Journal of Engineering Science and Technology
Vol. 19, No. 5 (2024) 1617 - 1644

DEVELOPMENT OF E-LEARNING ETHNO SOCIOSCIENTIFIC ISSUES (ESSI) "WASTE AND ITS HANDLING" TO EMPOWER STUDENTS' CREATIVE THINKING SKILLS

AHMAD KHOIRI[1,*], HIDAYATUS SIBYAN[1], SIGIT MURYANTO[2], QORI AGUSSURYANI[1], ISHAQ ABDUL HANNAN[1], M. MISBAH[3,4], BUDIYONO SAPUTRO[5], MOHD FAUZI SEDON[6]

[1]Universitas Sains Alqur an, Wonosobo, Central Java, Indonesia
[2]Universitas Boyolali, Central Java, Indonesia
[3]Universitas Pendidikan Indonesia, Bandung, Indonesia
[4]Universitas Lambung Mangkurat, Banjarmasin, Indonesia
[5]Universitas Islam Negeri Salatiga, Central Java, Indonesia
[6]Universiti Pendidikan Sultan Idris, Perak, Malaysia
*Corresponding Author: akhoiri@unsiq.ac.id

Abstract

This research aims to develop ethno socioscientific issues (ESsI) e-learning to empower students' creative thinking abilities. The design-based research (DBR) method consists of 4 steps, namely, analysis of e-learning needs, design planning, development, and reflection on results. The research subjects were high school students in the experimental group and control group. Collect pre-test and post-test data on creative thinking abilities, teacher and student response questionnaires. The data analysis technique uses the prerequisite tests for normality, homogeneity, and t-test hypothesis testing. The research results show that the development of ESsI e-learning meets the criteria of being valid, practical, and effective in empowering creative thinking skills. The practicality of ESsI e-learning through student and teacher responses is in a good category, meaning it is easy to use the product developed. Based on the t-test, there are differences in the results of the creative thinking skills of experimental and control group students. The effectiveness of ESsI e-learning is because it can provide opportunities for scientific thinking in exploring scientific issues developing in society in the reconstruction of materials. The impact of research in the form of innovative ESsI e-learning can provide opportunities for students to think creatively, making learning meaningful without abandoning culture.

Keywords: Creative thinking skills, E-learning, Ethnoscience, Socioscientific issues strategy, Waste and handling.

1. Introduction

E-learning as a characteristic of science learning in the 21st century emphasizes high-level thinking processes to solve global problems through technology. Technological developments require online learning systems to be developed to suit the needs of the times [1, 2]. However, the e-learning used still only provides learning materials and resources to be read and understood [3]. Lack of interaction between students and teachers makes learning less meaningful, lack of student understanding which triggers failure in science learning using e-learning [4, 5].

Apart from internet access, students' opportunities to think in the learning system are also not optimal. Meaningful learning loss in terms of learning loss is a form of attention for researchers to analyse the instructional impact of learning that occurs. Previous research on e-learning to provide an overview of the research positions needed can be presented in Table 1.

Table 1. Previous research on e-learning.

No.	Title	Ref.
1	Development of a design learning management system (LMS) to improve student skills: case study in a science learning media development course	[6]
2	Development of an e-module based on local wisdom ethnoastronomy in the digital era to strengthen the pedagogical competence of social studies teachers	[7]
3	Design of web-based digital module for improving student understanding and skills in graphic design lessons in vocational school	[8]
4	Game based learning media on system of units material based on assessment analysis results for children with mathematics learning difficulties	[9]
5	Implementation of e-UKBM-assisted wenning inquiry learning to improve students' scientific skills	[10]
6	Development of an e-module based on a guided inquiry learning model in natural science subjects in elementary schools	[11]
7	E-Learning as education media innovation in the industrial revolution and education 4.0 era	[12]
8	Socio-technical e-learning innovation and ways of learning in the ICT-space-time continuum to improve the employability skills of adults	[13]
9	Development of physics e-module based on integrated project-based learning model with ethno-STEM approach on smartphones for senior high school students	[14]
10	The effect of online argumentation of socio-scientific issues on students' scientific competencies and sustainability attitudes	[15]
11	Facilitating critical thinking in decision making-based professional training: An online interactive peer-review approach in a flipped learning context	[3]
12	Effects of human factors in engineering and design for teaching mathematics: a comparison study of online and face-to-face at a technical college	[16]

Table 1 shows that the impact of e-learning used by schools has not been able to provide students with opportunities to develop thinking skills, one of which is creative thinking skills. The impact of e-learning can adapt a flexible learning system [17-21].

Based on the results of the 2024 final semester exams in natural and social sciences (IPAS) subjects, SMA obtained an average of 43.67 in the low category. These results are confirmed in several regions of Indonesia, namely; Klaten regency was 13.71% and learning outcomes were 43.56% (low category), Karanganyar regency was 27.1%, and Jambi city by 17% [22-24]. International creative thinking skills show a gap between environmental creation and the creative skills needed by students [25]. Next, previous research regarding the impact of e-learning on students' creative thinking skills needs (see in Table 2).

Table 2. Impact of ethnoscience learning on creative thinking skills.

No.	Title	Ref.
1	How are students' creative thinking skills? An ethnoscience learning implementation	[26]
2	Science integrated learning model to enhance the scientific work independence of student teacher in indigenous knowledge transformation	[27]
3	Problem-based learning module of environmental changes to enhance students' creative thinking skill	[28]
4	Ethno-STEM project-based learning: Its impact to critical and creative thinking skills	[29]
5	Improving science attitude and creative thinking through science education project: A design, implementation and assessment	[30]
6	Creative thinking skills of students on harmonic vibration using model student facilitator and explaining (SFAE)	[31]
7	The contribution of the ILESSI-DCF Model to promote creative thinking skills of Madrasah Aliyah (MA) students	[32]
8	A contextual semi assisted project-based learning (SA-PjBL) about ocean wave energy: Creative thinking of pre-service physics teachers	[33]
9	Creative problem solving in primary education: exploring the role of fact finding, problem finding, and solution finding across tasks	[34]
10	Effect of ethnoscience instructional approach on students achievement and interest in upper basic science and technology in Benue State Nigeria	[35]
11	Prospective teachers' scientific literacy through ethnoscience learning integrated with the indigenous knowledge of people in the frontier, outermost, and least developed regions	[36]
12	Scientific literacy profile of student teachers on science for all context	[37]
13	Local wisdom to grow students soft skills (study cash: Development RKH on science learning).	[38]

Table 2 shows that explains the low level of creative thinking skills due to less than optimal use of e-learning. It's still online without any interaction for students to think about. The e-learning system that was built only consists of pictures and learning resource information. Moreover, ethnoscience problems in the form of traditions, culture, and local potential are still rarely utilized in e-learning. The development of ethnoscience can improve students' thinking skills [39-44].

Furthermore, the teaching materials used are still based on the textbooks held by each student [45]. Ideally, creative thinking skills are characterized by giving divergent questions and having higher-order thinking skills [46]. Future education is not just about studying material and concepts, but to achieve a healthy and prosperous society, it is very necessary to have a cultural environment for students' lives. Moreover, it is integrated into the online learning system, e-learning which can foster students' creative thinking skills. The e-learning used in general has not been able to answer problems, so it is necessary to develop e-learning that is meaningful, creative, and has cultural characteristics based on an ethnoscience approach.

The results of previous research also confirm that the ethnoscience approach can stimulate science process skills activities and student appreciation, learning achievement, scientific knowledge abilities through issue strategies in society, and can foster an attitude of caring for the environment, maintaining traditions and culture. public. The 21st century is important for achieving creative education graduates in the global era with technological capabilities through e-learning, while still upholding cultural traditions [47-50]. Tables 1 and 2 show a comparison of e-learning research and the contribution of ethnoscience learning to empowering creative thinking skills.

The contribution of e-learning shows the development of technological literacy in 21st century learning, which is its characteristic, but what needs to be strengthened is the essence of its use, not just advanced technology. The presentation of a technology system that can provide dominant learning activities and interactions for students is highly recommended.

