



## 1. Introduction

Education is an important instrument for fostering national progress and strengthening the quality of human resources, as stated in the 1945 Constitution of the Republic of Indonesia. In addition, Article 3 of Law Number 20 of 2003 concerning the National Education System explains that the national education is intended to shape students' character so that they develop independence and creativity (Undang-Undang Republik Indonesia, 2003). The concept of independence in learning refers to changes in students' behavior to take the initiative in overcoming obstacles and to have high self-confidence in accomplishing tasks independently without assistance from others. According to Tintarahardja and Sulo (Hadi and Farida, 2012), independent learning is defined as a learning activity driven by one's own will, choices, and responsibility. Meanwhile, Nasution *et al.* (2018), state that students with a high level of learning independence are generally able to determine effective learning strategies, monitor their progress, and take responsibility for their academic achievements. Therefore, students are considered to have independent learning behavior when they can complete tasks on their own without assistance and are not dependent on others. Wulandari (2023) states that students' self-directed learning can be reflected through several indicators, including the ability to set learning goals, select appropriate strategies, seek relevant learning resources, and evaluate learning outcomes, as well as demonstrating initiative, responsibility, discipline, and self-regulation.

Regarding creativity, Appulembang (2017) stated that creativity is the ability to create new combinations based on previously acquired knowledge and available information. Individuals who exhibit creative behavior are generally also intelligent, as creativity is one manifestation of cognitive processes (Suraji, 2019). According to Banaji (Lucas *et al.*, 2013), the urgency of incorporating creativity into education is to enable students to solve problems and challenges beyond the classroom, thereby enhancing self-esteem, motivation, and achievement, as well as preparing them for real-life situations. Indications that students have creative behavior are not only seen from the products produced. According to Rhodes in Cramond (2020), the measure of individual creativity can be measured from the individual as a person, process, product, and the context in which the creativity takes place (press). From a process perspective, creative individuals have one of two types of abilities,

divergent thinking or associative ability. Individuals who have divergent thinking will generally respond to tasks by providing responses in the form of alternative ideas. Evaluation of the responses can be conducted based on several aspects, including fluency, which represents the amount of ideas produced; flexibility, which shows the variation of ideas; originality, which reflects the uniqueness of the ideas; and elaboration, which indicates how well the ideas are explained in a detailed and complete way.

As explained by Geoffrey E. Mills and David F. Treagust in Amish and Jihan (2023), the effectiveness of learning can be enhanced through the use of various instructional methods and tools, one of which is the implementation of active learning and Project-Based Learning (PjBL). Meanwhile, according to Harrison's research in Asan and Haliloglu (2005) related to PjBL, although the instructions given by the teacher are only a little, the instructions will be responded by exploring and engaging in discussions with each other about how to solve problems. Students often feel motivated when they are given the chance to discover and explore new ideas with their peers. In addition, PjBL approach encourages the development of creative thinking, problem-solving skills, and student interaction to support the construction and application of new knowledge. According to Moursund in Jagantara *et al.* (2014), learning with PjBL model has several advantages when applied in the classroom, including: 1) increasing learning motivation, 2) increasing problem-solving skills, 3) improving research skills, 4) increasing cooperation, and 5) improving students' ability to manage their skills. According to Wena, as referenced in Jalinus and Nabawi (2017), PjBL promotes the development of several important student competencies, including designing projects, addressing problems, making decisions, conducting investigations, and performing tasks independently. In addition, this approach allows students to independently develop cognitive, affective, and psychomotor domains.

Furthermore, learning effectiveness can be improved through the integration of technology, especially when teachers apply flexible teaching strategies in the instructional process. One type of learning media that can address issues related to fostering independence and creativity is the e-learning module. This module is designed with various content presentations that are more concrete and realistic, aligning with differentiated learning approaches. The e-learning module is an innovation of the printed

module, allowing access through electronic devices such as mobile phones or personal computers. The e-learning module developed in this study is designed using a student-centered learning approach, referring to the Merdeka curriculum, and utilizing easily accessible technology (both online and offline). Ease of access is a key consideration in developing this product to ensure its benefits can also be enjoyed by students in other schools with similar characteristics. This is supported by Priliyadi (2018), whose research on e-learning modules concluded that such products can be used in other schools, provided that the supporting facilities and school conditions are similar to those in which the module was initially developed.

