

## **Interactive E-Module of Mixture for Improving Students' Creative Thinking Skills**

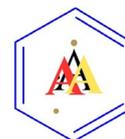
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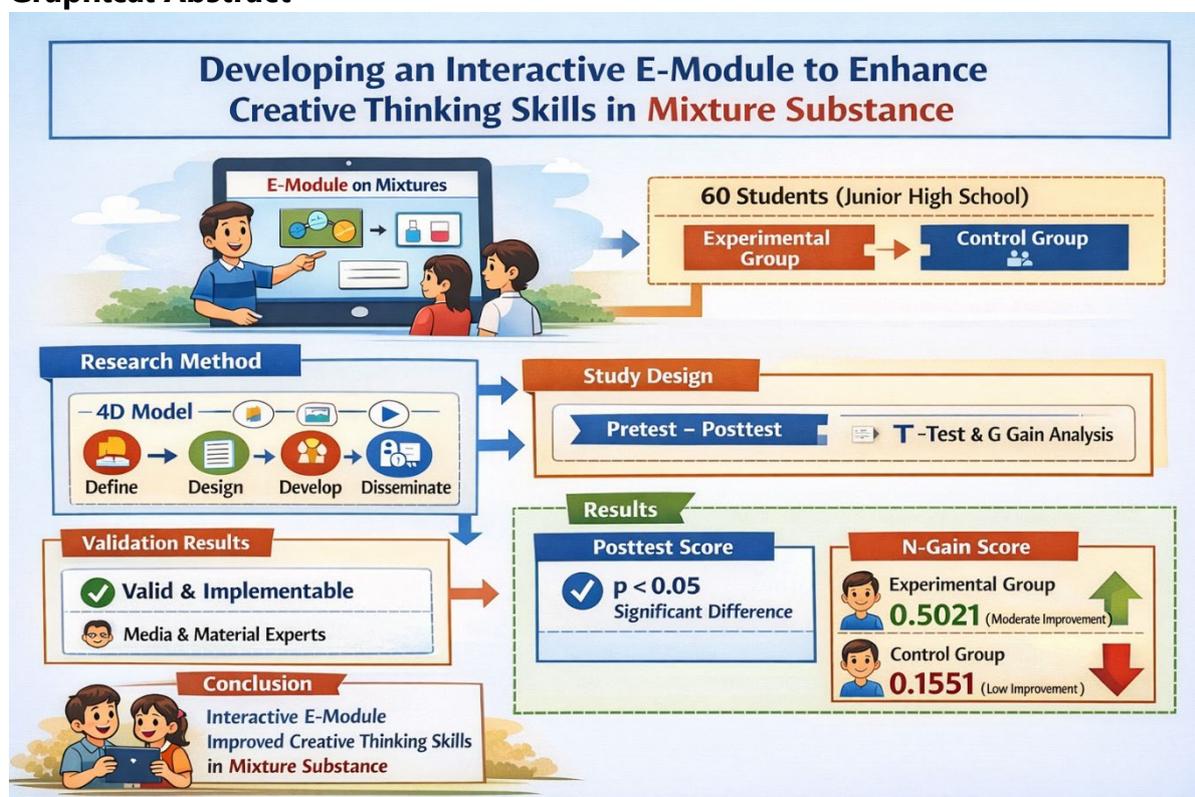
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**Abstract:** This study aims to develop an interactive e-module that is valid and implementable to help improve students' creative thinking skills in Mixture Substance. This developmental study utilises the 4D model from Thiagarajan et al. (1974). This study involved 60 eighth-grade students from a public junior high school in Karangploso, Malang, using a convenience sampling technique and a nonequivalent control group design. Descriptive analysis techniques were used to explain the pretest-posttest results; an independent-samples t-test was used to analyse differences in creative thinking ability between the experimental and control groups; and an N-Gain test was used to determine improvement categories in creative thinking ability. Media and material validation results from expert validators and educators showed agreement, with almost perfect agreement in the categories. The posttest t-test results for both groups showed p-values less than 0.05, indicating a significant difference in creative thinking ability after learning. The experimental group's N-Gain value was higher than the control group's, at 0.5021, indicating that students improved their creative thinking skills in the moderate category, while the control group achieved only 0.1551 in the low improvement category. Based on these findings, learning mixture materials using interactive e-modules in experimental classes is effective in improving students' creative thinking skills.

