IJIS Edu : Indonesian J. Integr. Sci. Education, 7 (2) 2025

Volume 7 Issue 2 , July 2025
P-ISSN: 2655-2388, E-ISSN: 2655-2450

Development of STEM-Oriented E-Module Integrated EDP Pattern SSI on Excretory System Material to Train Creative Thinking Skills of Junior High School

Sabillatush Oktaviani[1]*, Erti Hamimi[2]

[12] *Universitas Negeri Malang, Indonesia.*
Corresponding E-mail:[1]*sabillatush.oktaviani.1903516@students.um.ac.id, erti.hamimi.fmipa@um.ac.id*

Abstract: The rapid deevelopment of the 21st century is characterized by technological advances and increasingly complex problems, requiring students' creative thinking skills. E-modules using a STEM approach in the EDP pattern, integrated with SSI, can help train students' creative thinking. This research aims to produce a valid and practical e-module with a STEM-based EDP pattern integrated with SSI, and to test its effectiveness in encouraging students' creative thinking skills on excretory system material. Development followed the ADDIE model, which includes five stages: analysis, design, development, implementation, and evaluation. Qualitative data were collected through teacher interviews, suggestions, and questionnaire comments. Quantitative data came from validator, teacher, and student scores, as well as pretest and posttest results. Data analysis used validity and reliability tests, normality, homogeneity, t-tests, and N-Gain tests. Media and material validation results were 94.67% and 96.45%, respectively. Teacher and student practicality results were 91.67% and 93.03%, respectively. The N-Gain test showed a comparison of effectiveness with low criteria in the control class and medium in the experimental class. It can be concluded that the developed e-module is valid, practical, and effective in training creative thinking skills.

Keywords: Crative Thinking, STEM, SSI

How to cite this article :

Oktaviani, S., & Hamimi, E. (2025). Development of STEM-Oriented E-Module Integrated EDP Pattern SSI on Excretory System Material to Train Creative Thinking Skills of Junior High School. *IJIS Edu : Indonesian Journal of Integrated Science Education, 7*(2). doi:http://dx.doi.org/10.29300/ijisedu.v7i2.4811

1. Introduction

The 21st century is marked by rapid technological development and increasingly complex problems, demanding students to possess creative thinking skills (Haryanti & Saputra, 2019). Torrance in Widodo (2021) states that creativity is the process of identifying problems, formulating ideas, testing and modifying ideas, and communicating the results. However, the results of the Trends in International Mathematics and Science Study (TIMSS) in 2015 show that Indonesian students' scientific thinking skills are still low, with only 6% of students able to solve questions in the high category (Martin & Mullis, 2015). Furthermore, the results of the Global Creativity Index in 2017 ranked Indonesia 87th out of 132 countries with a score of 30.10, indicating it is still within the low indicators compared to other countries (Duwi Meidha Sari et al., 2020). Other research also reveals that students' creative thinking skills are still relatively low, with an achievement percentage of indicators less than 50% (Kartina et al., 2021; Kurnia, 2021; Meika & Sujana, 2017). One of the reasons is that the learning process is still teacher-centered and has not actively involved students in problem-solving (Fahmi et al., 2021).

As an effort to address the challenges of the 21st century and the 4.0 industrial revolution, the government is implementing the Merdeka Curriculum, which emphasizes essential and flexible learning, and gives teachers the freedom to choose or develop teaching materials according to the needs of the students (Kemdikbud, 2022)This curriculum allows for deeper and more meaningful learning, but in practice, the facilities and appropriate teaching materials are still limited (Angga et al., 2022). One form of teaching material that has the potential to be developed is the e-module.

The e-module is a self-directed digital teaching material that contains texts, images, and may include videos, thereby enhancing student understanding and encouraging better interaction in learning (Imansari & Sunaryantiningsih, 2017). Compared to other teaching materials, the e-module is systematically designed and uses language adapted to students' abilities, promoting self-directed learning without constraints of time and place (Laili et al., 2019). The e-module can also be collaborated with innovative learning models such as the STEM (Science, Technology, Engineering, and Mathematics) approach, which encourages active student involvement in the learning process (Almuharomah et al., 2019; Nessa et al., 2017).

One of the key characteristics of the STEM approach is engineering design, which can be realized through the Engineering Design Process (EDP) model. This model emphasizes decision-making, analysis, and the application of STEM principles to solve problems (Mangold & Robinson, 2013). EDP has six stages: defining the problem, studying the problem, planning the solution, trying the solution, testing the solution, and evaluating whether the solution is good enough (Douglas et al., 2016). Furthermore, STEM EDP is iterative, open to various solutions, and stimulates contextual thinking in the fields of science, technology, and mathematics (Sutia & Mahdalena, 2017). This approach can also train students' creative thinking skills through exploration and solving real problems around them (Sukmawijaya et al., 2019).

Problem-based learning for students can also be implemented through the Socio Scientific Issues (SSI) approach. SSI makes science learning more meaningful as it

Online ISSN 2655-2450 | Print ISSN 2655-2388

connects science with social issues in real life (Karisan & Zeidler, 2016). Zeidler (2019) state that this approach can enhance students' ability to consider various problem-solving possibilities. The learning stimulus in the form of SSI also develops intellectual abilities, ethics, and an understanding of the relationship between science and social life (Imaduddin & Khafidin, 2018).