Regarding the variables of student learning independence and creativity, researchers have observed students at SMAN 2 Yogyakarta. The basis for selecting SMAN 2 as a research sample included its strategic and easily accessible location, the availability of facilities and infrastructure to support the research, the availability of information and data, cooperative respondents, and its representativeness as a sample of schools implementing the Merdeka curriculum. The background of students who have experienced online learning during the pandemic has further added to teachers' challenges in fostering indicators of independence and creativity.

Observations on the learning independence level of 36 phase E students at SMA Negeri 2 Yogyakarta reveal that two indicators of learning independence have relatively low achievement percentages: responsibility (52.96%) and the habit of disciplined behavior (57.41%). These indicators referring to Wulandari's statement (2023) regarding learning independence indicators. Researchers assume that one contributing factor is the compounded effect of students' online learning experiences in previous education levels.

Furthermore, observations on the creativity levels of 36 phase E students indicate that certain creativity indicators have relatively low achievement percentages compared to others. These include the ability to produce unconventional ideas (51.67%) and the willingness to be nonconforming and unafraid to be different (33.33%). These indicators referring to Rhodes (Cramond, 2020) regarding creativity indicators. Regarding the teacher's assessment of students' creativity and learning independence, the teacher stated that the students they taught had a moderate level of creativity. Meanwhile, their level of learning independence was between

moderate and high. The average achievement of students' basic competencies was around 50% above the class average. This is also a consideration for researchers to conduct development research in order to increase student creativity.

Researchers also analyzed the needs of biology teachers at SMAN 2 Yogyakarta. The analysis showed that teachers used several learning resources, such as the internet, the school environment, reference books, and journals. The teachers used learning videos and PowerPoint presentations, which are not the teacher's own creation. Learning activities carried out by teachers on biodiversity included environmental observation, identification of animal and plant characteristics, and identification of flora and fauna in Indonesia. These learning activities were designed by teachers to be implemented in groups. Teachers understood and had implemented learning using PjBL model. In learning activities, teachers also used learning modules, but not in electronic versions. Teachers stated that the use of modules in biodiversity learning was necessary, especially in electronic versions. The teacher also expressed approval of the development of electronic learning modules used in PjBL biology learning to enhance students' creativity and learning independence.

In relation to the support for learning activities, the researcher also gathered information about students' learning needs through a questionnaire. This is considered important because students' learning needs are a supporting factor in achieving learning objectives. Indicators used to identify students' learning needs include: 1) use of electronic devices; 2) characteristics of learning materials; 3) utilization of learning media; 4) use of electronic modules in learning; and 5) PjBL. In the electronic device usage indicator, 100% of students have digital devices that can be used to access teacher assignments and submit assignments online through an application. In terms of the characteristics of the learning material, specifically biology material for phase E, 47.22% of students stated that biology lessons are difficult to understand because the material is very broad and largely requires memorization. Meanwhile, 19.5% of students stated that the material on biodiversity, which includes genetic, species, and ecosystem diversity as well as the classification of living organisms, is considered difficult to comprehend.

Based on the challenges faced by both teachers and students at SMAN 2 Yogyakarta, the

researchers believe that there is a need to develop an e-learning module using the PjBL model, particularly for biodiversity material. The objectives of this development research are to: produce a feasible e-learning module based on the PjBL model; to evaluate the level of practicality of the PjBL-based e-learning module and to assess its effectiveness in promoting learning independence and creative thinking among Phase E students in biodiversity topics.

**2. Materials and Methods**

The subjects of this study were phase E students at SMAN 2 Yogyakarta, consisting of two classes: 36 students from grade 10 E7 as the control group and 36 students from grade 10 E6 as the experimental group. The study was conducted over approximately three months, from July to September 2024. A Research and Development (R&D) design was employed in this study using the ADDIE model (Amish and Jihan, 2023), which comprises the stages of analysis, design, development, implementation, and evaluation. The resulting product is an electronic biology module developed to support the application PjBL in biodiversity instruction. In the analysis stage, data were collected through interviews with phase E biology teachers at SMAN 2 Yogyakarta, covering student characteristics, needs identification, curriculum, and school-provided learning facilities. In the design stage, activities included drafting the framework of the e-learning module, gathering supporting materials, structuring the sequence of content presentation, and developing instruments to assess the module’s quality. In the development stage, activities included pre-compilation, compilation, editing, revision, and limited trials. In the implementation stage, a field trial was conducted to test the use of the e-learning module on biodiversity topics, involving phase E students at SMAN 2 Yogyakarta. A non-equivalent control group pretest-posttest research method was used for the large-scale trial. In the evaluation stage, assessments were carried out at each stage of the research and development process to refine and finalize the e-learning module.