Based on the research problem, it is important to study integrated e-learning on ethnoscience issues developing in society, so the research aims to develop ESsI e-learning to empower students' creative thinking skills as well as the responses and impacts arising from learning using ESsI e-learning. The novelties of this study are e-learning development to overcome the problem of lack of interaction between students and teachers in active involvement in developing creative thinking skills. Apart from that, it can also provide meaningful learning for students' lives because it uses an ethnoscience approach and strategies for issues developing in society ethno sociocientific issues. Not just learning science through an online system, but student interaction with an environment that can maintain culture and opportunities to think.

2. Literature Review

2.1. Ethno Socioscientiffic Issues (ESsI)

The ethnoscience approach gives rise to individuals increasingly mastering scientific concepts in culture because learning takes a contextual approach to the environment [51]. Cultural appreciation and scientific process skills can be improved through increasing ethnoscience learning achievement and scientific knowledge [42, 52]. Other appreciations in the form of curiosity, care, and attention to traditions are increasing. Ethnoscience learning trains students' habits in understanding native knowledge that they are not yet familiar with. Habits are in the form of an introduction to traditions and culture which are used as a source of knowledge and social values that are full of meaning in life.

The flow of globalization is shifting human social behaviour which is being replaced by increasingly sophisticated digitalization systems. Students are increasingly unconcerned and indifferent to the preservation of the surrounding environment [51-54]. An effective learning resource to utilize is students' direct experience rather than learning that presents abstract concepts.

The connection between ethnoscience and 21st-century learning is that a sophisticated digitalization system seems to be eroding traditions that are deeply rooted in society [55, 56]. Human life is centred on information technology as a medium for carrying out its activities [57, 58]. In the 21st century, it is important to produce educational graduates who can compete globally, have creative thinking, and are technologically literate while still upholding cultural traditions. Contributions to ESsI e-learning can provide students with opportunities to think through technological literacy which is used as a learning resource. Meaningful learning is not only accessing online, but the values of tradition, culture, and local potential that are rooted in society can provide students with an attitude of caring, respect, discovering scientific concepts, and flexible thinking.

Formal education and the social acculturation process are still separate because genuine knowledge is an experience that cannot be scientifically proven, Culture is a form of a community's way of life that is shared and passed down from generation to generation. The importance of the ethnoscience approach is so that people's culture is not eroded by the times due to globalization. Furthermore, the aim of science learning is so that students can adapt to an environment that requires mastery of knowledge, skills, values, and attitudes [59, 60]. The framework of the relationship between strategies for science issues developing in society, learning models as well as the limitations of students' science reconstruction in 21st-century learning are presented in Fig. 1.

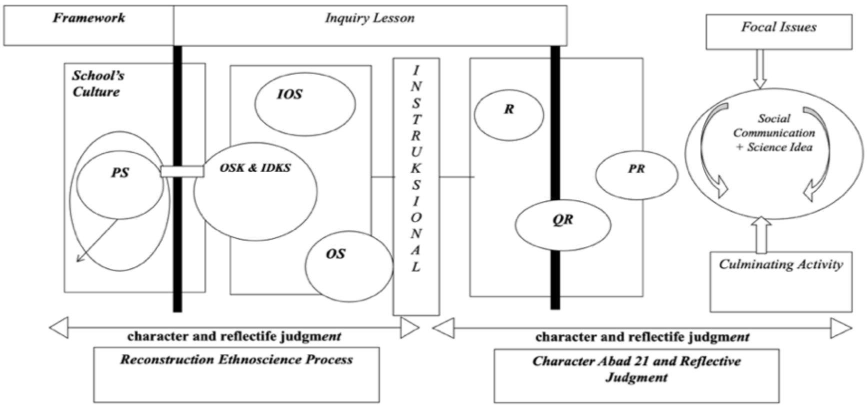

Fig. 1. Ethno socioscientific issues framework.

Figure 1 shows that students' reflection on the socioscientific issues (SSI) strategy can generate 3 types of thinking, namely: (i) pre-reflective (PR) with the belief that there is no need to justify the information obtained by proving it right or wrong; (ii) quasy reflective (QR) requires justification with evidence to find accurate data; and (iii) reflective (R) can conclude and explain the results to others. The e-learning system that presents social issues in society can provide boundaries for students' thinking as a reconstructive effort, categorized into five groups which are presented in Fig. 2 [61].

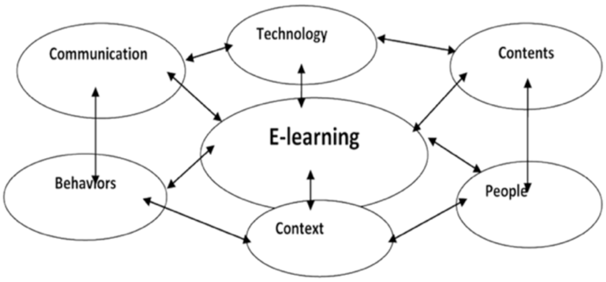

Fig. 2. The process of reconstructing original science in e-learning.

Figure 2 measurement of science reconstruction efforts in e-learning through the potential scientist student (PS) group. This group of students easily crosses cultures without boundaries between scientific science and students' daily culture. The other smart kids (OSK) group shows a group of students who can understand culture well, but still recognize science as a foreign culture. The i don't know student (IDKS) group states that students experience serious problems but try to study them continuously and the result is only memorizing concepts, not understanding science. The outsider (OS) group is an isolated group that is unable to cross cultures because of the strength of students' daily culture. Furthermore, the inside outsider (IOS) group is a group that feels cultural discrimination and does not receive scientific knowledge.

The characteristics of e-learning include science content for students to learn about waste management, technology designed to make it easier for students to learn through software and it is possible to carry out the online learning process optimally. The context of the SSI strategy provides an overview of the development of social issues in society to interact with the environment as closely as possible. Behaviours in developing an attitude when learning online that is not just about understanding scientific material but is able to take actions and attitudes as characteristics of 21st-century learning.

2.2. Characteristics and Contributions of E-Learning

Learning using e-learning will be more effective and efficient. To answer these challenges, there is a need for a supportive learning system [11-13]. The system is formed through a network, namely online learning or e-learning. The conception of e-learning components that influence each other is presented in Fig. 3 and Table 3 [62].

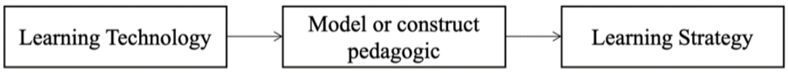

Fig. 3. Scheme relations meaningful interaction component adaptation.

Figure 3 shows that technology-based e-learning applications provide fast access to learning materials, enable more interactive and visual learning, and provide flexibility in managing time and place of study. All these factors indicate that e-learning will continue to be a major trend in the world of education. E-learning makes it possible to form different formative scenes, which if combined can provide more significant learning [63]. The comparison of traditional and modern learning types is presented in Table 3.

Table 3. Different types of learning.

Type of learning	Traditional formation	E-learning
Synchronic	Typical class in which it takes part a teacher and several students	All the class is connected to internet in a chat. The participants present ideas to the class using audio or text or video conference.
Synchronic or asynchronic	Groups of students meet outside the class timetable to make some task	Groups of students meet in a chat to make a proposed task
	The teacher meets with students during tutorship hours	The teacher uses the tutorship hours to advise, in a chat, to students
Asynchronic	The students complete individually assigned tasks, making report for the teacher	The students download the tasks and resources of information from the website. The teacher provides to the student tutorship hours by e-mail
	The library is used as formation resource	The students have access to the excellent information of Internet through proposed connections

Table 3 shows that at characteristics of e-learning have the responsibility to generate an effective learning experience. Successful e-learning design can contribute to student capabilities. E-learning design considerations must be by student needs, adequate facilities, adequate resources, and commitment to optimal use of e-learning. Based on Fig. 4 e-learning design must be applied to all learning components such as curriculum, teaching modules, assessment systems, and student learning media. Consideration of e-learning design by integrating social issues developing in society requires special preparation and consideration [63].