In the science subject of junior high school, one of the quite abstract and theoretical materials is the excretory system, as it relates to physiological processes in the body that are difficult to understand through textbooks (Saragih, Lisca Eirene., & Tarigan, 2016). Based on the Independent Curriculum, eighth-grade students are expected to be able to analyze the relationships between organ systems based on their functions and the disorders that occur in the digestive, circulatory, respiratory, and reproductive systems (Kemendikbudristek BSKAP, 2022). However, interviews with science teachers at SMPN 1 Pakis revealed that students' creative thinking skills are still rarely trained, and the implementation of the Independent Curriculum is still limited to seventh grade. A needs questionnaire filled out by 37 students indicated that 56.8% of students found the material on the excretory system difficult to understand, 73% are not accustomed to creatively solving real problems, and 56.8% stated the need for engaging learning materials that can be accessed digitally and support self-directed learning.

Previous research has discussed the benefits of the STEM approach in improving learning outcomes in the excretory system (Herak, 2021), the role of SSI-based modules in fostering creative thinking, although not lasting long (Pursitasari et al., 2022), and the effectiveness of EDP in enhancing problem-solving skills (Ulum et al., 2021). However, no research has yet been found that specifically develops e-modules with the integration of the STEM approach using the EDP and SSI patterns to train students' creative thinking skills, particularly on the topic of the excretory system.

Therefore, this research aims to develop an e-module based on the STEM approach with an integrated EDP pattern with SSI that is valid, practical, and effective in training the creative thinking skills of junior high school students on the topic of the excretory system. The development of this teaching material is important to provide a contextual, innovative learning experience that aligns with the needs of the implementation of the Merdeka Curriculum in the eighth grade.

2. Method

The research was conducted with a type of research and development (R&D) that aims to make certain products and assess how effective these products are (Sugiyono, 2016)In this study, a product was developed in the form of an e-module with a STEM approach to EDP patterns integrated with SSI. The research used the ADDIE model with 5 stages, namely analysis, design, development, implementation, and evaluation (Branch, 2009). A quasi experimental research design of nonequivalent control group design was used.

The analysis stage begins with a literature review and needs analysis through questionnaires to ninth-grade students and interviews with two science teachers at SMPN 1 Pakis. The aim is to identify the needs in the development of learning products.

The design stage includes the preparation of materials, the design of e-modules with the STEM EDP pattern approach using SSI, as well as learning devices in the form of teaching modules and questions. The development stage includes the creation of e-modules in the form of flipbooks based on the design, validation by media and material experts, and testing the validity and reliability of pretest and posttest questions. Data is collected through questionnaires and analyzed using percentage and qualitative descriptive techniques. The validity and reliability tests of the questions are conducted using IBM SPSS Statistic 25.

The implementation stage includes practical testing by teachers and students as well as effectiveness testing with pretest and posttest questions analyzed through normality test, homogeneity, t-test, and N-Gain using IBM SPSS Statistic 25. Practicality aims to assess the ease of use of the product, while effectiveness is measured by the achievement of goals after the use of the product. Data is analyzed quantitatively and qualitatively through questionnaires and user feedback. Evaluation is conducted at each stage of ADDIE to obtain a valid final product (Alfiriani & Hutabri, 2017). The five stages of ADDIE are depicted in Figure 1.

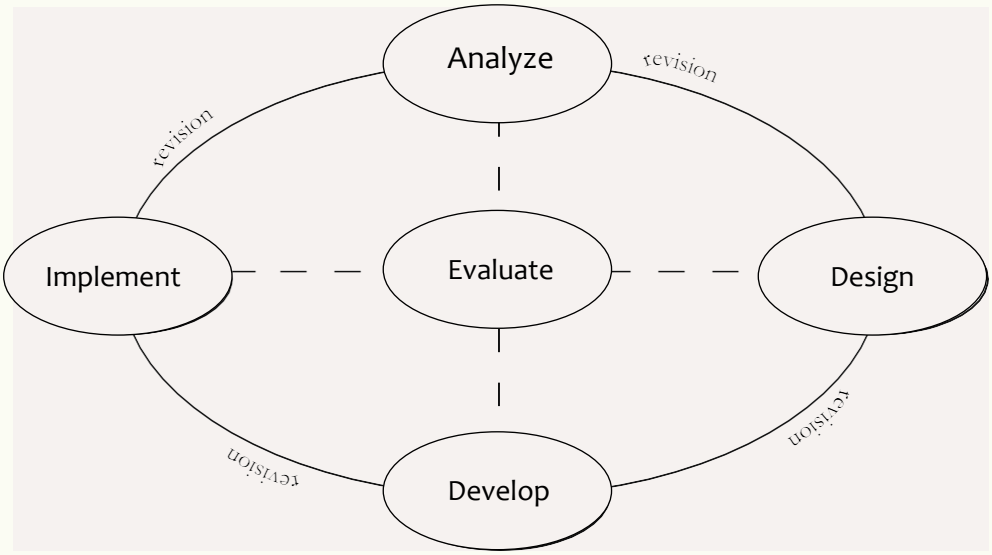

Figure 1 ADDIE Diagram
Source: (Branch, 2009)

When the e-module has gone through the validation stage by material experts and media experts, then the teacher practicality test and student practicality test are carried out on 32 students in grade VIII at SMPN 1 Pakis, then the effectiveness test to 32 students in the control class and 32 students in the experimental class at grade VIII at SMPN 1 Pakis using pretest and posttest questions. Qualitative data as well as quantitative data are listed in this study. Qualitative data comes from the results of interviews, comments, and suggestions on the media validation questionnaire, material validation, practicality test by teachers and students. While quantitative data is the result of the final score on media validation, material validation, teacher and student practicality tests according to the Likert scale score used consisting of 4 assessment criteria, where score 4 means strongly agree, score 3 means agree, score 2 means disagree, and score 1 means strongly disagree (sugiyono, 2016). Meanwhile, the material validation of the conceptual correctness aspect applies a Guttman scale

Online ISSN 2655-2450 | Print ISSN 2655-2388

based on 2 assessment criteria, where score 1 means correct and score 0 means wrong (sugiyono, 2016). The pretest and posttest questions were adjusted based on Torrance's creative thinking indicators, consisting of fluency, flexibility, originality, and elaboration (Widodo, 2021).

