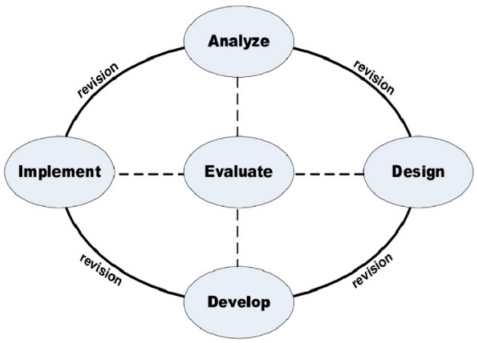

Figure 1. (Branch, 2009) ADDIE development model process.

The Analyze phase is the beginning stage in which the necessity for creating a digital escape room-assisted e-book in the environmental science curriculum is evaluated, specifically to enhance students' critical thinking abilities and conceptual understanding. This phase encompasses an analysis of the feasibility and prerequisites for the development of the e-book. The Design phase is subsequently conducted to validate the intended product design and provide suitable testing methodologies. The result of this phase is a preliminary design of the digital escape room-assisted e-book for the environmental science course, intended to improve critical thinking abilities and concept understanding.

The subsequent phase is the Develop phase, which emphasizes the creation and validation of the digital escape room-assisted e-book. Upon the completion of the product draft, the implementation phase commences. This phase entails utilizing the e-book in the environmental science program to enhance students' critical thinking skills and conceptual understanding. The implementation phase comprises two components: Prepare the Teacher and Prepare the Student.

The concluding phase, Evaluate, is crucial and is conducted to assess the quality of both the product and the instructional process prior to and following deployment. This evaluation aims to assess the attainment of study objectives and identify required further steps. This assessment is performed subsequent to the completion of all learning phases.

Product validation takes place subsequent to the finalization of the product draft. The validation method included two separate components: assessment of material quality and assessment of design quality. The product material was evaluated by two biology education specialists possessing master's degrees in biology. The validation of the product media was conducted with the participation of two experts in educational media, each holding a master's degree.

The data for product validation findings is collected through a closed questionnaire that includes a section for recommendations to be filled by the validator. The material validation questionnaire, derived from the work of the Indonesia National Education Standards Agency (2017), Permendikbud (2016), Thiagarajan (1974), comprises 19 statement items categorized into three aspects: alignment of material with study content, timeliness of the material, and accuracy of the material. The design

validation questionnaire, derived from research by Peraturan Menteri Pendidikan dan Kebudayaan Tentang Standar Proses Pendidikan Dasar dan Menengah (2016), comprises 9 statements that assess three dimensions: character, visual communication, and program.

Validated products undergo evaluation via individual trials with three students representing diverse academic capabilities: exceptional, ordinary, and below average. The students had finished the basic environmental course. Data from each trial were gathered through a closed questionnaire that provided a section for responders to submit suggestions. The trial response questionnaire, derived from the research of Nasution et al. (2023), comprises 18 statement items. Each question offers five response options that align with a Likert scale from 1 to 5. The response option of strongly disagree is allocated a score of 1, whilst strongly agree is allocated a value of 5.

Draft products are afterwards assessed through small-scale trials by actively involving students and evaluating their utilization of the product. The small-scale trials were conducted with a cohort of six students who had successfully completed the basic environmental studies course. Data from small-scale trials were gathered through a closed questionnaire that provided an opportunity for respondents to submit suggestions. The data collection procedure is the same as the questionnaire utilized in individual trials.

The large trials encompassed a singular class, namely class Bio 3 of Biology Education Study Program in UIN Kiai Haji Achmad Siddiq Jember Jember. Twenty-two students provided responses and experiments were performed to obtain feedback from students. The data collection procedure mirrors the questionnaire utilized in individual and small-scale trials.

The validation evaluation scores derived from experts (as per the previously established standards) and student trials are expressed as percentages (P) by summing the total scores assigned by validators or respondents, dividing by the maximum possible score, and subsequently multiplying by 100. Moreover, the aggregated percentage is subsequently classified based on the criteria outlined in Table 1 below.