Based on Fig. 5 the components that must be considered in designing e-learning. The e-learning design considers content, context, and student and teacher resources. The practicality of using e-learning without abandoning the essence of implementation goals in science learning according to the characteristics of the 21st century [63].

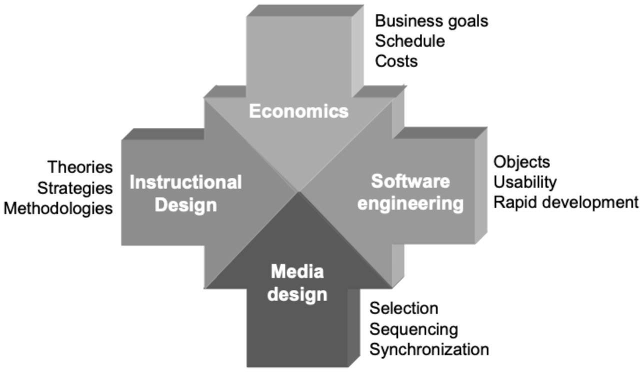

Fig. 4. Consideration of e-learning various perspectives.

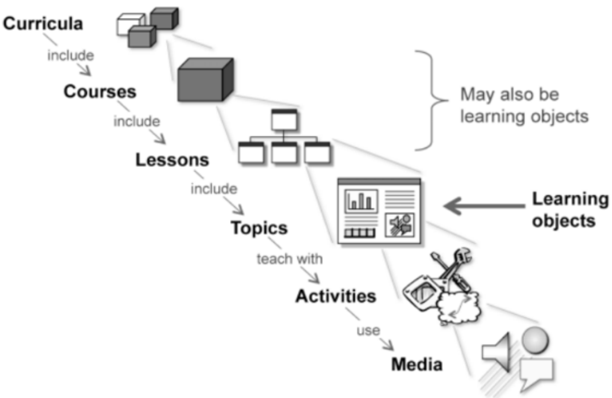

Fig. 5. Design all e-learning units.

2.3. Waste and Handling

The application of IPAS learning regarding "waste and its handling" (as shown in Table 4) through technical analysis is carried out to determine the rate of generation, composition, density, and recovery factors as a developing issue in society [47, 52].

Reconstruct science from waste materials by introducing ethnoscience, life activities that utilize waste as a learning resource. Utilization of social issues developing in society as original knowledge that can be learned by students through e-learning. Students' understanding is increasingly optimal, which is marked by learning activities.

The results of the reconstruction of science into scientific knowledge describing the implementation of high school science and science learning using ESsI e-learning in the material "waste and its handling". Table 4 is based on a literature review regarding SSI strategies, ethnoscience approaches, characteristics, and contributions of e-learning, as well as science reconstruction simulations in empowering students' skills as a basis for developing ESsI e-learning.

Table 4. Scientific reconstruction of the material "waste and its handling" in Wonosobo regency.

Reconstructing science in ESsI e-learning	Socioscientific issues	Science	Concept
Waste at Wonorejo landfill		The potential for waste accumulation could reach 130 tons per day, assuming 70 tons go to the landfill	Understanding waste
Waste from the plywood processing factory in Sapuran is used to make houses and the like		This type of waste is in the form of pieces of various sizes, shavings and powder which has long-term impacts if it is not handled seriously	Long term waste
Geodipa energy waste in Dieng Kulon is waste gas produced by the geothermal power plant (PLTP) which is used as an electricity supply for the Central Java area		The total geothermal energy potential around Dieng is estimated at 400 MW, however there is PT Geodipa Energy gas waste that must be considered	Long term waste
Arabica coffee skin waste in Bowongso village is waste from coffee processing that is not used		The use of coffee skins in agriculture is by processing them into compost, coffee skins as a source of organic material containing nutrients	Solid waste

The technical analysis carried out by students is as follows: (i) Population projection analysis is carried out to determine population developments in the next few years, using 3 (three) alternative calculation methods, namely arithmetic, geometry, and least squares; (ii) Waste generation projection analysis is carried out by considering existing waste generation data and is based on projected population growth rates. Mass balance analysis and waste recycling potential analysis. From data on waste generation rates, waste composition, and recovery factors, mass balance analysis can be carried out to determine the potential for waste recycling and the amount of residue produced; (iii) The steps in carrying out mass balance analysis are the results of calculating the recovery factor (RF) for each waste composition, then calculating the weight of waste that can be recycled (kg) using the formula weight of recycled waste (kg) is RF (%) cross weight of waste per composition (kg), calculate the remaining waste for each composition. Residue (kg) is weight of waste before recycling (kg) minus weight of waste that can be recycled (kg); (iv) From mass balance analysis and waste recycling potential analysis, the waste processing database also provides information to the public regarding waste processing.

3. Method

This research uses a design-based research (DBR) approach to understand the purpose of e-learning which has an instructional impact on high school students' creative thinking skills. DBR was adapted to produce ESsI e-learning products consisting of 4 steps, namely, analysis, design planning, development, and reflection on results (as shown in Fig. 6).

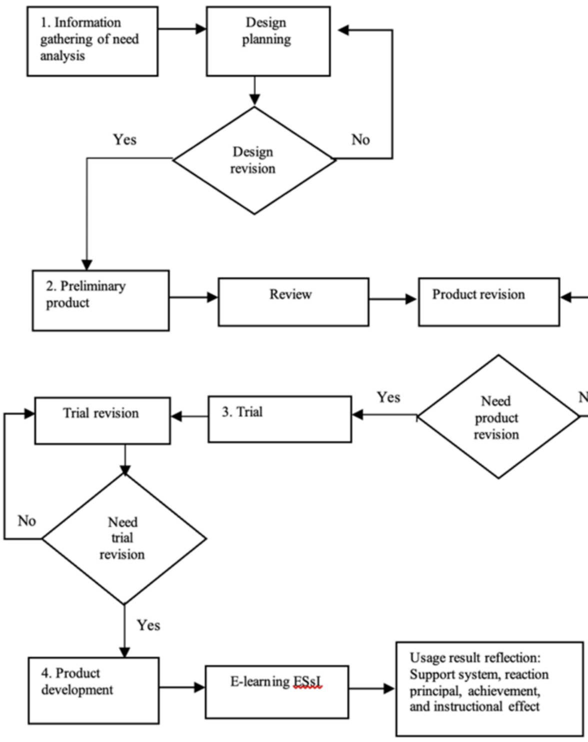

Fig. 6. Design-based research procedure.

Figure 6 shows that at needs analysis, the initial e-learning design is developed at the planning, design, and development stages. Finally, the successful use of e-learning is collected in the reflection stage. At the development stage for product trials using a quantitative research design for experimental and control groups (pre-test posttest control group design). Subjects' Initial product trials were carried out at SMA A with as many as 25 students. Furthermore, research trials after the final product were carried out at SMA B for the experimental group (N=37 students) and the control group (N=35 students). The type of quantitative data is in the form of student's creative thinking skills on pre-test and post-test questions, student and teacher response questionnaires, as well as the implementation of science and science learning using ESsI e-learning with the material "waste and its handling". In addition, all statistical analysis data was calculated using SPSS, in which detailed information for the use of SPSS is explained elsewhere [64].

4. Results and Discussion

4.1. ESsI E-Learning Needs Analysis

Initial research to analyse needs and design ESsI e-learning products consisted of three components, namely: (i) exploration of ethnoscience and SSI in Wonosobo regency; (ii) analysis of variable needs for creative thinking skills; and (iii) preliminary analysis of ESsI e-learning. Needs analysis by collecting information from literature studies from various libraries, reviewing theories, relevant research results, and field observations.

The results of the ESsI e-learning needs analysis are presented in Table 5 is the basis for the development of ESsI e-learning, after the needs analysis is obtained by considering the users and product targets, then the ESsI e-learning design is carried out based on the development objectives. Data needs to consider the product that will be developed by considering all aspects involved in the implementation process. One of them is users of ESsI e-learning products, namely students and teachers. Needs analysis is used as the first step in developing products based on goals, benefits and functions. Appropriate design with all aspects of needs that must be met by users to improve creative thinking skills.