Data in the study were obtained through interviews, questionnaires, and questions with instruments in the form of interview guidelines, needs analysis questionnaire sheets, validation sheets, practicality test sheets, and pretest and posttest questions. Qualitative data was studied by applying qualitative descriptive analysis techniques and percentage analysis techniques to examine quantitative data obtained from validity and reliability tests, normality tests, homogeneity tests, t-tests, along with N-Gain tests. The validity of the product was analyzed using the following equation:

$$P=\frac{\sum R}{N}\times 100\%$$

Source: (Riefani, 2020)

Description:

P : the acquisition of the percentage of validity

ΣR : total score obtained

N : total maximum score

Based on the calculation of the equation above, the percentage of the validity test and practicality test results can be categorized in table 1 as follows:

Table 1 Percentage Categories

Percentage (%)	Criteria
81-100	Very valid/very practical
61-80	Valid/practical
41-60	Quite valid/moderately practical
21-40	Less valid/less practical
0-20	Not valid / not practical

Source: (Riefani, 2020)

The pretest and posttest questions play a role in the effectiveness test to assess students' creative thinking skills. The questions developed amounted to 5 items in the form of essays tailored to Bloom's taxonomy levels and four indicators of creative thinking. Essay questions are questions that have many problem-solving solutions shown to encourage the development of creative thinking skills according to the level of student ability (Tangio et al., 2018). The problem in the problem is an SSI problem. However, before the question is used, it begins with a validity and reliability test using IBM SPSS Statistic 25. In the validity test when the coefficient is more than 0.3, it is declared valid (sugiyono, 2016). Meanwhile, the reliability test is seen from the Cronbach Alpa value if it is more than 0.60, the instrument is declared reliable (Dewi & Sudaryanto, 2020).

The pretest and posttest scores were analyzed using IBM SPSS Statistic 25 in order to test normality and homogeneity as a requirement for the t-test (Hamid et al., 2019). If the significance in the Shapiro Wilk normality test exceeds the actual threshold value of 0.05, then the data is declared normally distributed (Ahadi et al., 2023). In the homogeneity test, when the significance value exceeds 5%, it means that

the data obtained has a homogeneous variation (Usmadi, 2020). In the t-test, if the significance value is lower than 5%, H0 is rejected while H1 is accepted, meaning that the two groups are significantly different. However, if the opposite happens, namely the significance value is higher than 5%, H0 is accepted while H1 is rejected, meaning that the two groups are not significantly different (Payadnya & Jayantika, 2018). The t-test hypotheses of this study are:
H0 : There is no significant difference between the two groups on students' creative thinking skills. Students' creative thinking ability
H1 : There is a significant difference between the two groups on students' creative thinking ability students' creative thinking ability

The N-Gain test is the last stage in this study to determine the level of creative thinking skills on each indicator, with the following equation:

$$\text{N} - \text{gain} = \frac{\text{postetst score} - \text{pretest score}}{\text{ideal score} - \text{pretest score}}$$

Source: (Sukarelawan et al., 2024)

Based on the calculated results of the above equation, the magnitude of the N-Gain test results can be categorized based on the following table 2:

Table 2. N-Gain Categories

Score	Criteria
0.70 ≤ g ≤ 100	High
0.30 ≤ g ≤ 0.70	Medium
0.00 ≤ g ≤ 0.30	Low
g = 0.00	No Increase
-1.0 ≤ g < 0.00	Decrease

Source: (Sukarelawan et al., 2024)

3. Result and Discussion

The condition of the research location and analysis of the needs for e-modules

This study develops an e-module with a STEM approach integrated with EDP patterns and SSI on the topic of the excretory system to enhance the creative thinking abilities of junior high school students. Interviews with two science teachers at SMPN 1 Pakis revealed that students' creative thinking skills are rarely practiced and are considered low. This aligns with Kartina (2021), who stated that the low level of creative thinking is due to learning still being centered on the teacher. Furthermore, the new Merdeka Curriculum faces challenges due to limited learning resources that train student creativity (Angga et al., 2022). Among 37 respondents, 56.8% stated that the excretory system material is difficult to understand, 73% are not accustomed to solving real-world problems creatively, and 56.8% are interested in digital teaching materials that can be learned independently. This is consistent with Imansari & Sunaryantiningsih (2017), which found that digital teaching materials enhance understanding and the effectiveness of learning.

Online ISSN 2655-2450 | Print ISSN 2655-2388

Development of e-modules

In the design phase, materials on the excretory system were developed in accordance with the Merdeka Curriculum. This material is a subtopic of the structure and function of living beings, covering excretory organs, their functions, and disorders (Maryana et al., 2021). In addition, e-modules, teaching modules, and pretest and posttest questions were designed. The e-modules were developed based on the BSNP criteria (2006), which include graphic and language aspects, with a clear and communicative cover and content that corresponds to the students' level of ability.