Table 1. Assessment criteria

Criteria	Percentage interval
Very valid/Very appealing	86% ≤ P ≤ 100%
Valid/Appealing	76% ≤ P ≤ 85%
Fairly valid/Fairly appealing	60% ≤ P ≤ 75%
Somewhat invalid/ Somewhat unappealing	55% ≤ P ≤ 59%
Not valid/not unappealing	P ≤ 54%

(Source: Akbar, 2013)

RESULT AND DISCUSSION

This research and development srudy produced a digital escape room-assisted e-book, developed according to the ADDIE design model (Branch, 2009). The phases of the ADDIE model consist of Analyze, Design, Develop, Implement,

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and Evaluate.

This study presents a digital escape room-assisted e-book, published in an electronic version accessible via a website, which may be interactively used on smartphones, personal computers, or laptops by anyone with the URL, particularly students and educators. The e-book functions as a digital educational resource that students can employ to augment their understanding of the subject (Ontowiryo et al., 2024). The e-book, enhanced by a digital escape room, is available online via the FlipHTML5 platform, allowing users to navigate pages, zoom in or out, and utilize numerous electronic functionalities.

The e-book, designed for the environmental science course and combined with a digital escape room, requires an internet connection for initial loading. Upon successful access to the website page, students may utilize it directly on their smartphones, laptops, or PCs at the university. The development of the digital escape room-assisted e-book used multiple software tools, such as CorelDRAW X7 for visual design, Microsoft Word 2016 for word processing, Visual Studio Code for source code editing, and various hosting and domain-related software to facilitate student access to the digital escape room game. The hardware utilized in the development of this product comprised a personal computer equipped with 16 GB of RAM, a Windows 10 operating system, and an Intel i5 CPU.

Table 2 presents the content list of the developed digital escape room-assisted e-book.

Table 2. Content list of the developed digital escape room-assisted e-book

Part	Content
Cover	Title and author
Foreword	Foreword to the e-book from the author
Table of Contents	E-book outline
Materials	Content material in each chapter
Critical Features	5 forms of critical thinking skills exercises in each chapter related to the content material
Exercises	Collection of practice questions
Bibliography	References/libraries used as references when compiling the e-book
Author Biography	Brief information about the author

The list of materials and contents in the developed digital escape room-assisted e-book is presented in Table 3.

The e-book is supported by an online game known as the digital escape room. This game is a problem-solving exercise wherein students must resolve a sequence of puzzles to finish the game. Escape rooms are interactive, team-oriented games in which participants discover clues, solve puzzles, and accomplish tasks within one or many rooms to attain a specific goal, typically departing the premises, within a designated time limit (Nicholson, 2015). The game is designed with a theme in which students are confined in a room and must devise a method to escape. As physically confining students in a tangible space is impractical, the designed escape room game is digital, wherein students will be virtually ensnared in a room.

Table 3. The list of chapters and subchapter in the developed digital escape room-assisted e-book