**Keywords:** high level of thinking, HOTS, 21<sup>st</sup> century skills, technology-enhanced learning, teaching instrument



## Graphical Abstract



## INTRODUCTION

Technological development in the 21st century has greatly influenced the world of education. Scientific progress has led to various innovations, as evidenced by increasingly sophisticated information and communication technologies. Education must equip students with 21st-century skills (Lailia, 2025; Martalinda, 2025). These competencies are known as the 4Cs: critical thinking, communication, collaboration, and creativity and innovation (Aliftika et al., 2019).

One of these competencies is creative thinking ability, which students must have. Students with high creative thinking skills tend to think and solve problems more effectively than those without this skill. They can more easily find new ideas to solve problems (Ishlahul et al., 2023). Therefore, students need creative thinking skills. However, according to Ardhini and Hamimi (2023), students in Indonesia have low levels of creative thinking. PISA results in 2022 showed that Indonesia was among the 12 countries with the lowest performance in creative thinking (OECD, 2024).

Creative thinking is a way of dealing with gaps, contradictions, opportunities, challenges, or concerns, then finding meaningful new ways to connect various aspects by creating various possibilities (from different points of view), generating unique or original ideas, and adding details to expand possibilities (Treffinger et al., 2002). Treffinger et al. (2002) identified 4 main components of the creative thinking process, which include fluency that refers to the quantity or ability to generate many ideas in



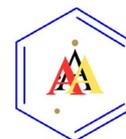
response to open-ended questions, flexibility refers to the ability to find many possibilities from various points of view, originality refers to the ability to generate new ideas, and elaboration refers to the ability to add details and expand ideas (Nafiah et al., 2025).

Mixture is one of the topics in chemistry that junior high school students must study. Students' interest in learning mixture is relatively low. This is based on the results of the Hasanah et al. (2021) questionnaire, which found that this material is dominated by abstract and symbolic concepts that are difficult for students to understand and require students to read and see a lot. The results of the Hasanah questionnaire also showed that most students need interesting learning media. The abstract concepts in this material can be visualised through images, videos, and simulations, thereby making the material more engaging for students.

One way technology influences education is through the media used for learning. Learning media are tools that channel messages to achieve learning goals (Ichsan et al., 2021). However, Sholikha et al. (2024) reported that students often feel bored during instruction due to low media use. This is because very few teachers design learning media into the syllabus and lesson plans. This statement is consistent with the findings of Nurwidodo et al. (2022), which indicate that, in general, teachers primarily use guidebooks to provide materials and pose questions that do not stimulate students' creativity. A study by Kassi et al. (2021) at a junior high school in Pakisaji found that most students were categorised as less creative.

Effective learning can be achieved through creative media that attract students' attention, such as technology-based interactive modules (electronic modules). The characteristics of interactive learning media are the interaction between students and the media, enabling students not only to pay attention to objects but also to actively engage in learning (Harsiwi & Arini, 2020). Through interactive learning, a conducive and enjoyable learning atmosphere is created, thereby making students more enthusiastic and developing their creative potential during the learning process (Ratno et al., 2024). Electronic modules (e-modules) are digital learning resources that incorporate audio, video, animation, and engaging, communicative learning activities to achieve learning goals (Ninawati et al., 2021). E-modules can be accessed flexibly from various locations using a computer or smartphone with an internet connection. When learning with e-modules, students can be more active in independent learning (Romayanti et al., 2020).