In the development stage, an e-module was produced using a STEM approach with an integrated EDP pattern in the form of a flipbook created with Flip PDF Corporate software, which makes its appearance more attractive (Romayanti et al., 2020). This e-module supports effective learning (Imansari & Sunaryantiningsih, 2017). It is A4 sized and consists of 58 pages, covering a cover page, description of the approach, guidelines, materials, student activities, reflection journals, summaries, evaluations, and information about excretory organs. Student activities are organized based on the stages of the STEM EDP pattern with SSI issues to encourage creative thinking. Two activities are presented with the topics of disorders of the kidneys and lungs, and are connected to live worksheets through interactive buttons according to the e-module guidelines. The developed e-module product is displayed in Figure 2.

Figure 2 E-Module Display in Flipbook Form: a) E-Module Cover; b) Relation of EDP Syntax, STEM Aspects, and Creative Thinking Indicators in Student Learning Activities; c) Student Learning Activity Display with SSI
Source: Personal Documentation

The validation from media experts achieved an average of 94.67% with very valid criteria. The graphic aspect reached 93.25%, meeting the indicators for cover and content design of the e-module. The language feasibility aspect obtained 95.83%, covering indicators of clarity, communicativeness, relevance to students' development, and appropriate use of language and symbols. Suggestions include improving subheadings to align with the content, consistency in image captions, and reducing font variations. The importance of language aspects is supported by Asri & Dwiningsih (2022), stating that language that adheres to rules, is sequential, and communicative facilitates reader understanding. The media expert validation results are presented in Table 3.

Table 3. Media Expert Validation

Aspects	Percentage (%)	Criteria
Graphics	93.52	Very valid
Language	95.83	Very valid
Average	94.67	Very valid

The validation of the material achieved an average of 96.67% with a very valid criterion. The aspect of content feasibility reached 92.18%, covering the appropriateness of the material with the competency standards and learning objectives, accuracy, up-to-dateness, as well as encouragement for curiosity. Suggestions included adding depth to the material, which is a detailed outline of important concepts for students to learn (Arifin, 2015). The feasibility aspect of the presentation obtained 96.88%, meeting techniques, supporting elements, and the flow of presentation; with suggestions to improve the order of concepts to facilitate students' understanding (As-Syiba et al., 2023). The contextual assessment received 92.18%, fulfilling the indicators of the nature and components of context. The pretest and posttest question aspects reached 97.46% with suggestions for language improvement, while the aspects of concept correctness and teaching modules obtained 100%, in accordance with the criteria of the Merdeka Curriculum teaching module. The results of the material validation are presented in Table 4.

Table 4. Material Expert Validation

Aspects	Percentage (%)	Criteria
Content eligibility	92.18	Very valid
Presentation feasibility	96.88	Very valid
Contextual assessment	92.18	Very valid
Correctness of concept	100	Very valid
Teaching module	100	Very valid
Pretest and posttest questions	97.46	Very valid
Average	96.45	Very valid

The validity and reliability tests were conducted on the validated questions. The questions are declared valid if the correlation coefficient > 0.3 (Sugiyono, 2016), and the test results showed that all five questions met this criterion. The reliability test used Cronbach's Alpha, where the instrument is considered reliable if the value > 0.60

Online ISSN 2655-2450 | Print ISSN 2655-2388

(Dewi & Sudaryanto, 2020). The results showed a value of 0.661, thus the instrument is declared reliable. In the implementation stage, the practicality test showed very practical results, with 91.67% from teachers and 93.03% from students. Teachers provided input regarding the accuracy of language and instructions for use. This is in accordance with Asri & Dwiningsih (2022) who stated that the accuracy of language in e-modules affects the reader's understanding of the content. The criteria for the practicality test results from teachers and students are presented in Table 5.

Table 5. Teacher and Student Practicality Test Results

Indicator	Percentage	Criteria
Teacher Practicality Test	91,67	Very practical
Student Practicality Test	93,03	Very Practical

Implementation at the research location

In the effectiveness test, data collection was accompanied by student observers to ensure the implementation of each stage of the teaching module, which showed a result of 100%. Data collection was conducted over 4 meetings (10 JP/400 minutes). The control class used the lecture method, while the experimental class applied the developed e-module. Students were divided into two learning activities, each consisting of 4 groups. In the first meeting, a pretest was conducted along with learning activity 1 on the topic of SSI "Syrup Medication and Kidney Failure," and learning activity 2 on "Pro and Contra of Vaping." Activities included "Let's Identify," "Let's Investigate," and "Let's Find Solutions." The second meeting continued with the activities "Let's Create" and "Let's Test," while the third meeting focused on "Let's Improve" along with material on the liver and skin. The fourth meeting concluded with a posttest. The learning followed a STEM approach with an Engineering Design Process (EDP) pattern.

The developed e-module contains two learning activities. Learning activity 1 addresses the SSI issue "UGM Professor Responds to the Use of Syrup Medications Suspected of Causing Kidney Failure" (kidney disorders), and learning activity 2 discusses "Pro and Con of Vape, Is It Safer than Tobacco Cigarettes?" (lung disorders). Based on the assessment rubric, the average scores of students increased in each activity. In the activity "Let's Identify" (define the problem), students are asked to find problems from the SSI article, express pro or con opinions along with their reasons, thus involving the science aspect in STEM. This activity encourages the originality indicator of creative thinking, and most students are able to write the problems and opinions in their own words. In the 'Let's Investigate' activity, students search for information from various sources and perspectives, honing the flexibility indicator as they present diverse information related to disturbances of the excretory organs. Meanwhile, the 'Let's Find a Solution' activity invites students to discuss and present solution ideas, involving the technology aspect in STEM as well as the fluency and originality indicators. Although students are able to convey many ideas, they still struggle to produce solutions that are truly unique or new.