Chapter	Subchapter
Environment: an introduction	Environmental components; Biotic components; Abiotic components; Atmosphere; Hydrosphere; Lithosphere; Biosphere Physical elements; Biological elements; Cultural elements Environmental functions; Environment and distribution of living things; Geological conditions; Climate; Altitude; Biotic factors; Soil factors and their quality; Human activity factors; Water influence factors; Ecological interaction factors; The importance of understanding environmental science; Future environmental issues
History of environmental science	Past; 18th century; 19th century; 20th century; 21st century; Technological developments in the 21st century; International conventions
Ecosystem	Definition; Ecosystem structure; Organic and inorganic; Environmental conditions; Temperature; Humidity; Sunlight; Topography; pH; Salinity; Air quality; Producers; Consumers; Decomposers and detritivores; Primary production; Energy flow; Nutrient cycle; Human interactions with ecosystems
Natural resources	Environmental carrying capacity; Biological natural resources; Plants; Animals, livestock, and fisheries; Non-biological natural resources; Water; Wind; Land; Mining products; Stage of natural resource development; Potential natural resources; Actual natural resources; Reserve natural resources; Stock natural resources; Limited quantity of natural resources; Renewable natural resources; Non-renewable natural resources; Ownership of natural resources; Individual natural resources; Community-owned natural resources; National natural resources; International natural resources; The tragedy of the commons; Natural resources and the economy
Biodiversity	Distribution; Latitudinal gradient; Hotspots; Number of species; Functions and benefits of biodiversity; Biodiversity threats; Habitat destruction; Introduced and invasive species; Genetic pollution; Overexploitation; Climate change; Human overpopulation; Biodiversity conservation; Resource allocation; Conservation areas
Environmental pollution	Water pollution; Soil pollution; Bioremediation; Air pollution; Noise pollution; Light pollution; Impact of environmental pollution; Disrupting environmental balance; Extinction of various species of flora and fauna; Reduced soil fertility; Water pollution; Prevention of environmental pollution
Sustainable development	Benefits of sustainable development; Values of sustainable development; Environment and sustainable development; Components of sustainable development

The produced ebook contains multiple digital escape room themes accessible to students via a barcode. The accessible digital escape room games align with Chapter I: Environment: an introduction, Chapter III: Ecosystems, Chapter V: Biodiversity, and Chapter VII: Sustainable Development. The digital escape rooms

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have themes such as evading a kidnapper, outer space, a laboratory, and an espionage mission. Students can access the pertinent digital escape room game using the barcode included in the e-book for each chapter. They will be redirected to a website to engage in the digital escape room game. Students do not need to download any software, as the digital escape room games may be viewed immediately using normal browsers like Chrome or Safari, given they have internet connectivity.

The e-book, helped by a digital escape room, was validated by experts. The validity of the e-book is a criterion that determines its suitability for usage (Hikmaturrosyidah & Rachmadiarti, 2022). Validation confirms the e-book's suitability for use (Ontowiryo et al., 2024). The validation procedure assessed the validity of the digital escape room-assisted ebook from a content perspective by biology specialists and from a product design perspective by educational media experts in biology. Experts' validation typically evaluates the quality of both content and design (Dalimunthe et al., 2023). Table 4 presents the content validation for environmental science conducted by experts in biology and biology education. Table 5 presents the validation of media design by experts in biology teaching.

The validation results from experts, as shown in Table 4 and Table 5, show an average percentage score of 93.6%, classified as highly valid for material quality, and 94.7%, also classified as highly valid for educational media design quality. Therefore, the digital escape room-assisted e-book was deemed highly valid by the validators, allowing the advancement of the development procedure to the subsequent step. Several studies utilizing the ADDIE model emphasize the importance of the validity of the developed product (Isnaniah & Rahmawati, 2024; Rizal et al.,

Table 4. Content validation result of digital escape room-assisted e-book

Assessment Aspect	Validator 1		Validator 2	
	%	Category	%	Category
Suitability of materials with study materials	95	Very Valid	95	Very Valid
Recency of materials	93.3	Very Valid	93.3	Very Valid
Accuracy of materials	93.3	Very Valid	93.3	Very Valid
Supporting learning materials	95	Very Valid	90	Very Valid
Language aspects of learning materials	96	Very Valid	92	Very Valid
Mean	94.5	Very Valid	92.7	Very Valid

Table 5. Content validation result of digital escape room-assisted e-book

Assessment Aspect	Validator 1		Validator 2	
	%	Category	%	Category
Character	90	Very Valid	95	Very Valid
Visual Communication	100	Very Valid	90	Very Valid
Program	100	Very Valid	93.3	Very Valid
Mean	96.7	Very Valid	92.7	Very Valid

2021; Yulia et al., 2023).