This research will develop an interactive e-module using the Google Sites website platform to improve students' creative thinking skills. This e-module will display images, videos, online simulation activities, and practice questions, making it easy and efficient for students to learn. The purpose of this research is to develop an interactive e-module that is valid and can be used to improve students' creative thinking skills in mixed materials.



## METHOD

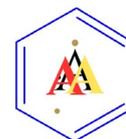
This research is classified as development research, also known as research and development (RnD), which aims to create and test the effectiveness of a product (Sugiyono, 2017). The development of interactive e-modules was carried out using the 4D development model, which includes define, design, develop, and disseminate, as proposed by Thiagarajan et al. (1974). The define stage aims to identify and formulate problems that will be the basis for developing the product. There are 5 main processes in the define stage, one of which is front-end analysis, which identifies science learning problems related to creative thinking skills through literature studies. The learner analysis aims to understand students' general characteristics, so that information can be used to choose learning media that align with their characteristics and needs. Task analysis is conducted to identify the basic competencies that students have, so that they can understand the material well. Concept analysis to organise the concept of mixed materials logically and systematically. Specifying instructional objectives is done to design and formulate learning objectives that students are expected to achieve (Thiagarajan et al., 1974). The design stage involves creating the initial e-module design, including selecting its format and design, choosing interactive media, and preparing its initial appearance. The development stage involved creating e-modules based on the designed design. After development, the e-module will undergo validation by media and materials experts. Questionnaire scores from the experts will be assessed using the percentage agreement to measure interrater reliability. The categories of agreement, based on reliability percentages, as presented by McHugh (2012), are shown in Table 1.

**Table 1.** Percentage agreement

Interpretation	Percentage agreement
None	0 – 4%
Minimal	4 – 15%
Weak	15 – 35%
Medium	35 – 63%
Strong	64 – 81%
Almost perfect	82 – 100%

The empirical test of pretest-posttest questions was conducted with 26 ninth-grade students from A public junior high school. The questions will undergo validity testing using IBM SPSS Statistics to ensure they measure students' creative thinking skills. The four questions proved to be valid, with an r-count greater than the r-table (for an r-table value of 5% and  $N = 26$ , the r-table value is 0.388). After the questions were validated, a reliability test was conducted. The obtained Cronbach's Alpha value is 0.607 ( $>0.60$ ), indicating that the items are reliable and consistent in measuring the variable (Sugiyono, 2017). The last stage is dissemination, which involves distributing interactive e-module products.

This research was conducted in April 2025 at A public junior high school using a quasi-experimental, nonequivalent control group design. The study population comprised



all eighth-grade students at the school, using nonprobability convenience sampling. This technique is used based on the ease of access and availability of respondents who meet the criteria; these respondents were part of groups that had formed naturally and were encountered by researchers (Cresswell, 2014). In this study, the sample comprised 30 students from class VIII A, who served as the experimental group, and 30 students from class VIII B, who served as the control group.

The pretest-posttest values of the two groups will be analysed using an independent-samples t-test and the N-Gain test. Before conducting the independent samples t-test, the data must pass the normality and homogeneity tests. If the results of these tests indicate that the data are normally distributed and homogeneous, the next step is to conduct an independent samples t-test to determine whether there is a difference between the experimental and control groups. If the significance value is  $<0.05$ , then the two groups have a significantly different. The increase in students' creative thinking skills, as measured by pretest-posttest scores, is assessed using the N-Gain test. N-Gain criteria according to Hake (1998) are shown in Table 2.

**Table 2.** N-Gain score criteria

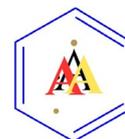
<b>N-Gain score</b>	<b>Interpretation</b>
$-1.00 \leq g < 0.00$	Decrease
$g = 0.00$	No increase
$0.00 < g < 0.30$	Low
$0.30 \leq g < 0.70$	Moderate
$0.70 \leq g \leq 1.00$	High

The research method used must be written in a scientific manner, namely, rational, empirical and systematic. It is advisable to specify the research's time and place, as well as the data, tools, and materials used.