In the activity 'Let's Create' (try a solution), students are asked to design solutions in the form of products that involve all aspects of the STEM approach. This activity encourages the achievement of creative thinking indicators such as

elaboration and originality, as students detail the solutions and STEM concepts in the products they create. In the activity 'Let's Test' (test a solution), students present their products and evaluate the works of other groups, thus fostering the creative thinking indicator of flexibility as students provide various inputs as a form of evaluation. In the activity 'Let's Improve' (decide whether solution is good enough), students offer alternative improvements based on evaluations from other groups, which involves the engineering aspect of the STEM approach and encourages the creative thinking indicator of elaboration. The connection between the EDP syntax, STEM aspects, and creative thinking indicators in student learning activities is presented in Table 6.

Table 6: Relation between EDP Syntax, STEM Aspects, and Creative Thinking Indicators

Syntax	STEM Aspects	Creative Thinking Indicators
Define The Problem	Science	Originality
Learn About The Problem	Science	Flexibility
Plan a Solution	Technology	Fluency, Originality
Try a Solution	STEM	Elaboration, Originality
Test a Solution	Engineering, Mathematic	Flexibility
Decide Whether Solution Is Good Enough	STEM	Elaboration

The Shapiro-Wilk normality test was performed on the pretest and posttest data of the control and experimental classes. The control class showed significance of 0.407 (pretest) and 0.895 (posttest), while the experimental class showed significance of 0.075 (pretest) and 0.091 (posttest). All values > 0.05, thus the data are assumed to be normally distributed (Ahadi et al., 2023). The results of the normality test are presented in Table 7.

Tabel 7. Perolehan Uji Normalitas

Class	Data	Sig.	Criteria
Control	Pretest	0.407	Normal
	Posttest	0.895	Normal
Experiment	Pretest	0.075	Normal
	Posttest	0.091	Normal

After the data was declared to be normally distributed, a homogeneity test was conducted. The significance value of the pretest was 0.076 and the posttest was 0.331, both > 0.05, so the data is considered homogeneous (Usmadi, 2020). With normal and homogeneous data, an independent sample t-test can be performed (Payadnya & Jayantika, 2018). The test results show a pretest significance of 0.454 > 0.05, indicating no significant difference between the two classes, meaning the initial abilities are equivalent. Meanwhile, the posttest value shows a significance of 0.000 < 0.05, indicating a significant difference between the two classes (Payadnya & Jayantika, 2018). The results of the homogeneity test and the independent sample t-test are presented in table 8.

Online ISSN 2655-2450 | Print ISSN 2655-2388

Table 8 Results of Homogeneity Test and Independent Sample t-test

Data	Homogeneity Test		Independent Sample t-test	
	Sig.	Criteria	Sig.	Criteria
Pretest	0.076	Homogenous	0.454	There is no difference
Posttest	0.331	Homogenous	< 0.001	There is a difference

Achievement of creative thinking indicators after the use of e-modules

The change in creative thinking abilities is analyzed through the N-Gain test, after it was previously known that there were differences in the results of the pretest and posttest based on the t-test. Improvement is seen in each indicator. According to Torrance in (Widodo, 2021), the indicators of creative thinking include fluency, flexibility, originality, and elaboration. The data analysis is focused on comparing N-Gain between the control class and the experimental class. The comparison of N-Gain for each indicator is shown in figure 3.

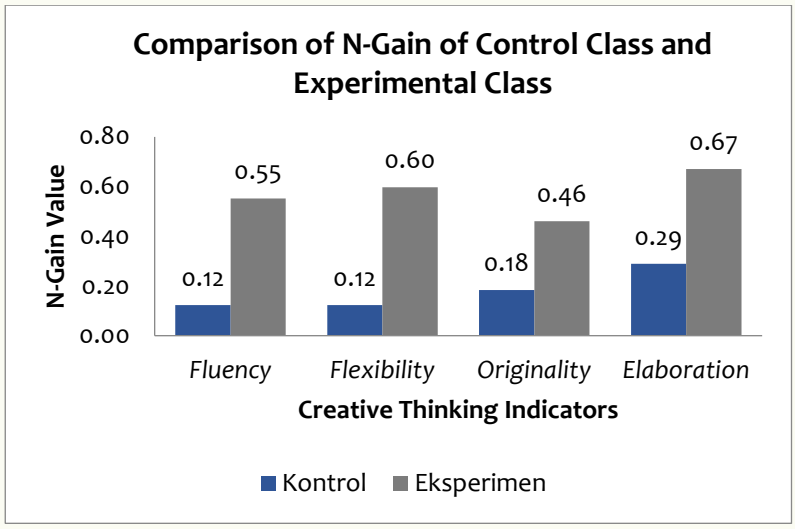

Figure 3 Comparison Results of N-Gain Values of Control Class and Experimental Classes
Source: Personal Documentation

The integrated SSI EDP pattern STEM approach is effective in enhancing the fluency indicator, where students are more actively generating a lot of ideas they have. This depicts that problem-solving learning can encourage students to think openly and responsively towards the challenges they face. In line with the research by Sudrajat et al (2023), the improvement of fluency in creative thinking will be more effective when the learning environment supports active participation, thus capable of creating various solutions. This is consistent with the statement by Amtiningsih (2016) that fluency is the ability of students to provide more than one response and solve problems quickly, as well as aligned with the findings of Nurhamidah et al (2018) which indicate that low fluency among students can be caused by learning that focuses on one correct answer.

