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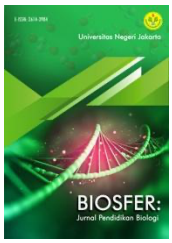

Validity of e-modules integrated with game-based problem-based learning to improve 21st century skills in Biology learning

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ABSTRACT

Given how quickly technology is developing, 21st-century learning must connect with it and focus on giving students the skills they need to succeed in the twenty-first century. This research aims to design e-modules integrated with game-based problem-based learning to improve 21st-century skills. The research method uses the ADDIE development model, which is limited to the development stage. The validation test was conducted on four expert validators consisting of 2 researchers and two practitioners. The findings indicated that the e-module received an 83% score for its content/material component, an 84% score for its systematic component, an 83% score for its language component, and an 84% score for its visual component. With an average percentage of 84%, the e-module design met extremely valid requirements when taken as a whole. These results indicate that the e-modules that have been designed have a relatively high level of validity so that the e-module is ready to be tested without revision.

INTRODUCTION

Learning is a complex and dynamic process that involves interaction between students, teachers, and the environment. In this process, students not only receive information but also actively construct their knowledge and abilities (Deslauriers et al., 2019; Gu, 2021; Jusniani & Nurmasidah, 2021; Kong, 2014). Effective learning requires active student involvement, as well as the teacher's ability to create a conducive and supportive atmosphere (Ahmad et al., 2017; Dörnyei & Muir, 2019; Franklin & Harrington, 2019). Thus, students can develop their abilities, increase self-awareness, and gain valuable experience. Today's learning is often known as "21st-century learning".

21st-century learning refers to an approach that focuses on the abilities and skills students need to succeed in the 21st century (Care et al., 2018; Cholilah et al., 2023; Dewanti & Santoso, 2020; Mardhiyah et al., 2021; Qian & Clark, 2016). In this era, technology and information are developing very rapidly, so students need to have the ability to adapt, think critically, and solve problems effectively (Rahmatullah et al., 2022; Septikasari & Frasandy, 2018). 21st-century learning also emphasises communication, collaboration, creativity, and the ability to learn independently and continuously (Bernhardt, 2015; Binkley et al., 2012; Mishra & Mehta, 2017). Thus, students can become individuals ready to face future challenges and changes. Professional teachers are indispensable in this discipline to deliver high-quality teaching (Bourke et al., 2015; Fordham, 2016). Improvements and advancements in the learning process will increase the effectiveness of learning (Hanjowo et al., 2023; Tarihoran, 2019; Wang, 2014). In addition, the development of technology in the 21st century requires 21st-century learning to integrate information and communication technology (ICT) learning in the teaching-learning process (Dakhi et al., 2020; Garba et al., 2015; Liesa-Orús et al., 2020).

The use of technology as learning media to improve student's learning ability is one of the primary needs in 21st-century learning (Alhamuddin et al., 2022; Shadiev & Wang, 2022). Teachers are expected to integrate technology into the learning process and abandon conventional methods by using more modern facilities (Batane & Ngwako, 2016; Jeffrey et al., 2014). Teachers should keep up with technological developments so that the information conveyed to students is always up-to-date (O'Neal et al., 2017; Ozdamli & Ozdal, 2018; Stoilescu, 2015). Thus, 21st-century education requires teachers to organize learning according to student's needs by using modern teaching materials and learning media and integrating with technology to explore students' skills (Siddiq et al., 2016).

One of the most crucial subjects taught in schools is biology. Learning biology not only helps students comprehend life and biological processes but it also gives them the information they need to address issues like environmental sustainability, public health, and climate change (Read et al., 2023; Yli-Panula et al., 2018). Given the rapid advancement of knowledge and technology in the twenty-first century, it is critical that students comprehend biological ideas thoroughly and in their practical applications. Students may learn via problem-solving, teamwork, and practical experience by incorporating biology into 21st-century teaching methods (Rojas et al., 2021). This will better prepare them to contribute to a society that is becoming more complicated by the day (Lewinsohn et al., 2015).

Incorporating 21st-century skills like communication, critical thinking, and teamwork into biology education enables students to not only grasp the subject matter but also gain proficiency in data analysis, experiment design, and teamwork (Asmara & Nindianti, 2019; Aufa et al., 2021; Ulger, 2018). For instance, students can use their biology knowledge while developing their interpersonal and teamwork skills through research-based projects tackling regional environmental challenges (Yli-Panula et al., 2018). As a result, biology education combined with a 21st-century perspective not only enhances students' academic comprehension but also equips them to lead responsibly and creatively in the future (Ardoin et al., 2020; Mortensen & Nicholson, 2015; Read et al., 2023).