The use of two experts as validators is due to the absence of limitations in the ADDIE model; this approach enhances the quality of validation as it is a common practice (Rosmiati & Siregar, 2021). Relying on a single validator increases the likelihood of overlooking mistakes throughout the validation process.

The peak average score for material validity pertained to the alignment of the content with the curriculum, with Validator 1 and Validator 2 both awarding a score of 95%. Both validators determined that the content of the product is very compatible with the undergraduate environmental science curriculum, especially in the realm of biology education. Alignment of content with the target audience is a crucial measure of content validity (Ennouamani et al., 2020; Nasution et al., 2024). The second-highest average score for material validity pertained to the language utilized in the instructional material, with Validator 1 assigning a score of 96% and Validator 2 assigning 92%. Both validators concurred that the language employed in the product is commendable and complies with the appropriate requirements of the Indonesian language. Clear, unambiguous, and comprehensible language elements have been validated, allowing the e-book to effectively assist students in comprehending the content (Panjaitan et al., 2021; Rahmi et al., 2023).

The validators evaluated the material's timeliness and accuracy, achieving scores of 93.3%, classified as very valid by both Validator 1 and Validator 2. This signifies that both validators concurred that the content in the digital escape room-assisted e-book is current as well as precise. Timeliness is an essential factor in the practicality of content within an e-book (Azizah & Budijastuti, 2021; Pratiwi & Rachmadiarti, 2021). The final material feature assessed by the experts was the learning support resources, which received a score of 95% and were deemed highly valid by Validator 1, and 90%, also classified as highly valid, by Validator 2. This indicates that the product was considered very valid for learning assistance materials. Learning support resources are crucial elements that must be validated for the e-book product to be deemed suitable for utilization (Azizah & Budijastuti, 2021).

In terms of design validity, visual communication had the highest average score, with Validator 1 assigning a score of 100%, classified as highly valid, and Validator 2 awarding a score of 90%, also classified as highly valid. This indicates that both validators concurred that the product design is very compatible with effective instructional media that is visual. Aspects of visual communication encompass navigation, music, imagery, animations, and the overall visual presentation, including layout, typography, and color (Bilqis et al., 2023). Effective visual communication enables the e-book to transmit information with more detail (Mahrawi et al., 2023).

The subsequent design element, the program, received strong scores from the validators, with Validator 1 giving a

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score of 100% and Validator 2 assigning a score of 93.3%. This signifies that the program components of the generated product are of excellent quality and appropriate for utilization. The program component is one of the factors assessed by design experts in order to confirm that the created instructional media is valid in terms of design (Ulfa & Nurmayani, 2023). The character design of the Digital Escape Room-Assisted E-Book received high ratings, with Validator 1 scoring it at 100% and Validator 2 at 90%, signifying its substantial validity. A validated design signifies that the media's presentation has been carefully developed, hence enhancing the probability of student involvement with the instructional media (Nasution, 2022).

Thespecialistsofferedrecommendations and critiques for modifications to improve

Table 6. Revision suggestions from validators.

Revision suggestions	After revision
The recommended number of expert summaries related to the definition of environmental science is increased from 2 to 4.	
Add a discussion of the history of environmental science in the past.	

continuation of table 6

Revision suggestions	After revision
Add discussion of the greenhouse effect in chapter VI expanded with the addition of the impacts of global warming.	
Addition of image with title changes that can be implemented to achieve sustainable development.	
Addition of several images and tables that are in accordance with the material to improve student understanding.	 
Added from 4 to 5 quizzes in each game to accommodate the game duration.	
Improved e-book cover to match book theme.	

the quality of the generated product. The researcher enhanced the product in accordance with these recommendations. Upon concluding the revision procedure, the researcher advanced to the trial phase. The recommendations, critiques, and ensuing modifications are summarized in Table 6.

Individual Trial Results

Upon validation of the instructional media product, the development process proceeded to the trial phase. The e-book requires evaluation by prospective readers to assess their responses and confirm its functionality (Palupi et al., 2022). The trial began with an individual trial involving three students who had finished the environmental science course, using a digital escape room-assisted e-book. A continuous testing methodology, commencing with a limited cohort of participants, is a common approach in developmental research (Borg & Gall, 1983; Branch, 2009).