## RESULTS AND DISCUSSION

### Define

There are 5 main processes in the define stage: front-end analysis, learner analysis, task analysis, concept analysis, and the specification of instructional objectives. In the front-end analysis, the results indicate that junior high school students' creative thinking skills are relatively low in science learning. Most educational institutions still use conventional learning methods that emphasise the teacher as the centre of attention, resulting in limited student involvement in the learning process. As a result, students focus only on listening to the teacher's material. This aligns with the findings of Wijaya & Harahap (2022), which show that a learning approach that does not stimulate student creativity leads students to become mere recipients of information rather than engaging in independent exploration. In fact, student-centred learning positively affects students' creative thinking skills (Aytaç & KULA, 2020). The use of conventional learning media also contributes to students' low levels of creative thinking. This statement aligns with a study by Nurholipah et al. (2023), which found that students'



interest in learning is not triggered by conventional learning media, making it difficult for teachers to develop students' creative thinking skills.

The learner analysis process shows that low student enthusiasm during science learning is related to the incompatibility between learning methods and media and students' learning styles. Research by Grazella et al. (2022) shows that the decline in student interest in learning is due to the learning process that does not accommodate visual and kinesthetic learning styles. Therefore, interactive learning media are needed to foster student interest in learning. Furthermore, in the task analysis process for mixtures, students are required to identify the mixture's type and properties and choose the appropriate method for separating it based on its characteristics. This ability requires a systematic task design, so that students can optimally develop analytical and applicative skills. The concept analysis process involves mapping all concepts in the mixture material to align with the 8th-grade science textbook compiled by Maryana et al. (2021).

The concepts in this e-module are arranged systematically, starting with the definition of mixtures, their types, and methods of separating mixtures, to facilitate student understanding. The specification of instructional objectives aims to formulate learning objectives that encourage the development of students' creative thinking skills, enabling them to be more innovative in solving a range of problems. The formulation of learning objectives is (1) Learners are able to categorize homogeneous and heterogeneous mixtures through simulation activities appropriately according to the indicators of creative thinking skills, (2) Learners are able to analyze various mixture separation methods based on the physical properties of the mixture through simulation activities appropriately according to the indicators of creative thinking skills, (3) Learners are able to design tools to separate mixtures through discussion activities appropriately according to the indicators of creative thinking skills.

## Design

The purpose of this study is to develop an interactive e-module of mixture materials to enhance students' creative thinking skills. The interactive e-module contains material explanations accompanied by images, videos, and online simulations. It was designed using Google Sites with the help of Canva; interactive quizzes were created using Quizziz, a diagnostic assessment using Google Forms, and reflection activities using Live worksheets. The design of the interactive e-module is shown in Figure 1.



**Figure 1.** List of menus in the interactive e-module

## Development

At the development stage, an interactive e-module was produced, comprising several menus, including instructions for use, learning outcomes and objectives, concept maps, materials, quizzes, student worksheets, reflections, glossaries, and author profiles. The instructions for use menu contains procedures for using the interactive e-modules, illustrated with images and easy-to-understand sentences, so that students can follow the steps to use the e-modules effectively. The learning outcomes and learning objectives menu provides information on the mixture's learning outcomes and the learning objectives students will achieve. The concept map menu includes a concept map of a mixture that helps students see the outline of the material to be studied in the e-module.

The e-module material includes the definition of a mixture, its types, and methods for separating mixtures. The material menu contains online simulation activities that support an interactive learning process. This is in line with Susanti & Ishafit's (2023) research, which suggests that practicum activities using virtual labs can help students learn the material more purposefully and increase their creativity. There is a quiz menu that students can access after completing the sub-material in the e-module. This quiz aims to strengthen understanding and recall previously learned concepts. The student worksheet menu includes open-ended questions about mixture materials. The reflection menu contains fill-in-the-blank questions to help students evaluate their understanding, identify difficulties, and develop more effective learning strategies. The glossary menu lists special words and terms, along with their definitions, to help students understand the material.