In terms of flexibility indicators, students who can view a problem from various perspectives will be able to generate solutions with various variations. Providing space for exploration can encourage student engagement in learning. This can be

stimulated by presenting social issues around the students. Project-based learning can expand perspectives and enhance students' thinking flexibility (Kwon & Lee, 2025). This aligns with Qomariyah & Subekti (2021), who state that flexibility is related to the number of varied answers.

On the originality indicator, students are given the opportunity to create original ideas as a solution to problems. This ability depends on prior knowledge and the amount of information obtained previously. Sudrajat et al (2023)state that originality will develop effectively if students gain sufficient access to information and transdisciplinary learning. This is in line with Widodo (2021) where originality is the ability to generate new ideas and is supported by Samura (2019), who mentions that originality is the ability of students to solve problems in a unique way.

In this study, the elaboration indicator shows the highest achievement. Students tend to be able to detail their ideas about the designed products. Real product-based learning has proven to train students' detailed thinking skills. Sudrajat et al (2023) show that the stages of product design in STEM learning enhance students' elaborative abilities because it involves integrating various knowledge into one structured representation of ideas. These findings are supported by Widodo (2021) and Firdaus et al (2018), who state that elaboration reflects the ability to develop ideas in detailed forms.

4. Conclusion

The development of e-modules with STEM approach of EDP pattern integrated with SSI on excretory system material received very valid and very practical criteria based on validity test and practicality test. Furthermore, the acquisition of the t-test shows a difference in posttest scores between the control class and the experimental class and the acquisition of the N-Gain value in the experimental class illustrates moderate criteria. It is concluded that based on the research, the e-module is valid, practical, and effective to train students' creative thinking skills. For further development, it is recommended that the articles in the questions contain richer information in order to optimize the originality indicators, and this approach can be expanded to other materials and thinking skills to make the impact more comprehensive.

References

Ahadi, G. D., Nur, N., & Ersela, L. (2023). The Simulation Study of Normality Test Using Kolmogorov-Smirnov , Anderson-Darling, and Shapiro-Wilk. *Eigen Mathematics Journal*, *6*(1), 11–19.

Alfiriani, A., & Hutabri, E. (2017). KEPRAKTISAN DAN KEEFEKTIFITASAN PEMBELAJARAN BILINGUAL BERBASIS KOMPUTER. *Jurnal Kependidikan*, *1*(1), 12–23.

Almuharomah, F. A., Mayasari, T., & Kurniadi, E. (2019). Pengembangan Modul Fisika STEM Terintegrasi Kearifan Lokal "Beduk" untuk Meningkatkan Kemampuan Berpikir Kreatif Siswa SMP. *Berkala Ilmiah Pendidikan Fisika*, *7*(1), 1.

Online ISSN 2655-2450 | Print ISSN 2655-2388

https://doi.org/10.20527/bipf.v7i1.5630

Amtiningsih, S., Dwiastuti, S., & Puspita Sari, D. (2016). Peningkatan Kemampuan Berpikir Kreatif melalui Penerapan Guided Inquiry dipadu Brainstorming pada Materi Pencemaran Air Improving Creative Thinking Ability through Guided Inquiry Combined Brainstorming Application in Material of Water Pollution. *Proceeding Biology Education Conference*, *13*(1), 868–872.

Angga, A., Suryana, C., Nurwahidah, I., Hernawan, A. H., & Prihantini, P. (2022). Komparasi Implementasi Kurikulum 2013 dan Kurikulum Merdeka di Sekolah Dasar Kabupaten Garut. *Jurnal Basicedu*, *6*(4), 5877–5889. https://doi.org/10.31004/basicedu.v6i4.3149

Arifin, M. S. (2015). Pengembangan Materi Pembelajaran Makassar. *Education Sience and Technology*, *1*(1), 1–12. http://ojs.unm.ac.id/index.php/JEST

As-Syiba, G. N., Yudianto, S. A., & Kusumawaty, D. (2023). Pengembangan Modul Sistem Imun Terintegrasi Nilai Religi untuk Meningkatkan Sikap Spiritual dan Penguasaan Konsep Peserta Didik. *Lectura : Jurnal Pendidikan*, *14*(1), 15–27. https://doi.org/10.31849/lectura.v14i1.10910

Asri, A. S. T., & Dwiningsih, K. (2022). Validitas E-Modul Interaktif sebagai Media Pembelajaran untuk Melatih Kecerdasan Visual Spasial pada Materi Ikatan Kovalen. *PENDIPA Journal of Science Education*, *6*(2), 465–473. https://doi.org/10.33369/pendipa.6.2.465-473

Branch, R. M. (2009). Approach, Instructional Design: The ADDIE. *Department of Educational Psychology and Instructional Technology University of Georgia*. https://doi.org/10.1007/978-3-319-19650-3_2438

Dewi, S. K., & Sudaryanto, A. (2020). Validitas dan Reliabilitas Kuesioner Pengetahuan , Sikap dan Perilaku Pencegahan Demam Berdarah. *Seminar Nasional Keperawatan Universitas Muhammadiyah Surakarta (SEMNASKEP) 2020*, 73–79.

Douglas, K. A., Moore, T. J., & Adams, R. S. (2016). Core Engineering Design Competencies for Intermediate and Middle Grades. *Purdue University Research Foundation*.