This phase had three students representing strong, medium, and low intellectual abilities as assessed by their cumulative grade point average (GPA). Table 7 presents the outcomes of the students' responses in the individual trial for the digital escape room-assisted e-book. Recommendations from this phase of the individual trial are shown in Table 8.

The mean percentage score given by participants throughout the individual trial phase was 91.9%, categorizing it as "very good." The individual trial results demonstrate that the digital escape room-assisted e-book is highly practical.

According to the one-on-one trial findings, all participants scored two aspects highly: their opinion that utilizing the digital escape room-assisted e-book is not a waste of time, and the simplicity of using the e-book for educational activities. Both components achieved a perfect score of 100%, signifying that students perceived the generated product as neither time-consuming nor challenging to utilize. Nieveen et al. (2006) posits that a product is deemed practical if consumers, which are students, indicate that it is user-friendly.

Following the implementation of improvements based on student feedback, the development advanced to the small group trial. A trial with a small sample of six biology education students, who had completed the environmental knowledge course, was conducted to look at their responses to the e-book assisted by a digital escape room. The outcomes of the small group trial are presented in Table 7, and the recommendations from this phase are enumerated in Table 8. The mean percentage score for this phase was 94.1%, categorized as “very good”. Therefore, the findings of the small group trial validated that the developed digital escape room-assisted e-book is highly practical.

In the small group experiment, all participants gave the highest ratings to the aspect, indicating that the digital escape room-assisted ebook facilitated valuable information acquisition for students. This aspect achieved a flawless score of 100%, signifying that students perceived the product as beneficial in enhancing their learning. Gaining valuable knowledge

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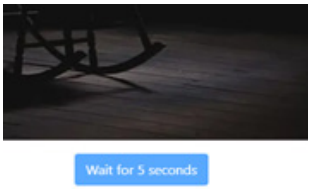
Table 7. Field trial response results for developed products

Assessment Aspects	Individual Trial Results		Small Group Trial Results		Field Trial Results	
	%	Category	%	Category	%	Category
Using the digital escape room-assisted e-book is far from a waste of time.	100	Strongly Agree	96.7	Strongly Agree	99.1	Strongly Agree
I like the idea of incorporating the digital escape room-assisted ebook into the coursework because it makes learning enjoyable	93.3	Strongly Agree	90	Strongly Agree	90.9	Strongly Agree
The digital escape room-assisted e-book is a great concept to support lectures	93.3	Strongly Agree	93.3	Strongly Agree	99.1	Strongly Agree
Using the digital escape room-assisted ebook has taught me various knowledge/skills, which ultimately improved my academic performance	93.3	Strongly Agree	93.3	Strongly Agree	95.5	Strongly Agree
The digital escape room-assisted e-book is suitable and easy for me to use	86.7	Strongly Agree	96.7	Strongly Agree	97.3	Strongly Agree
I have learned a lot of useful knowledge through studying with the digital escape room-assisted e-book	93.3	Strongly Agree	100	Strongly Agree	95.5	Strongly Agree
The digital escape room-assisted e-book is a positive tool that makes the lectures more engaging.	93.3	Strongly Agree	96.7	Strongly Agree	95.5	Strongly Agree
If I were a lecturer, I would use the digital escape room-assisted e-book in my classes.	93.3	Strongly Agree	90.0	Strongly Agree	94.5	Strongly Agree
Using the digital escape room-assisted e-book in lectures encourages me to practice my critical thinking skills and concept mastery.	86.7	Strongly Agree	93.3	Strongly Agree	97.3	Strongly Agree
Learning with the digital escape room-assisted e-book is more engaging to me compared to traditional lecture-based learning.	86.7	Strongly Agree	96.7	Strongly Agree	93.6	Strongly Agree
Learning with the digital escape room-assisted e-book allows me to communicate and interact with my peers.	86.7	Strongly Agree	93.3	Strongly Agree	96.4	Strongly Agree
The learning experience with the digital escape room-assisted e-book leaves a lasting impression on me, and the knowledge gained is not easily forgotten.	100	Strongly Agree	90.0	Strongly Agree	94.5	Strongly Agree
I find it easy to use the digital escape room-assisted e-book for the learning activities I want to do.	86.7	Strongly Agree	93.3	Strongly Agree	92.7	Strongly Agree
I find it easy to interact with the digital escape room-assisted e-book	93.3	Strongly Agree	86.7	Strongly Agree	97.3	Strongly Agree
I find it easy to understand how to use the digital escape room-assisted e-book.	93.3	Strongly Agree	96.7	Strongly Agree	96.4	Strongly Agree
If I had access to the digital escape room-assisted e-book, I would intend to use it further.	93.3	Strongly Agree	96.7	Strongly Agree	96.4	Strongly Agree
I look forward to using the digital escape room-assisted e-book in the future	93.3	Strongly Agree	93.3	Strongly Agree	95.5	Strongly Agree
I feel that the time allocation for learning with the digital escape room-assisted e-book is sufficient (ideal).	86.7	Strongly Agree	96.7	Strongly Agree	97.3	Strongly Agree
Total	91.9	Very Good	94.1	Very Good	95.8	Very Good