Table 5. Analysis of ESsI e-learning needs.

Aspect	Description
Exploration of ethnoscience and socioscientific issues	Exploration of local potential related to waste in Wonosobo regency; Choose intrinsic and extrinsic ethnoscience that is relevant to science material in high school; exploration needs to strengthen scientific literacy for reconstruction activities
The need for creative thinking skills for high school students	Potential for creative thinking skills; Analysis of creative thinking variable indicators; the potential for creative thinking is more optimal and meaningful
The need for e-learning to take an ethnoscience and socioscientific issues approach	Consideration of e-learning content with social issues; Access the practicalities of ESsI e-learning;

4.2. ESsI E-Learning Product Design

ESsI e-learning product design in addition to developed skills. The ESsI e-learning support system consists of 3 parts, namely ESsI media, environmental learning resources with an ethnoscience approach, and learning tools. The learning tool uses the ESsI teaching module. Meanwhile, the assessment sheet uses an evaluation instrument for creative thinking skills test questions.

ESsI e-learning design to provide easy access to meaningful and contextual learning. Students' creative learning activities, scientific reconstruction of materials and waste literacy (as shown in Fig. 7). ESsI e-learning implementation has been carried out with various philosophical foundations of supporting theories, models, strategies, assessments, media, class, and time management. E-learning is packaged based on needs and provides solutions to empower students' creative thinking skills. The instrument for evaluating creative thinking skills is the Torrance test with 15 essay questions. Online-based learning support materials, which can be accessed directly by students, so that learning becomes practical and effective. Online learning requires wifi or a strong network, this is an evaluation material in the implementation process because not all students can access e-learning smoothly.

Fig. 7. ESsI e-learning design; (a) Home menu, (b) Socioscientific issues strategy, (c) Ethnoscience approach, (d) Science literacy.

E-learning design uses student activity sheets through creative activities that support the development of students' scientific skills activities [47]. System planning by creating student or teacher accounts independently allows for maximum creative work (Fig. 8) and provision of ESsI material content (Fig. 9).

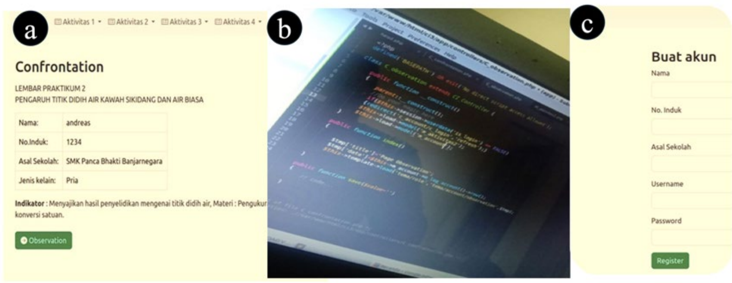

Fig. 8. Account of students' creative thinking stages; (a) Student login, (b) Coding system, (c) Member account.

(a) Creative thinking activity. (b) Ethno socioscientific issues.

Fig. 9. Material and e-learning ESsI activity.

Consideration of achieving students' creative thinking skills in ESsI e-learning design is the main target in product development. Creative thinking activities must be reflected in the content and context of ESsI material. The creative thinking skills of high school students in creating a waste-resilient society by creating graphic designs for waste literacy and its handling are presented in Fig. 10.

(a) Poor waste management. (b) Communal waste management.

Fig. 10. Waste handling literacy.

Figure 10 shows explain the impact of poor waste management on life activities that need to be addressed and activities that should not be imitated. This provides awareness and opportunities for students to think about finding solutions to overcome these problems. Hierarchy of waste management from the smallest things to the bigger impacts so that waste problems can be resolved effectively. Communal waste processing from various related parties who have their respective responsibilities to regional or larger scale waste management policies.

E-learning design on literacy about waste problems and how to handle them. Students' thinking opportunities are explored through analysis of problems and alternative solutions and evaluation of activities that hurt the environment. Next, students can create work that can provide practical solutions. This activity shows the optimal performance indicators of students' creative thinking skills with the willingness and ability to think after using ESsI e-learning.

4.3. ESsI E-Learning Product Development

The development of the ESsI e-learning product is to ensure that the effectiveness of ESsI e-learning in developing students' creative thinking skills is based on trials carried out at SMA B. Previously, product validation was carried out to find out whether the product being developed was suitable for testing. To test the effectiveness of using the t-test, the differences in the results of the creative thinking skills of experimental and control group students were previously carried out, namely the normality test and homogeneity test.

The ESsI e-learning validation results have 13 assessment aspects. Validation of the product design used 7 experts consisting of 2 learning model experts, 2 ESsI e-learning module and media experts, 2 evaluation tool experts, and 1 cultural expert and educational practitioner. ESsI e-learning media as a product being developed. ESsI e-learning validation results using validation score scale 4 are presented in Table 6.

Table 6. ESsI e-learning validation results by experts.

No.	Assessment Aspects	Score
1	Breadth of e-learning materials	4.0
2	Concept truth	4.0
3	Students are creative in confronting problems	3.5
4	Students are creative in observing problems	4.0
5	Students are creative in integrating and reconstructing concepts	3.5
6	Students are creative in explaining data	3.5
7	Students are creative in applying concepts in life	3.5
8	Responsive to the rich culture, traditions and local potential of the region.	3.5
9	Relevance of assessment tools	3.5
10	Up to date references based on 21st century learning	4.0
11	Using the socioscientific issues (SSI) strategy	3.0
12	Material can foster students' creative thinking skills	4.0
13	Material related to environmental activities	4.0
	Sum (∑)	48.0

Table 6 shows the average validation score of 48.0 very good categories. Expert repair suggestions, namely; (i) The media used needs to be refined in terms of ethnoscience content and social issues, made detailed on each social issue that explains scientific concepts; (ii) The material is adapted to the objectives of science learning, applied material needs to be removed because it will make it difficult for students to learn, student activities need to be considered again the level of difficulty considering online learning; iii) Students' creativity in carrying out learning activities is good, only the narration of each step is lacking in more detail to make it easier for students, and (iv) indicators of science learning objectives use the audience, behaviour, condition, and degree (ABCD) principle in more effective operational sentences.

The product validation process is suitable for testing. Implementation of ESsI e-learning in the experimental group with waste literacy used as a learning resource to be able to reconstruct science. The data obtained from the results of research trials are the implementation of ESsI e-learning at each meeting, the results of students' achievement of creative thinking skills through pre-test and post-test data, as well as the results of student and teacher responses after using ESsI e-learning (see in Table 7).

Table 7. Science learning implementation assessment results.

Implementation of learning	**Sum**	**Score activity**			
		1	**2**	**3**	**4**
Opening activity	1.0	1.0	1.0	1.0	1.0
Core activities	17.0	15.0	15.0	16.0	17.0
Closing activity	1 .0	1.0	1.0	1.0	1.0
Sum	19.0	17.0	17.0	18.0	19.0
Average			17.8		
Percentage			17: 19 × 100% = 93%		

Table 7 shows that the implementation of learning in research trials is observed by providing assessments on the observation sheet. The learning implementation assessment sheet is the syntax of the inquiry model with the assessment results. The implementation of science and science learning has increased at each meeting, namely 93% carried out very well. Input and suggestions are used as evaluation material for further research trials so that the results are maximum.

Furthermore, the average creative thinking skills of experimental group students was 78.6 with learning completeness 62% or 23.0 out of 37.0 (as shown in in Fig. 11). Achievement of creative thinking skills is based on pre-test and post-test on each indicator of fluency, flexibility, originality, elaboration, and redefinition. The average percentage to determine the achievement of creative thinking skills for each indicator. Figure 11 shows that the pre-test and post-test data have increased in each indicator of creative thinking skills for the experimental group.

Fig. 11. Data on creative thinking achievement of experimental group.