Duwi Meidha Sari, I., Saifuddin Zuhri, M., & Rini Rubowo, M. (2020). Profil Kemampuan Berpikir Kreatif Siswa dalam Memecahkan Masalah Matematika pada Materi SPLTV Ditinjau dari Gaya Kognitif Reflektif dan Impulsif. *Imajiner: Jurnal Matematika Dan Pendidikan Matematika* , *2*(5), 391–400.

Fahmi, Abdullah, & Irhasyuarna, Y. (2021). Empowering Peat Lands as a Resource of Learning Natural Science to Strengthening Environment Care. *Proceedings of the 2nd International Conference on Social Sciences Education (ICSSE 2020)*, *525*(Icsse 2020), 428–431. https://doi.org/10.2991/assehr.k.210222.072

Firdaus, H. M., Widodo, A., & Rochintaniawati, D. (2018). Analisis Kemampuan Berpikir Kreatif dan Proses Pengembangan Kemampuan Berpikir Kreatif Siswa SMP pada Pembelajaran Biologi. *Assimilation: Indonesian Journal of Biology Education*, *1*(1), 21–28. https://doi.org/10.17509/aijbe.v1i1.11452

Hamid, M., Sufi, I., Konadi, W., & Akmal, Y. (2019). Analisis Jalur Dan Aplikasi Spss Versi 25. In J. Iddris (Ed.), *Sefa Bumi Persada* (1st ed.). Sefa Bumi Persada.

Haryanti, Y. D., & Saputra, D. S. (2019). Instrumen Penilaian Berpikir Kreatif Pada Pendidikan Abad 21. *Jurnal Cakrawala Pendas*, 5(2), 58–64. https://doi.org/10.31949/jcp.v5i2.1350

Herak, R. (2021). Peningkatan Hasil Belajar IPA Peserta Didik Kelas VIII Materi Sistem Ekskresi melalui Pengaruh Model STEM. *Jurnal Studi Guru Dan Pembelajaran*, *4*(1), 127–134. https://doi.org/10.30605/jsgp.4.1.2021.516

Imaduddin, M., & Khafidin, Z. (2018). Ayo Belajar IPA dari Ulama: Pembelajaran Berbasis Socio-Scientific Issues di Abad ke-21. *Jurnal Thabiea*, *01*(02), 102–120.

Imansari, N., & Sunaryantiningsih, I. (2017). Pengaruh Penggunaan E-Modul Interaktif Terhadap Hasil Belajar Mahasiswa pada Materi Kesehatan dan Keselamatan Kerja. *VOLT : Jurnal Ilmiah Pendidikan Teknik Elektro*, 2(1), 11. https://doi.org/10.30870/volt.v2i1.1478

Karisan, D., & Zeidler, D. L. (2016). Contextualization of Nature of Science Within the Socioscientific Issues Framework: A Review of Research. *International Journal of Education in Mathematics, Science and Technology*, 139–152. https://doi.org/10.18404/ijemst.270186

Kartina, A. A., Suciati, S., & Harlita, H. (2021). Keterampilan Berpikir Kreatif Siswa Smp Kelas Viii Dalam Memecahkan Masalah Pada Materi Zat Aditif Dan Adiktif Selama Pandemi Covid-19. *Quantum: Jurnal Inovasi Pendidikan Sains*, *12*(2), 149. https://doi.org/10.20527/quantum.v12i2.10364

Kemdikbud. (2022). *Buku Saku Kurikulum Merdeka; Tanya Jawab*. Kementerian Pendidikan Dan Kebudayaan. https://kurikulum.kemdikbud.go.id

Kemendikbudristek BSKAP. (2022). Salinan Keputusan Kepala Badan Standar, Kurikulum, dan Asesmen Pendidikan, Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 008/H/KR/2022 Tentang Capaian Pembelajaran Pada Pendidikan Anak Usia Dini Jenjang Pendidikan Dasar dan Jenjang Pendid. In *Kemendikbudristek BSKAP RI* (Issue 021).

Kurnia, A. (2021). Profil Kemampuan Berpikir Kreatif Siswa Menggunakan Soal Tes Pilihan Ganda pada Pembelajaran Ilmu Pengetahuan Alam. *Indonesian Journal of Educational Science (IJES)*, *4*(1), 27–32. https://doi.org/10.31605/ijes.v4i1.1147

Kwon, H., & Lee, Y. (2025). A meta-analysis of STEM project-based learning on creativity. *STEM Education*, *5*(2), 275–290. https://doi.org/10.3934/steme.2025014

Laili, I., Ganefri, & Usmeldi. (2019). Efektivitas Pengembangan E-Modul Project Based Learning Pada Mata Pelajaran Instalasi. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *3*(3), 306–315. https://ejournal.undiksha.ac.id/index.php/JIPP/article/download/21840/13513

Mangold, J., & Robinson, S. (2013). The engineering design process as a problem solving and learning tool in K-12 classrooms. *ASEE Annual Conference and*

Online ISSN 2655-2450 | Print ISSN 2655-2388

Exposition, Conference Proceedings. https://doi.org/10.18260/1-2--22581

Martin, M. O., & Mullis, I. V. S. (2015). *TIMSS 2015 International Results in Science*. TIMSS & PIRLS International Study Center.