This study applied several data collection methods, including interviews, surveys, questionnaires, observations, and tests. The instruments used comprised interview guidelines, expert validation questionnaires, response questionnaires, and general questionnaires. Expert validation is carried out by two lecturers from the Faculty of Mathematics

and Natural Sciences, Yogyakarta State University, who were experts in developing learning media. They assessed e-learning module’s feasibility, including content feasibility, presentation feasibility, language and readability, and graphic feasibility, according to the following Table 1.

Table 1. Validation Criteria or Material Experts and Media Experts

Score	Criteria
$X \leq 6$	Very poor
$6 < X \leq 7$	Poor
$7 < X \leq 8$	Enough
$8 < X \leq 9$	Good
$9 < X \leq 10$	Very good

(Source: Subali, 2010)

Meanwhile, validation of the practicality of e-learning module was obtained from two practitioners, namely Biology teachers at SMAN 2 Yogyakarta, through observation during learning activities. They assessed module’s material, module’s language, module’s graphics, and module’s practicality, according to the following Table 2.

Table 2. Validation Criteria for The Practicality of The Module

Score	Criteria
$X \leq 6$	Very poor
$6 < X \leq 7$	Poor
$7 < X \leq 8$	Enough
$8 < X \leq 9$	Good
$9 < X \leq 10$	Very good

(Source: Subali, 2010)

Content feasibility scored 9.7, categorized as very good; presentation feasibility scored 9.8, categorized as very good; language and readability feasibility scored 9.8, categorized as very good; and graphic feasibility scored 9.7, categorized as very good. The validated aspects included material obtained a score of 3.8 with a very appropriate category; language obtained a score of 3.8 with a very appropriate category; graphics obtained a score of 3.7 with a very appropriate category; and practicality obtained a score of 3.8 with a very appropriate category.

The reliability test of the research instruments was conducted using the QUEST program. The observation data on learning implementation were analyzed quantitatively using the Guttman scale with “yes” and “no” categories. Analysis of the pretest and posttest results for the variables of learning independence and student creativity was carried out by calculating the mean and percentage values. The

improvement in these variables was further measured using the N-gain formula, as presented in Table 3.

**Table 3. Normalized N-Gain Criteria**

N-gain Score	Classification
N-Gain > 70	High
30 ≤ N-Gain ≤ 70	Medium
N-Gain < 30	Low

(Source: Sugiyono, 2019)

According to Wulandari (2023) and Cramond (2020), the indicators of learning independence used in this study are independence from others, having self-confidence, behaving in a disciplined manner, having a sense of responsibility, behaving based on one's own initiative, and exercising self-control. Meanwhile the indicators for creativity are deep curiosity, asking questions, having lots of ideas, freely expressing opinions, seeing problems from various points of view, and being imaginative.

The analysis of learning independence and creativity data employed non-parametric inferential statistics using the Wilcoxon Ranked Test. Prior to the main analysis, assumption tests were conducted, including a normality test with the Shapiro–Wilk method and a homogeneity test using Levene’s test, both at a significance level of 0.05. The statistical hypotheses in this study were formulated as follows:

$H_0$ : The implementation of the e-learning module does not significantly affect students’ learning independence and creativity.

$H_1$ : The implementation of the e-learning module significantly affects students’ learning independence and creativity.

### 3. Result and Discussion

According to Laili *et al.* (2019), the e-learning module is a teaching material that helps students learn independently and assess their own understanding of the subject. Based on the evaluation results, the e-learning module satisfies the aspects of feasibility, practicality, and effectiveness, which suggests that it can be properly utilized in instructional activities. According to Akker in Prabowo *et al.* (2016), the feasibility of a developed product can be determined by three criteria: validity, practicality, and effectiveness. In line with these criteria, the primary goal of the product development in this study is to produce an e-learning module that is feasible, practical, and effective in improving students' learning independence and creativity.

According to the validation results from subject matter experts and media experts, the developed e-learning module met the criteria for use in instructional activities and was categorized as having a very good level of quality. According to Sugiyono (2019), validation to determine the feasibility of a product not only serves as a measurement tool or evaluation tool but also as a guide to improve the quality and acceptance of the developed product. The sentences used were effective, the language was communicative, the discourse was appropriate to the learning context, and the linguistic structure was suitable for the cognitive development of phase E students. Graphically, the design of the e-learning module met the criteria for being suitable for use in teaching.