Furthermore, group pre-test data before learning took place using conventional e-learning. Achievement of students' creative thinking skills using post-test scores after carrying out science learning that does not use ESsI (conventional) e-learning. Next, the achievement of creative thinking skills of control group students. The average creative thinking skill is 70.9 with learning completeness of 54%. The average percentage of determination of achievement in Fig. 12.

Fig. 12. Achievement of creative thinking for control group.

Figure 12 shows that details of pre-test data on achievement of creative thinking skills for each indicator. pre-test before learning using ESsI e-learning with creative thinking skills achievement of 65.2, then post-test data in the form of students' creative thinking skills scores after learning that did not use ESsI (conventional) e-learning. the data on the achievement of creative thinking skills of control group students experienced an increase before and after conventional learning, although slightly.

Testing the research hypothesis with analysis prerequisite tests consisting of the normality test with Shapiro-Wilk and the homogeneity test with Levene's test of equality of error variances. The results of the normality analysis prerequisite tests are presented in Table 8.

Table 8. Experimental group data normality test.

Group	Kolmogorov-Smirnov			Shapiro-Wilk		
	statistic	df	Sig.	Statistic	df	Sig.
Pre-test	0.085	37.000	0.117*	0.880	37.000	0.074
Post-test	0.137	37.000	0.129	0.945	37.000	0.074

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 8 normality test results are sig or p-value for all residues > 0.05, so all residual normality tests use the Lilliefors test to accept H0 which means normal distribution. Pre-test and post-test data, the results of the entire group (0.074) are normally distributed because the p-value (sig) of the Lilliefors test is > 0.05 or accepts H0. so that the hypothesis testing analysis can be continued using the t-test.

This means that the data can be used as a research sample that represents the population. Next is the normality test for the control class as a comparison for the population group as a parametric statistical requirement.

The prerequisite test for control group analysis is based on post-test data consisting of a normality test with one-Shapiro-Wilk and a homogeneity test with Levene's test of equality of error variances. The prerequisite test results for the control group normality analysis are presented in Table 9.

Table 9. Control group data normality test.

Group	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	0.076	35.000	0.103*	0.870	35.000	0.061
Post-test	0.101	35.000	0.112	0.957	35.000	0.061

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 9 shows that normality test results are sig or p-value for all residues > 0.05, so all residual normality tests use the Lilliefors test to accept H0 which means normal distribution. Based on Table 9 which shows pre-test and post-test data, the results of the entire group (0.061) are normally distributed because the p-value (sig) of the Lilliefors test is > 0.05 or accepts H0. so that the hypothesis testing analysis can be continued using the t-test. This means that the data can be used as a research sample that represents the population.

The results of the pre-test and post-test homogeneity test for experimental group students with a significance level of 5% using Levene's test are presented in Table 10. The homogeneity test results show a sig or p-value > 0.05 (1.121 and 0.956), so H0 is accepted which means the sample data has a homogeneous variant.

Table 10. Experimental group homogeneity test.

Levene's test of equality of error variances		Levene statistic	df1	df2	Sig.
Pre-test	Based on mean	1.121	1.000	74.000	51.000
	Based on median	0.694	1.000	74.000	0.408
	Based on median and with adjusted df	0.694	1.000	79.263	0.408
	Based on trimmed mean	0.432	1.000	74.000	0.315
Post-test	Based on mean	0.956	1.000	74.000	0.407
	Based on median	0.251	1.000	74.000	0.729
	Based on median and with adjusted df	0.251	1.000	82.072	0.729
	Based on trimmed mean	1.121	1.000	74.000	534.000

In the homogeneity test, the control group only used ethnoscience learning without ESsI e-learning. The control class consisted of 35 students who carried out the post-test. The answer results are presented in Table 11 the homogeneity test results show that the sig or p-value is > 0.05 (0.856 and 1.117) so H0 is accepted which means the sample data is homogeneous in variance.

Table 11. Control group homogeneity test.

Levene's test of equality of error variances		Levene statistic	df1	df2	Sig.
Pre-test	Based on mean	0.856	1.000	70.000	49.000
	Based on median	0.692	1.000	70.000	0.298
	Based on median and with adjusted df	0.692	1.000	65.263	0.298
	Based on trimmed mean	0.632	1.000	70.000	0.315
Post-test	Based on mean	1.117	1.000	70.000	0.297
	Based on median	0.753	1.000	70.000	0.729
	Based on median and with adjusted df	0.753	1.000	74.042	0.729
	Based on trimmed mean	1.431	1.000	70.000	474.000

Furthermore, t-test analysis to determine the effectiveness of ESsI e-learning in empowering students' creative thinking skills in experimental classes. The effectiveness indicators are differences in post-test scores for the experimental class and the control class (as shown in Table 12).

Table 12. T-test analysis.

Paired differences	Value
Mean	7.64
Std. deviation	6.37
Std. error mean	1.15
t_{count}	3.71
Df	70.00
Sig (2 tailed)	0.00

Table 12 shows sig (2-tailed) (0.00 < 0.05) Ho is rejected and H1 is accepted, meaning that there are differences in students' creative thinking skills between the experimental and control groups. The difference in students' creative thinking skills is based on the difference in the post-test average of the experimental group and the control group (78.55-70.91= 7.64). Mean paired difference shows that the experimental group has a higher average of creative thinking skills than the control class. Therefore, the experimental class using ESsI e-learning is effective in empowering students' creative thinking skills.

4.4. Reflection on ESsI E-Learning Results

Feedback in the form of student responses to ESsI e-learning is one of the research objectives which is based on student feedback and assessment of teaching materials. A positive or negative response means that students fully accept what is used as a learning resource or even reject what is used as a reference for implementing learning with an indication of learning success if the student gives a good response. Indications of effective ESsI e-learning for experimental group students, the author presents the results of student responses obtained from the statement questionnaire method presented in Table 13.

Table 13. Student response to e-learning ESsI.

Criteria	Strongly disagree	Agree	Don't agree	Strongly disagree
Actual score	686	121	56	62
Ideal score	148	111	74	37
Percentage	74%	13%	6%	7%
Average	88%			

Table 13 shows that 88% of student responses are in the very responsive category. The research success indicators are in the very responsive category, so it can be stated that ESsI e-learning can provide positive results on students' creative thinking skills.

Respond to attractiveness and practicality to achieve goals. ESsI e-learning is a new model that is unique and fun because studying science is not just a formula but recognizing the community environment as a source of meaningful learning. Student responses in learning science while recognizing traditions and culture based on social issues. E-learning ESsI can provide a unique new nuance and motivate learning physics [53]. E-learning ESsI with explanatory activities provides more attention to the lesson because students observe directly [52]. Student responses to e-learning ESsI show the attractiveness of the model is very good.

Students feel they understand more about the concepts they are studying after linking the material to social issues in society (ethnoscience). ESsI e-learning always confronts students with complex learning problems to solve issues creatively, in line with Wallas's statement that one of the conditions for someone to be able to think creatively is to get out of their ego, out of the comfort zone (out of the box) so that students can thinking fluency, flexibility and being able to find new ideas (originality) as proof that students have been able to improve their creative thinking.

The reasons why students feel enthusiastic about ESsI e-learning are; (i) there are new things in presenting learning resources that integrate traditions, culture, and local potential of the Wonosobo area with science material; (ii) students gain new experiences and knowledge in constructing community knowledge into scientific knowledge that has never been done before; (iii) e-learning ESsI is fun and makes it easier for students to understand science concepts; (iv) ESsI e-learning can increase students' environmental and community awareness; and (v) improve students' creative thinking skills.

Learning welfare (learning for well-being) is an important aspect of student responses that determines the quality of learning. ESsI e-learning provides students with intellectual freedom in overcoming learning difficulties that do not make students stressed or damage their cognitive structure. Students develop creative thinking skills and environmentally caring attitudes for social interaction and other self-development. The concept of student wellbeing in e-learning ESsI is reflected in the usefulness of positive attitudes and care for students' lives and the environment. The nature of fanaticism towards the traditions and culture of society is increasing through investigative ethnoscience and SSI studies [63]. Learning to use ESsI e-learning is a permanent change in behaviour, knowledge, and creative thinking skills and becomes a valuable experience for students.