Maryana, O. F. T., Inavuy, V., & Sutia, C. (2021). *ILMU PENGERAHUAN ALAM*. Pusat Perbukuan Badan Standar, Kurikulum, dan Asesmen Pendidikan Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. https://buku.kemdikbud.go.id

Meika, I., & Sujana, A. (2017). Kemampuan Berpikir Kreatif Dan Pemecahan Masalah Matematis Siswa Sma. *Jurnal Penelitian Dan Pembelajaran Matematika*, *10*(2), 8–13. https://doi.org/10.30870/jppm.v10i2.2025

Nessa, W., Hartono, Y., & Hiltrimartin, C. (2017). Pengembangan Buku Siswa Materi Jarak pada Ruang Dimensi Tiga Berbasis STEM Problem Based Learning. *Jurnal Elemen*, *3*(1), 1–14.

Nurhamidah, D., Masykuri, M., & Dwiastuti, S. (2018). Profile of senior high school students' creative thinking skills on biology material in low, medium, and high academic perspective. *Journal of Physics: Conference Series*, *1006*(1). https://doi.org/10.1088/1742-6596/1006/1/012035

Payadnya, P. A. A., & Jayantika, G. A. N. T. (2018). *Panduan Eksperimen Beserta Analisis Statistik dengan SPSS*. DEEPUBLISH.

Pursitasari, I. D., Alfitriyani, N., & Kurniasih, S. (2022). Enhancing Students' Creative Thinking Skills through Biotechnology Module based Socio-Scientific Issues. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 939–948. https://doi.org/10.29303/jppipa.v8i2.1438

Qomariyah, N. D., & Subekti, H. (2021). Analisis Kemampuan Berpikir Kreatif: Studi Eksplorasi Siswa Di Smpn 62 Surabaya. *Pensa E-Jurnal : Pendidikan Sains*, *9*(2), 242–246. https://ejournal.unesa.ac.id/index.php/pensa/article/view/38250

Riefani, M. K. (2020). Validitas Dan Kepraktisan. *Jurnal Vidya Karya*, *34*(2), 193–204. https://doi.org/10.20527/jvk.v34i2.7578

Romayanti, C., Sundaryono, A., & Handayani, D. (2020). Pengembangan E-Modul Kimia Berbasis Kemampuan Berpikir Kreatif Dengan Menggunakan Kvisoft Flipbook Maker. *Alotrop*, *4*(1), 51–58. https://doi.org/10.33369/atp.v4i1.13709

Samura, A. ode. (2019). Kemampuan Berpikir Kritis dan Kreatif Matematis Melalui Pembelajaran Berbasis Masalah. *Journal of Mathematics and Science*, *5*(1), 20–28.

Saragih, Lisca Eirene., & Tarigan, R. (2016). PERBEDAAN HASIL BELAJAR SISWA DENGAN MENGGUNAKAN MODEL PEMBELAJARAN KOOPERATIF SCRIPT DAN PROBLEM BASED INSTRUCTION PADA MATERI POKOK SISTEM EKSKRESI MANUSIA. *Jurnal Pelita Pendidikan*, *4*(2), 148–152.

Sudrajat, U., Ardianto, D., & Permanasari, A. (2023). Engineering Design Process (EDP)-Based Learning to Enhance High School Students' Creativity in Alternative Energy Topics. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9547–9553. https://doi.org/10.29303/jppipa.v9i11.5248

sugiyono. (2016). metode penelitian pendidikan (kuantitatif kualitatif dan R & D). *Bandung: Alfabeta*. https://doi.org/10.1164/rccm.200409-1267OC

Sugiyono. (2016). *Metode Penelitian kuantitatif dan Kualitatif*. Alfabeta.

Sukarelawan, M. I., Indratno, T. K., & Ayu, S. M. (2024). N-Gain vs Stacking. In *Surya Cahya*.

Sukmawijaya, Y., Suhendar, & Juhanda, A. (2019). Pengaruh Model Pembelajaran Stem-Pjbl Terhadap Kemampuan Berpikir Kreatif Siswa Pada Materi Pencemaran Lingkungan. *BioEdUIN*, *9*(9), 28–43.

Sutia, C., & Mahdalena, M. (2017). Laporan Penelitian Seameo Qitep in Science Motivasi Dan Kemampuan Memecahkan Masalah Dalam Pembelajaran Engineering Design Procces. *Journal of Chemical Information and Modeling*, *53*(9), 1689–1699.

Tangio, J. S., Suleman, N., & Jumi, W. (2018). Identifikasi Kemampuan Berpikir Kreatif Siswa Menggunakan Soal Tes Open Ended Problem Pada Materi Elektrokimia di SMA Negeri 1 Telaga. *Jurnal Entropi*, *13*(1), 35–43. https://www.neliti.com/publications/277442

Ulum, M. B., Putra, P. D. A., & Nuraini, L. (2021). Identifikasi penggunaan EDP (Engineering Design Process) dalam berpikir engineer siswa SMA melalui Lembar Kerja Siswa (LKS). *Jurnal Riset Dan Kajian Pendidikan Fisika*, *8*(2), 53. https://doi.org/10.12928/jrkpf.v8i2.20753

Usmadi. (2020). Pengujian Persyaratan Analisis (Uji Homogenitas Dan Uji Normalitas). *Inovasi Pendidikan*, *7*(1), 50–62. https://doi.org/10.31869/ip.v7i1.2281

Widodo, A. (2021). Pembelajaran Ilmu Pengetahuan Alam Dasar-Dasar untuk Praktik. In *UPI Press*.

Zeidler, D. L., Herman, B. C., & Sadler, T. D. (2019). New directions in socioscientific issues research. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 1–9. https://doi.org/10.1186/s43031-019-0008-7

Online ISSN 2655-2450 | Print ISSN 2655-2388