However, in reality, learning objectives based on the demands of the 21st century have yet to be achieved optimally. This is due to the lack of a variety of technology-integrated teaching materials implemented in learning (Hsu, 2016; Khlaif, 2018; Singh, 2019). Many teachers still have difficulty adapting to 21st-century learning (Anagün, 2018; Kim et al., 2019). Students only have a package book that contains practice questions and little discussion, so it is easier to cause boredom and does not meet student needs. Therefore, students still need teaching materials that are more adequate and meet the needs of students by utilizing existing technology (Delgado et al., 2015; McKnight et al., 2016; Uerz et al., 2018).

To overcome the existing problems, it is necessary to develop new teaching materials that meet the demands of 21st-century education to assist teachers in carrying out the learning process. One example

of teaching materials that can help students in the 21st-century education era is e-modules (Kowitlawakul et al., 2017; Seruni et al., 2020). E-modules are modules based on information and communication technology (Franke et al., 2021; Irwansyah et al., 2017). E-modules have advantages such as the ability to incorporate graphics and animation, make learning interactive, and provide quick feedback on completed tasks, thus facilitating learning (Bhat et al., 2022). E-modules can improve student learning outcomes (Lahti et al., 2014; Logan et al., 2021; Nazifah & Asrizal, 2022). One of the learning models that can be combined with e-modules is problem-based learning, which can help students develop critical thinking and problem-solving skills (Mahmudah et al., 2022; Prasetya et al., 2022; Rahmat et al., 2020).

Problem-based learning is a learning approach that focuses on using real-world problems as the basis for student learning (Choi et al., 2014; Kokotsaki et al., 2016; Kong et al., 2014; Loyens et al., 2015). According to Woods (2014) Problem-based learning is part of problem-solving-oriented teaching, which involves presenting inquiry-based challenges to students to facilitate their understanding of concepts. With problem-based learning, students are faced with real-world problems that they can learn from based on previous knowledge and experience, thus forming new knowledge and experience that makes students better understand the concepts presented (Barron et al., 2014; Fidan & Tuncel, 2019; Han et al., 2015; Kokotsaki et al., 2016). Based on existing research, e-modules based on problem-based learning can improve 21st-century skills such as critical thinking, communication, and collaboration (Anggraeni et al., 2023; Aufa et al., 2021; Nilyani & Ratnawulan, 2023; Serevina et al., 2018). In addition to using e-modules with problem-based learning models, 21st-century skills can be honed with game-based learning (Chan et al., 2020; Dankbaar et al., 2017; Petrović et al., 2022).

Game-based learning is an educational approach that priorities the concept of "learning through play" (Barzilai & Blau, 2014; Plass et al., 2015; Qian & Clark, 2016; Tsai et al., 2016). Some researchers have used game-based learning media to improve 21st-century skills (Abdul Jabbar & Felicia, 2015; All et al., 2016; Bai et al., 2020; Pellas et al., 2019). Khan, Ahmad, & Malik (2017) Research shows that the game method can increase students' interest and activeness in learning, thus achieving learning objectives. In addition, game-based learning can also improve students' learning motivation, communication skills, and collaboration (Abdul Jabbar & Felicia, 2015; Plass et al., 2015; Qian & Clark, 2016; Troussas et al., 2020).

Based on the problems described, developing a game-based e-module integrated with problem-based learning is necessary. According to previous research, developing game-based e-modules integrated with problem-based learning has great potential to improve students' 21st-century skills. In addition, this research is expected to contribute to science and provide novelty to teaching materials used in learning. Renewal of the teaching materials used in learning. This research aims to design a game-based e-module integrated with problem-based learning to enhance students' critical thinking, collaboration, and communication skills.