The achievement of students' creative thinking skills through the post-test showed an increase in students' creative thinking skills based on test results in the experimental group which was higher than in the control group. Sources of waste in the community are identified based on social issues. This ethnoscience study is used as a source of creative learning for students (see in Table 14).

Table 14. Literacy waste generation before and after government policy.

No.	Waste source	Waste generation before restrictions (ton/day)	Waste generation after restrictions (ton/day)
1	Adiwiyata school	0.184	0.137
2	Non adiwiyata school	1.069	0.471
3	College	0.160	0.097
4	Islamic boarding school	1.438	0.670
5	Office	0.848	0.415
6	Market	6.772	3.239
7	Health service	0.208	0.108
8	Swalayan	0.212	0.088
9	Market mini	0.229	0.119
10	Hotel	0.159	0.104
11	Restaurant	0.564	0.338
12	Correctional institutions	0.718	0.400
13	Bus terminal	0.078	0.044
14	Prayer place	0.870	0.381
15	Tourist place	0.351	0.204
16	City park	0.030	0.013

Table 14 shows that fact occurs because the science concepts studied in ethnoscience-based teaching materials, students feel new and unique and can be understood because learning is contextual. [54]. Apart from that, student literacy and waste handling analysis also carried out an analysis of waste generation in Wonosobo regency before and after the waste handling policy.

Learning activities that present facts will be more meaningful, where students can immediately think about real things and how to find alternative solutions for handling waste which greatly disrupts the ecosystem and pollutes the surrounding water. The ethnoscience approach provides students with the opportunity to learn about the culture and unique conditions of an area in Wonosobo regency, one of which can be a pioneer for the community to participate in government programs to overcome waste problems.

Teacher responses as responses from ESsI e-learning users are needed to assess its practicality so that the results of the analysis of teacher responses are modelled as a product evaluation to improve and can be used at the next research stage. Based on the teacher response questionnaire, the percentage of ESsI e-learning responses is presented in Fig. 13.

Figure 13 teachers provide several additional opinions and suggestions regarding ESsI e-learning. Teacher responses to the implementation of ESsI e-learning showed an average of 84.3%. The response results show that the practical success indicator of ESsI e-learning is more than or equal to 75%. Based on teacher responses with the highest percentage of answers on the indicator "the use of ESsI e-learning has changed students' perceptions". Phenomena related to local wisdom as knowledge that can be explained scientifically contribute to improving creative thinking skills. The response with the lowest percentage was on the indicator "the implementation of e-learning ESsI must provide more time than the time planned in learning planning".

Fig. 13. Results of teacher responses to ESsI e-learning.

The teacher's response to the implementation of e-learning ESsI had a positive influence on increasing mastery of science and science concepts and creative thinking skills for high school students. The three teachers gave positive responses to the planning, content, and presentation of ESsI e-learning. ESsI e-learning has presented clear learning objectives covering core competency standards. Questions and assignments before students start learning are used to improve creative thinking skills and mastery of concepts. The teacher provided several additional opinions and suggestions regarding ESsI e-learning. Teacher suggestions generally concern technical implementation issues in the classroom and can be used to improve ESsI e-learning.

Students' creative thinking achievements based on test questions and questionnaires have increased after using ESsI e-learning. The results show that environmental learning resources using an ethnoscience approach can accommodate students' creative thinking habits. The indicator of formulating ideas in solving problems is part of creative thinking skills for analysing scientific phenomena through ethnoscience studies developed in science and science learning [54]. Controversial issues are an important factor in designing ideas to find solutions to the problems they experience so that students' creative thinking and positive attitudes toward the environment can be improved. Creative ideas emerge through the learning discovery process which allows students to explore sources of information. Strategic sources of information on environmental issues make learning more meaningful and contextual. Ethnoscience as a learning nuance provides students with the knowledge and character to appreciate regional culture.

ESsI e-learning characteristics focus on developing students' creative thinking skills through inquiry learning settings. Students are given information about ethnoscience in class, so they will better understand its potential, traditions, and culture [38-40]. Ethnoscience is used in the classroom as an applicable and independent learning resource. Student activities train students' creative thinking abilities.

E-Learning ESsI can develop the performance of creative thinking skills as shown by the differences in students' creative thinking skills between the experimental class and the control class based on t-test analysis. The use of ethnoscience can foster students' creative thinking skills regarding the surrounding environment and can train students' independence in learning [40]. Ethnoscience-based teaching materials can provide good feedback or responses to students' work.

Learning success can be identified from students' creative thinking skills in connecting with other friends through presenting and presenting theories appropriately and systematically, conveying ideas clearly and easily to achieve learning goals. Linking science problems with ethnoscience provides information to be used for students' creative ideas. If a student's ability to analyse, evaluate, and create is good, it means that the student has understood the content or concept being studied. Logically, students will not be able to communicate if they don't know what to say.

There is a positive response as an indicator of motivation that is explored through the teaching materials presented by providing ethnoscience information, and scientific problems that utilize ethnoscience. Activities provide attention, interest, and concern for students to find solutions in learning science concepts. An important component in learning is motivation in the form of students' psychological encouragement which can change the situation for the better.

Science learning has long-term hope for students' survival when they utilize all the local and ethnoscientific potential they have and then utilize it optimally [51]. Ethnoscience-based learning is the process of forming and designing a learning environment with traditional and cultural nuances. The research results confirm that the way to improve creative thinking skills using an inquiry learning approach is by the characteristics of 21st-century education.

The role of ethnoscience in reconstructing because contextual learning gives students an understanding of science and can be implemented in real life. Integration of students with the environment can be realized if learning is oriented towards the surrounding environment being studied in a meaningful way. So that students can establish reciprocal relationships with the surrounding environment, students can recognize and understand the local potential of their region, regional environmental sustainability becomes an important factor in learning with ethnoscience. Characteristics of the ethnoscience approach in construction as a form of strategy and design of learning experiences by creating a cultural and traditional environment that is integrated into the learning process [46]. The results of human creativity and initiative are developed as original knowledge and can be transformed into formal science. The term ethnoscience can be studied in terms of traditional ecological knowledge, Indigenous Science, local culture, and local wisdom.

ESsI e-learning with the material "waste and its handling" provides students with the opportunity to have an applicable and meaningful understanding of concepts, as well as being able to foster students' creative thinking skills. Habits and needs for environmental learning resources with traditional and cultural nuances to equip students to face the future. The relevance of ethnoscience learning to the real world encourages the formation of practical applications in science and science learning [47]. Vocational science learning includes knowledge and positive attitudes about local ethnoscience so that students can learn effectively and develop thinking skills according to ethnoscience studies [5].

Future education through ethnoscience learning approaches provides opportunities for students to think creatively in scientific reconstruction activities regarding waste materials and their handling. Future education with meaningful learning can give students hope that lifelong learning will provide meaning in life and enable them to find solutions to global problems.

5. Conclusion

The development of ESsI e-learning meets the criteria of being valid, practical, and effective in empowering creative thinking skills. ESsI e-learning through science reconstruction activities that prioritize technological literacy without abandoning regional culture as a characteristic of 21st-century learning can be fulfilled. The response of students and teachers was good in the implementation of ESsI e-learning which shows the practicality and ease of the product. Based on the t-test, there are differences in the results of the creative thinking skills of experimental and control group students. ESsI e-learning is effective in empowering creative thinking skills. Fulfilment of creative thinking skills through meaningful learning activities in recognizing local traditions, culture, and potential. Opportunities for scientific thinking in exploring scientific issues developing in society in the reconstruction of "waste and its handling" material. The impact of the research is that a teacher must be able to prepare e-learning-based ethnoscience learning resources and media to provide opportunities for creative thinking. Science learning using ESsI e-learning makes learning meaningful and contextual. The impact of research in the form of innovative ESsI e-learning can provide opportunities for students to think creatively, making learning meaningful without abandoning culture. Apart from that, e-learning-based learning answers the challenges of globalization and cares for the traditions and culture of the environment around students.