Referring to the data from the practitioner validation, the developed e-learning module was deemed very appropriate according to the product practicality indicators, which include aspects of content, language, graphics, and practicality. The validator stated that the e-learning module was engaging, good, and practical to use in teaching. To determine whether the developed product meets the practicality criteria, a practicality test is needed to ensure that the product can be easily and effectively used by users. Delianti and Jalinus (2020) stated that a practical learning module can support PjBL learning, as it is designed to enhance student engagement through solving real-world problems and producing concrete outcomes. Suciani *et al.* (2018) explained that the advantage of the PjBL model is its ability to encourage students to engage in more active learning, foster greater motivation, develop problem-solving skills, and enhance collaboration among students.

Table 4. Descriptive Analysis Results of Students' Learning Independence

Types of Analysis	Experimental Class Control Class			
	Class		Class	
	Pretest	Posttest	Pretest	Posttest
Number of Samples	36	36	36	36
Total Score	2170	3092	2620	2862
Minimum Score	40	77	50	62
Maximum Score	80	100	100	100
Standard Deviation	13,4	8,5	12,1	10,9

The results of the descriptive analysis on learning independence and creativity in students, using pretest and posttest scores as a reference, are presented in terms of sample size, total score, minimum score, maximum score, and standard deviation, as shown in Table 4.

Table 5. Analysis Results of Learning Independence Based on N-Gain Score

Class	Mean score		N-Gain Score	Criteria
	Pretest	Posttest		
Experiment	60	86	0,6	medium
Control	73	79	0,2	low

The results of the descriptive analysis were then analyzed using the N-gain score to determine the improvement in students' learning independence, both in the experimental and control groups. The results of the N-gain score analysis are presented in Table 5.

Table 6. Descriptive Analysis Results of Students' Creativity

Types of Analys	Experimental Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
Number of Samples	36	36	36	36
Total Score	1950	3067	2580	2875
Minimum Score	30	75	50	67
Maximum Score	80	100	90	100
Standard Deviation	13,4	8,5	10	10

The analysis of N-gain values derived from the pretest and posttest results in the experimental class produced a score of 0.6, categorized as a moderate improvement in learning independence. On the other hand, the control class showed an N-gain value of 0.2, which represents a low level of improvement. From these results, it can be inferred that the use of the e-learning module in the experimental class tends to be more effective in improving students' learning independence compared to the control class.

The outcomes of the descriptive statistical analysis of students' creativity scores in both the pre-test and post-test, including the sample size, total score, minimum and maximum scores, as well as the standard deviation, are summarized in Table 6.

Furthermore, the results of the descriptive analysis were analyzed using the N-gain score to identify the level of improvement in students' creativity in both the experimental and control classes. The results of this analysis are summarized in Table 7.

Table 7. Analysis Results of Creativity Based on N-Gain Score

Class	Mean score		N-Gain Score	Criteria
	Pretest	Posttest		
Experiment	54	85	0,7	medium
Control	72,2	80	0,3	low

The analysis of the N-gain values derived from the pretest and posttest results in the experimental class produced a score of 0.7, which falls into the moderate improvement category for creativity. On the other hand, the control class showed an N-gain value of 0.3, indicating a low improvement. From these results, it can be inferred that the use of the e-learning module in the experimental class tends to be more effective in increasing students' creativity than in the control class.

Shapiro-Wilk normality test was conducted to evaluate the distribution of the data. The results presented in Table 8 show a p-value  $\leq 0.05$ , indicating that the data are not normally distributed.

Table 8. Results of Normality Test Using Shapiro-Wilk Test

Variabel	Class	Treatment	Shapiro-Wilk test <i>Shapiro-Wilk</i>			Explanation
			Statistic	df	p	
Independent Learning	Experiment	Pretest	0,902	36	0,004	The data distribution is not homogeneous
		Posttest	0,825	36	0,000	
	Control	Pretest	0,914	36	0,008	
		Posttest	0,938	36	0,043	
Creativity	Experiment	Pretest	0,934	36	0,034	The data distribution is not homogeneous
		Posttest	0,860	36	0,000	
	Control	Pretest	0,904	36	0,004	
		Posttest	0,870	36	0,001	

The homogeneity test to determine the data variance was conducted using the Levene's test. The results of the homogeneity test presented in Table 9 show that the p-value  $\leq 0.05$ , indicating that the data variances are not equal or are not homogeneous.