METHODS

Research Design

This type of development research is better known as Research and Development (R&D). In this research, the development model used is the ADDIE model. The ADDIE learning development approach explains the learning product design process in a simple and easy-to-understand way (Nichols Hess & Greer, 2016). According to Zou et al. (2023), the ADDIE development model systematically designs products, resulting in effective, efficient, and creative products. There are five steps in the ADDIE development model, namely: 1) analysis, 2) design, 3) development, 4) implementation, and 5) evaluation (Nadiyah & Faaizah, 2015; Nichols Hess & Greer, 2016; Yeh & Tseng, 2019). However, by leaving out the implementation and assessment phases, this study altered the ADDIE model. This is because the creation of useful and pertinent educational resources or products is the primary emphasis of the research. In addition to making sure that the materials are easily comprehensible, the researcher aims to develop goods that meet the demands of 21st-century learning and student characteristics. For the research's findings to be more focused on the caliber and efficacy of the final products before they are evaluated in a larger learning context, it places greater emphasis on the design and development aspects, which include the choice of suitable learning techniques, media, and strategies.

Instrument

The instrument is a tool for obtaining data (Dewanti & Santoso, 2020). In this research, the instrument used at the analysis stage used a survey technique with an observation sheet in the form of a questionnaire. The validation instrument uses a validation sheet containing criteria that are used as a reference for assessing the validity of the product. The aspects presented include content/material, language, systematics, and graphics, which are accompanied by a score column and suggestions for improving the developed product (Siafis et al., 2024; Wagner & Heinzel, 2020). The content/material feasibility assessment is carried out to determine the validity of the product based on aspects of competence, content, material, and suitability for learning outcomes and learning objectives (Susilana et al., 2022). A systematic feasibility assessment aims to determine the order of presentation and components in the e-module product (Nilyani & Ratnawulan, 2023). The language feasibility assessment aims to determine the feasibility of the language compiled in the e-module (Almanasreh et al., 2019; Dwi Tisa Haspen, 2019). The graphics assessment aims to determine the feasibility of the presentation of illustrations, images, and e-module design developed. This e-module validation sheet is prepared with 5 (five) alternative answer scores, namely 1) not good, 2) less good, 3) quite good, 4) good, and 5) very good.

Procedure

The first step in the research process is analysis as a foundation for product creation. The analysis stage is considered very important because it is the basis for effective product development (Nadiyah & Faaizah, 2015). Analysis is used to identify the problems faced and analyse learning needs (Hsu et al., 2014). The needs analysis results are used as the basis for product development. The next stage is design, which is designing the product by making the framework and structure of the e-module content (Nadiyah & Faaizah, 2015). After that, the development stage is carried out, and the product is realized. At this stage, the e-module is developed by the previous design and then validated by the science subject teacher as a validator (Hsu et al., 2014; Zou et al., 2023). This validation aims to assess the quality of the e-modules developed (Azizah et al., 2018; Fitriansyah et al., 2018; Nilyani & Ratnawulan, 2023).

Data Analysis Techniques

Validation of e-modules was carried out by four expert validators consisting of 2 Biology Education lecturers from the Faculty of Teacher Training and Education, UNIROW, and two practitioners from SMPN 1 Senori and SMP Plus An-Nur Montong, Indonesia. Data was collected in June 2024 using research instruments in the form of validation sheets. The validation sheet contains several assessment criteria, including aspects of content/material, language, systematics, and graphics. The validation assessment criteria used a Likert Scale adapted from Phillips et al. (2016) are presented in Table 1.

Table 1.
Likert Scale Score Interpretation Criteria

Score	Criteria
5	Very Good
4	Good
3	Good Enough
2	Not Good Enough
1	Not Good

The calculated data is then evaluated and concluded according to the interpretation that refers to Irwandi et al. (2019). The interpretation of the percentage results obtained can be seen in Table 2. The e-module design integrated with game-based problem-based learning is declared valid if the validation results reach a percentage of ≥60.1%.

Table 2.
Interpretation of Validity Percentage Results

Presentation (%)	Criteria	Description
0-20	Invalid	Total Revision
20.1-40	Less Valid	Major Revision
40.1-60	Moderately Valid	Minor Revision
60.1-80	Valid	Minor Revision
80.1-100	Very Valid	No Revision Needed

Adapted: Irwandi et al. (2019)

RESULTS AND DISCUSSION

Based on the analysis, it was found that teaching materials that can assist students in building their knowledge and learning freely are needed. 92% of students have difficulty understanding biology concepts; one of the reasons is the lack of supportive teaching materials. E-modules integrated with game-based, problem-based learning were identified as an effective solution, as they can empower essential 21st-century skills, such as critical thinking, communication, and collaboration. By using this e-module, students are expected to be actively involved in the learning process, where they not only receive information but also interact with the material and their classmates (Barron et al., 2014; Prasetya et al., 2022; Ulger, 2018). Through this approach, students will be encouraged to develop analytical and creative abilities, as well as improve their ability to work together and communicate well, which are essential skills to face challenges in the modern world (Indarta et al., 2021; Rosdianto et al., 2019).