Acknowledgement

Thank are due to the Ministry of Research, Technology and Higher Education for regular fundamental research (PFR) which has funded this research with contract number 026/LL6/PB/AL.04/2024.

References

1. Al Husaeni, D.F.; Al Husaeni, D.N.; Nandiyanto, A.B.D.; Rokhman, M.; Chalim, S.; Chano, J.; Al Obaidi, A.S.M.; and Roestamy, M. (2024). How technology can change educational research? Definition, factors for improving quality of education and computational bibliometric analysis. *ASEAN Journal of Science and Engineering*, 4(2), 127-166.
2. Nandiyanto, A.B.D.; Al Husaeni, D.N.; Al Husaeni, D.F.; Hamidah, I.; Maftuh, B.; and Solehuddin, M. (2023). Is Universitas Pendidikan Indonesia ready for internationalization? A bibliometric analysis in the science and technology-related publications. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 32(2), 14-29.

3. Lin, H.C.; Hwang, G.J.; Chang, S.C.; and Hsu, Y.D. (2021). Facilitating critical thinking in decision making-based professional training: An online interactive peer-review approach in a flipped learning context. *Computers and Education*, 173(6), 104-266.
4. Gill, R. (2020). Through online internships and projects during the covid-19 pandemic: An australian example. *Journal of Teaching and Learning for Graduate Employability*, 11(1), 146-158.
5. Sangsawang, T. (2020). An instructional design for online learning in vocational education according to a self-regulated learning framework for problem solving during the covid-19 crisis. *Indonesian Journal of Science and Technology*, 5(2), 283-198.
6. Setiasih, O.; Setiawardani, W.; Najmul Hidayat, A.; Djoehaeni, H.; Robayanti, D.; Malik Ibrohim, M.; and Sholeh, M. (2024). Development of a design learning management system (LMS) to improve student skills: Case study in a science learning media development course. *Journal of Engineering Science and Technology* (*JESTEC*), 19(4), 1389-1400.
7. Wiyanarti, E.; Holilah, M.; Zahra, F.T.; and Dahalan, C.S. (2024). Development of an e-module based on local wisdom ethnoastronomy in the digital era to strengthen the pedagogical competence of social studies teachers. *Journal of Engineering Science and Technology* (*JESTEC*), 19(4), 1280-1301.
8. Soeteja, S.Z.; Kurnia, J.G.; and Setiawan, Y. (2024). Design of web-based digital module for improving student understanding and skills in graphic design lessons in vocational school. *Journal of Engineering Science and Technology* (*JESTEC*), 19(4), 1535-1569.
9. Juhanaini, J.; Rizqita, J.A.; Bela, R.W.A.TM.; Suherman, Y.; Ratnengsih, E.; and Ratmaningsih, N. (2024). Game based learning media on system of units' material based on assessment analysis results for children with mathematics learning difficulties. *Journal of Engineering Science and Technology* (*JESTEC*), 19(4), 1302-1328.
10. Kertiasih, E. L. (2018). Implementation of e-UKBM-assisted wenning inquiry learning to improve students' scientific skills. *Journal of Education Action Research*, 2(4), 363-374.
11. Maulia, E.; Hakim, R.; Bentri, A.; and Darmansyah, D. (2024). Development of an e-module based on a guided inquiry learning model in natural science subjects in elementary schools. *Jurnal Penelitian Pendidikan IPA*, 10(4), 1551-1555.
12. Vemmi, R.R.; Dewi, K.; Muslimat, A.; and Yuangga, K.D. (2021). E-learning as education media innovation in the industrial revolution and education 4.0 era. *Journal of Contemporary Issues in Business and Government*, 27(1), 2868-2881.
13. Cerdá, M.J.F.; and Sellens, T. (2020). Socio-technical e-learning innovation and ways of learning in the ICT-space-time continuum to improve the employability skills of adults. *Computers in Human,* 7(14), 176-191.
14. Yulkifli, Y.; Yohandri, Y.; and Azis, H. (2022). Development of physics e-module based on integrated project-based learning model with ethno-STEM approach on smartphones for senior high school students. *Momentum: Physics Education Journal*, 6(1), 93-103.

15. Tsai, C. Y. (2018). The effect of online argumentation of socio-scientific issues on students' scientific competencies and sustainability attitudes. *Computers and Education,* 116(1), 14-27.
16. Mativo, J.M.; Hill, R.B.; and Godfrey, P.W. (2014). Effects of human factors in engineering and design for teaching mathematics: a comparison study of online and face-to-face at a technical college. *Journal of STEM Education*, 14(4), 36-44.
17. Adeniran, T.A.; and Onasanya, S.A. (2024). Impact of e-learning on college of education lecturers' knowledge of quantitative data analysis in SPSS. *Indonesian Journal of Educational Research and Technology*, 4(2), 121-128.
18. Savytri, A.; and Ratri, D. (2023). A comprehensive design guide to adaptive e-learning system based on VARK learning styles. *Indonesian Journal of Multidiciplinary Research*, 3(2), 453-464.
19. Llupar, M.L.; Malones, L.J.L.; Sombria, A.J.F.; and Calixtro, V.L. (2022). Development of folk-dance videos for e-learning. *Indonesian Journal of Teaching in Science*, 2(1), 1-6.
20. Estrellan, A.; Ferrariz, K.J.; Lazona, P.A.; Madres, V.E.; and Estrellan, J.C. (2021). E-learning amidst the pandemic: Teachers' perspective in the Philippines. *ASEAN Journal of Science and Engineering Education,* 1(2), 93-96.
21. Nafsi, N.R.R.; and Maryanti, M. (2022). Analysis of teacher skills in e-learning content development during distance learning during the covid-19 pandemic. *ASEAN Journal for Science Education*, 1(1), 23-32.
22. Zulkifli, H.; and Hashim, R. (2019). The development of questioning skills through & local wisdom pedagogy. *Creative Education*, 10(12), 2593-2605.
23. Kashyap, U.; and Mathew, S. (2017). Corequisite model: An effective strategy for remediation in freshmen level quantitative reasoning course. *Journal of STEM Education: Innovations and Research*, 18(2), 23-29.
24. Armandita, P.; Wijayanto, E.; Rofiatus, L.; and Susanti, A. (2017). Analisis kemampuan berpikir kreatif pembelajaran fisika di kelas X MIA 3 SMA Negeri 11 kota Jambi. *Penelitian Ilmu Pendidikan*, 10(2). 12-18.
25. Davies, D.; Snape, J.D.; Collier, C.; Digby, R.; Hay, P.; and Howe, A. (2013). Creative learning environments in education a systematic literature review. *Thinking Skills and Creativity*, 8(1), 80-91.
26. Khoiri, A.; and Sunarno, W. (2019). How is students' creative thinking skills? An ethnoscience learning implementation. *Spektra*, 8(10), 153-163.
27. Parmin.; Sajidan.; Ashadi.; Sutikno.; and Fibriana, F. (2017). Science integrated learning model to enhance the scientific work independence of student teacher in indigenous knowledge transformation. *Jurnal Pendidikan IPA Indonesia*, 6(2), 365-372.
28. Anjarwati, P.G.P.; Sajidan, S.; and Prayitno, B.A. (2018). Problem-based learning module of environmental changes to enhance students' creative thinking skill. *Biosaintifika: Journal of Biology & Biology Education*, 10(2), 313-319.
29. Sumarni, W.; and Kadarwati, S. (2020). Ethno-STEM project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, 9(1), 11-21.