Table 9. Results of Homogeneity Test Using Levene's Test

Variable	Treatment	Levene Statistic	df1	df2	p	Explanation
Independent Learning	Pretest	3,155	3	140	0,02	The data distribution is not homogeneous
	Posttest				7	
Creativity	Pretest	3,551	3	140	0,01	The data distribution is not homogeneous
	Posttest				6	

Referring to the results of the normality and homogeneity tests, where the p-value  $\leq 0.05$ , it can be concluded that the data do not meet the requirements for parametric analysis. As a result, further hypothesis testing was conducted using the Wilcoxon Signed-Rank Test as a non-parametric statistical method. The results indicate p-value  $\leq 0.05$ , suggesting that  $H_0 (\mu_1 = \mu_2)$  is rejected and  $H_1$  is accepted. Accordingly, the findings demonstrate a significant difference in students' learning independence when the e-learning module is applied.

The results of the Wilcoxon Signed-Rank Test for the independent learning variable show that there were no negative ranks and no ties, while all 36 participants were categorized under positive ranks. This indicates that all students experienced an improvement in their independent learning after the intervention. The mean rank value of 18.5 further reflects a consistent increase across participants. Additionally, the obtained Z value was  $-5.236$  with a significance value (p) of 0.000, which is lower than the threshold of 0.05. Therefore, it can be concluded that there is a statistically significant difference in students' independent learning before and after the implementation of the treatment. These findings suggest that the applied learning approach effectively enhances students' independent learning.

A similar analysis was also conducted on the creativity variable. The results of the Wilcoxon Signed-Rank Test indicate p-value  $\leq 0.05$ , meaning that  $H_0 (\mu_1 = \mu_2)$  is rejected and  $H_1$  is accepted. Based on the formulated research hypothesis, it can be concluded that the

implementation of the e-learning module significantly influences students' creativity.

The results of the Wilcoxon Signed-Rank Test for the creativity variable indicate that there were no negative ranks and no ties, while all 36 participants were classified under positive ranks. This suggests that every student showed an improvement in creativity following the intervention. The mean rank of 18.5 reflects a consistent increase across all participants.

Furthermore, the obtained Z value was  $-5.237$  with a significance value (p) of 0.000, which is below the 0.05 significance level. Therefore, it can be concluded that there is a statistically significant difference in students' creativity before and after the implementation of the treatment. These findings demonstrate that the applied learning approach effectively enhances students' creativity.

Regarding the impact of learning media on students, Sugiyati and Djumali (2013) stated that the use of learning media significantly affects students' learning creativity. This is further supported by Jalinus and Ambiyar (Maurisa and Rahayu, 2021), who explained that the utilization of both software and hardware learning media can stimulate students' feelings, thoughts, interests, and attention, making the learning process more effective. It can be concluded that the importance of using learning media is to maximize the process in order to achieve the expected learning outcomes. Therefore, the development of the e-learning module in this study is important and feasible to undertake.

The descriptive analysis results demonstrate a tendency that the application of e-learning modules can promote students' learning independence as well as their creativity. Further hypothesis testing using non-parametric statistical analysis, the Wilcoxon Signed-Rank Test, shows that there are significant differences in the variables of learning independence and creativity in students who use the e-learning module. Therefore, it can be concluded that there is a positive correlation between learning independence and creativity. This is supported by the research of Sardiman (2006), which explains that students with learning independence tend to act on their own initiative, make plans to achieve their goals, think and act creatively, are full of initiative, and do not merely imitate. Thus, students who have learning independence ideally also have good creativity. Project-based learning modules can also enhance higher-order thinking skills and motivate students to learn independently.

#### 4. Conclusion and Suggestions

Based on the results of the research and development of the e-learning module in the PjBL model, three conclusions are obtained as follows: The e-learning module with the PjBL model on the topic of biodiversity is suitable for use in Biology learning to enhance students' learning independence and creativity, based on assessments from subject matter experts and media experts. The e-learning module with the PjBL model on the topic of biodiversity is practical for use in Biology learning to enhance students' learning independence and creativity, based on assessments from Biology teachers and student responses. The e-learning module with the PjBL model on the topic of biodiversity is effective in improving students' learning independence and creativity in phase E. This is supported by data from descriptive statistical analysis using N-gain scores on the variables of learning independence and creativity, which show a moderate improvement. The results of the inferential statistical analysis further reveal a significant difference in students' learning independence and creativity between those in the experimental group and those in the control group.

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