The notion of validity is fundamental in research and development. Validity is determined by the extent to which interpretations of a product's value are supported by theoretical foundations and empirical data (Voorhees et al., 2016). In other words, validity is the extent to which interpretations are supported by accepted theories and facts, ensuring that the value assigned to a product is accurate and reliable. If an e-module meets the validity requirements (content, organization, language, and visuals) set by knowledgeable validators, then the e-module can be considered valid for educational purposes (Almanasreh et al., 2019; Ghazali et al., 2024). If the measurement findings match the desired objectives, the validity of the e-module is considered high (Voorhees et al., 2016). In other words, the measurement results accurately represent the event or fact being assessed (Clark & Watson, 2019; Sireci & Faulkner-Bond, 2014).

The results of the validation test of e-modules integrated with game-based problem-based learning can be seen in Table 3.

Table 3.
E-Module Validation Test Results

		Percentage Score				
Number	**Assessment Aspect**	**Validator I**	**Validator II**	**Validator III**	**Validator IV**	**Average**
1	Content/Material	83%	83%	83%	83%	83%
2	Systematics	77%	80%	93%	87%	84%
3	Language	84%	80%	88%	80%	83%
4	Graphics	78%	83%	93%	85%	84%
	Average Total					84%

Based on Table 3, the validation value of the content/material aspects of the four expert validators obtained an average of 83%. This means that the validity level of the e-module from the content/material aspect is included in the very valid category. This indicates that the content/material in the e-module is based on the objectives and learning outcomes (Azizah et al., 2018). In addition, the information in the e-modules can help students develop communication, collaboration, and critical thinking skills (Aufa et al., 2021; Prasetya et al., 2022; Serevina et al., 2018). Content/material validity is evidence obtained through testing that shows the extent to which the content of the e-module matches the learning objectives (Borsboom et al., 2004). In addition, the validity test of the e-module was carried out systematically.

The validity value of the systematic aspect of the four expert validators obtained an average of 84%. This means that the validity level of the e-module based on its systematics is included in the very valid

category. This is due to the coherent presentation of material by the sub-matter of Human Influence on Ecosystems (Ghazali et al., 2024; Ismail et al., 2019). Researchers include learning outcomes and learning objectives before learning activities. Furthermore, learning activities are structured using the syntax of the problem-based learning model (Aufa et al., 2021; Ghazali et al., 2024; Serevina et al., 2018). In addition, the glossary, bibliography, and author profile are already listed on the e-module. In addition, the validity test of the e-module was also carried out on the language aspect.

The validity value of the language aspect of the four expert validators shows an average of 83%, which means that the language of the e-module is included in the very valid category. This is indicated by the use of communicative, effective and efficient sentences in the e-module (Ghazali et al., 2024; Ismail et al., 2019; Sireci & Faulkner-Bond, 2014). In addition, the e-module has used language that is by EYD without containing elements of racism (Ismail et al., 2019). In addition, the validity test of the e-module was also carried out on the aspects of grammar.

Based on the graphic aspect, the validity value of the e-module obtained an average result of 84%, which means it is very valid. Graphical validation is closely related to the design and presentation of e-module products (Ismail et al., 2019). The results of the graphic validation indicated that the researcher was able to create an attractive design by paying attention to the accuracy of font type, size, and colour, as well as arranging layouts and buttons consistently and proportionally (Ismail et al., 2019; Prasetya et al., 2022).

Referring to Table 3, the total average overall e-module validation score from all aspects is 84%. Overall, the designed e-module can be very valid, so it is ready to be tested without revision. This statement is based on the interpretation of the value of the validity percentage results adopted from Irwandi et al. (2019). The results of the design and development of products that have been validated can be seen in the following link: " https://bit.ly/EModulPengaruhManusiaTerhadapEkosistemPBL

CONCLUSION

The game-based e-modules and integrated problem-based learning that have been designed have a very high level of validity. The validation test result is 84%, meaning the e-module is very valid. This shows that the designed e-module is based on the learning objectives and can improve students' communication, collaboration, and critical thinking skills. In addition, the preparation of e-modules uses communicative language and has an attractive and proportional appearance.

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