Table 8. Revision suggestions from trial participants.

Revision suggestions	After revision
Enlarge QR Code in the e-book	
Added name input at the end of the game.	
Added back to home button in some needed places	
Game entry wait time adjusted from 10 seconds to just 6-4 seconds.	
Changed the first game sound to be quieter	

is a fundamental goal of any developed e-book (Latif et al., 2024).

The subsequent element that attained the highest average score of 96.7% in the small group trial encompassed multiple factors, including: the e-book's efficacy, its suitability and user-friendliness, its enhancement of lecture engagement, its greater appeal relative to traditional lectures, clarity in its usage, willingness to utilize it further if available, and the belief that the time designated for learning with the e-book was adequate (optimal). Nieveen & Folmer (2013) observed that a practical product is user-friendly and consistent with the research aims.

Following the incorporation of adjustments based on the feedback obtained at this stage, the development progressed to the field trial phase. A field trial was undertaken with a cohort of 22 biology education students who had finished the environmental knowledge course, with the objective of evaluating their reactions to the digital escape room-assisted e-book. The outcomes of the field trial are detailed in Table 7, accompanied by recommendations in Table 8. The mean percentage score from the field testing was 95.8%, categorized as "very good", affirming the high practicality of the digital escape room-assisted e-book.

According to the field testing results, all participants scored the digital escape room-assisted e-book highly, indicating it was not a waste of time and was an excellent supplementary tool for courses. The features received a score of 99.1%, signifying that students perceived the generated product as enhancing their interest in acquiring environmental knowledge. Educational media that engage students' attention have been demonstrated to enhance learning motivation (Aftiani et al., 2021).

Following the revision of the product informed by student input at this point, the trial phase concluded, and the product was recognized as both highly valid and very practical as an instructional instrument.

CONCLUSION

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In accordance with the research goals, the following conclusions have been drawn from this study: (1) The validation results of the digital escape room-assisted e-book by content experts showed an average percentage score of 93.6%, categorized as "very valid" in terms of content quality. The validation by design experts yielded an average percentage score of 94.7%, categorized as "very valid" in terms of the quality of the instructional media design; (2) The individual trial of the product resulted in an average percentage score of 91.9%, categorized as "very appealing". The small group trial resulted in an average percentage score of 94.1%, also categorized as "very appealing". The field trial yielded an average percentage score of 95.8%, again categorized as "very appealing". Based on these validation and trial results, it can be concluded that the digital escape room-assisted ebook developed is both highly valid and highly practical. Therefore, it should be implemented in the learning process to enhance students' thinking skills.

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