30. Şener, N.; Türk, C.; and Taş, E. (2015). Improving science attitude and creative thinking through science education project: A design, implementation and assessment. *Journal of Education and Training Studies*, 3(4), 57-67.
31. Malik, A.; Nuraeni, Y.; Samsudin, A.; and Sutarno, S. (2019). Creative thinking skills of students on harmonic vibration using model student facilitator and explaining (SFAE). *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 8(1), 77-88.
32. Khoiri, A.; Affandi, A.; Sedon, M.F.; Ahmad, C.N.C.; Agussuryani, Q.; and Ni'mah, A.M.B. (2023). The contribution of the ILESSI-DCF model to promote creative thinking skills of madrasah aliyah (MA) students. *Momentum: Physics Education Journal*, 7(1), 79-83.
33. Satriawan, M.; Liliasari, L.; Setiawan, W.; Abdullah, A. G.; and Rosmiati, R. (2021). A contextual semi assisted project-based learning (SA-PjBL) about ocean wave energy: Creative thinking of pre-service physics teachers. *Momentum: Physics Education Journal*, 5(2), 132-141.
34. Hooijdonk, V.M.; Mainhard, T.; Kroesbergen, E.H.; and Tartwijk, V.J. (2020). Creative problem solving in primary education: Exploring the role of fact finding, problem finding, and solution finding across tasks. *Thinking Skills and Creativity*, 37(5), 1-10.
35. Okwara, O.K.; and Upu, F.T. (2017). Effect of ethnoscience instructional approach on students' achievement and interest in upper basic science and technology in benue State Nigeria. *International Journal of Scientific Research in Education*, 10(1), 69-78.
36. Parmin, P.; and Fibriana, F. (2019). Prospective teachers' scientific literacy through ethnoscience learning integrated with the indigenous knowledge of people in the frontier, outermost, and least developed regions. *Jurnal Penelitian dan Pembelajaran IPA*, 5(2), 142.
37. Kembara, M. D.; Hanny, R.; Gantina, N.; Kusumawati, I.; Budimansyah, D.; Sunarsi, D.; and Khoiri, A. (2020). Scientific literacy profile of student teachers on science for all context. *Solid State Technology*, 63(6), 5844-5856.
38. Khoiri, A. (2016). Local wisdom to grow students soft skills (study cash: Development RKH on science learning). *Indonesian Journal of Early Childhood Education Studies*, 5(1), 14-17.
39. Amelia, T.; Jumini, S.; and Khoiri, A. (2021). Analysis of creativity and attitudes caring the environment of junior high school students: study of environmental physics learning using learning modules. *Jurnal Pendidikan Fisika Indonesia*, 17(1), 40-48.
40. Khoiri, A.; Sukarelawan; M.I.; Fauzi Sedon, M.; Ahmad, N.C.C.; Sukarmin, S.; Agussuryani, Q.; and Misbah, M. (2022). Socioscientific issues (SSI) strategy adjacent to ethnoscience: a critical analysis of science reconstruction. *Jurnal Penelitian Pendidikan IPA*, 8(5), 2380-2386.
41. Agussuryani, Q.; Sumarni, W.; Subali, B.; and Saptono, S. (2020). Implementation of stem integrated ethnoscience-based vocational science learning in fostering students' higher order thinking skills (HOTs). *International Journal of Active Learning*, 5(2), 53-61.
42. Fitria, M. (2018). The development of ethnoscience-based chemical enrichment book as a science literacy sorce of students. *IJCER*, 2(1), 154-167.

43. Khoiri, A.; Syifa, A.; and Mubin, N. (2018). Potential local physics based learning of Jepara district to improve science process skills and students entrepreneurship. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 8(1). 71-83.
44. Firdaus, F.; Khoiri, A.; Adi, N. P.; Al Adib, M. N.; Ariyani, M.; and Trisnowati, E. (2023). 21st century digital skills: Communication, creativity, collaboration, critical thinking in pre-service physics teacher. *SPEKTRA: Jurnal Kajian Pendidikan Sains*, 9(1), 112-123.
45. Sukawi, Z.; Khoiri, A.; Haryanto, S.; and Sunarsi, D. (2021). Psychoanalytic conceptual framework: A critical review of creativity in modeling inquiry training. *Jurnal Konseling Dan Pendidikan*, 9(1), 28-35.
46. Barry. (2016). Beverage engineers: Creative international STEM project. *International Journal of Humanities and Social Sciences*, 8(4), 18-28.
47. Khoiri, A.; Sunarno, W.; Sajidan, S.; and Sukarmin, S. (2021). Analysing students' environmental awareness profile using strategic environmental assessment. *F1000Research*, 305(10), 1-27.
48. Zeidler, D.L.; Sadler, T.D.; Applebaum, S.; and Callahan, B. E. (2009). Advancing reflective judgment through socioscientific issues. *Journal of Research in Science Teaching*, 46(1), 74-101.
49. Becker, K.; and Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students learning: A preliminary meta-analysis. *Journal of STEM Education*, 12(5), 132-147.
50. Sudarmin, S.; Mastur, Z.; and Parmin, P. (2014). Reconstructing scientific science knowledge. *Jurnal Penelitian Pendidikan*, 31(2), 55-62.
51. Khoiri, A.; Sunarno, W.; Sajidan, S.; and Sukarmin, S. (2020). Development of strategic environmental assessment (SEA) in science learning. *International Journal of Advanced Science and Technology*, 29(7), 3771-3782.
52. Rahayu, G.; Khoiri, A.; and Firdaus, F. (2022). Integrasi budaya lokal (Bundengan) pada pembelajaran gelombang dan bunyi untuk meningkatkan sikap cinta tanah air dan literasi sains siswa. *Jurnal Ilmiah Pendidikan Fisika*, 6(1), 117-125.
53. Khoiri, A.; and Sunarno, W. (2018). Ethnoscience approach in a philosophical review. *SPEKTRA: Jurnal Kajian Pendidikan Sains*, 4(2), 145.
54. Schröder, T. (2019). A regional approach for the development of TVET systems in the light of the 4th industrial revolution: the regional association of vocational and technical education in Asia. *International Journal of Training Research*, 17(1), 83-95.
55. Peters, M. A.; and Jandrić, P. (2017). Dewey's democracy and education in the age of digital reason: the global, ecological and digital turns. *Open Review of Educational Research*, 4(1), 205-218.
56. Alreemy, Z.; Chang, V.; Walters, R.; and Wills, G. (2016). Critical success factors (CSFs) for information technology governance (ITG). *International Journal of Information Management*, 36(6), 907-916.
57. Cataluña, R.F.J.; Gaitán, A.J.; and Correa, R.P.E. (2015). A comparison of the different versions of popular technology acceptance models a non-linear perspective. *Kybernetes*, 44(5), 788-805.

58. Parmin, P.; Nuangchalerm, P.; and Islami, R.A.Z. (2019). Exploring the indigenous knowledge of java north coast community (Pantura) using the science integrated learning (SIL) model for science content development. *Journal for the Education of Gifted Young Scientists*, 7(1), 71-83.
59. Murniawaty, I. (2019). An assessment of environmental awarness: The role of ethic education. *JSSH (Jurnal Sains Sosial Dan Humaniora)*, 2(2), 225-234.
60. Duda, A.; Korga, S.; and Gnapowski, S. (2014). The role of e-learning in educational processes. *Advances in Science and Technology Research Journal*, 8(1), 61-65.
61. Ariesta, F.W. (2019). Effectiveness of e-learning media to improve learning outcomes natural science in primary schools. *Journal of Education Research and Evaluation*, 3(2), 88-97.
62. Patel, C.S.; Library, A.; Maneklal, S.; and Pustakalay, J. (2016). E-learning: concept, features and it's types. *Science International Journal of Research in Humanities & Soc. Sciences*, 4(1), 57-60.
63. Freddy, A. W.; and Olifia, R. (2019). The effectiveness of e-learning media to improve natural science learning outcomes in elementary school. *Journal of Education Research and Evaluation*, 3(2), 88-94.
64. Fiandini, M.; Nandiyanto, A.B.D.; Al Husaeni, D.F.; Al Husaeni, D.N.; and Mushiban, M. (2024). How to calculate statistics for significant difference test using SPSS: Understanding students' comprehension on the concept of STEAM engines as power plant. *Indonesian Journal of Science and Technology*, 9(1), 45-108.