After development, the e-module underwent validation by media and materials experts and science teachers at a public junior high school. Media validation assesses aspects of e-module presentation and appearance, while material validation assesses the suitability of the material with respect to learning outcomes and objectives, the content, the suitability of e-modules for creative thinking, and language use. The validation results from all validators are presented in Table 3, which reports the percentage agreement for the various aspects tested.

**Table 3.** Interactive e-module validation results

<b>Media</b>		
<b>Aspects</b>	<b>%Similarity between validators</b>	
	Validator 1	Validator 2
Presentation of the e-module	82.50%	82.50%
Display of e-modul	93.18%	84.10%
<b>Average</b>	87.84%	83.3%
<b>Criteria</b>	Almost perfect	Almost perfect
<b>Content</b>		
<b>Aspects</b>	<b>%Similarity between validators</b>	
	Validator 1	Validator 2
The relevance of concepts to learning outcomes and objectives	87.50%	100%
Content	96.43%	92.86%
Suitability of creative thinking indicators	93.75%	93.75%
Language	93.75%	93.75%
<b>Average</b>	92.86%	95.09%
<b>Criteria</b>	Almost perfect	Almost perfect

The score of the interactive e-module media validation test, after being measured using interrater reliability, shows that all validators agree that this media is valid, with similarity percentages of 87.84% from media expert validators and 83.3% from science teacher validators, indicating almost perfect agreement. The result of the interactive e-module material validation test, following agreement measurement using interrater reliability, shows that all validators agree that the material in this e-module is valid, with a percentage similarity from material experts of 92.85% and from science teachers of 95.09%, indicating almost perfect agreement.

The next stage is the validity test of the pretest-posttest questions by the question expert. Four pretest-posttest items were used as instruments. The results of the question validation test showed that the four items had similarity percentages above 82% with both validators and were included in the almost perfect category.

**Table 4.** Pretest-posttest question validation results

<b>Question number</b>	<b>%Similarity between validators</b>	<b>criteria</b>
1	85.70%	Almost perfect
2	85.70%	Almost perfect
3	89.29%	Almost perfect
4	82.14%	Almost perfect



## Disseminate

The dissemination stage was carried out in class VIII A at a public junior high school in Karangploso for 8 JP (1 JP = 40 minutes). Students were given a link to an interactive e-module containing a mixture of materials. They were directed to read the instructions for using the interactive e-module, then to understand the learning outcomes and learning objectives. Using the concept map, students could get an overview of the material they would learn. After that, students were directed to complete online simulations and work on student worksheets in groups. They were also guided to study the material, which included pictures and videos. After completing a section, students were directed to take quizzes individually.

During the dissemination stage, the effectiveness of interactive e-modules in improving students' creative thinking skills was also tested. Students in class VIII A served as the experimental group, learning using interactive e-modules, while those in class VIII B served as the control group, learning without them. Both classes conducted the learning process over 3 meetings, totalling 8 JP. Before the first meeting, both classes were given pre-test questions, and at the end of the meeting, both were given post-test questions to assess their creative thinking skills. The test results are presented in Table 5.

**Table 5.** Experiment and control class pretest-posttest results

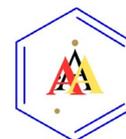
Group	Test type	N	Minimum value	Maximum value	Average	Std
Eksperiment	Pretest	30	31.25	81.25	51.02	13.85
	Posttest		62.50	93.75	77.50	8.93
Control	Pretest	30	31.25	68.75	48.12	10.27
	Posttest		37.50	75.00	57.08	9.95

The average pretest scores of the experimental and control groups did not show significant differences, with each score of 51.05 for the experimental group and 48.08 for the control group. However, after learning, the experimental group's average posttest score increased to 77.50, whereas the control group's average posttest score was only 57.08. Before conducting an independent-samples t-test, all pretest and posttest data must undergo prerequisite tests: a normality test using the Shapiro-Wilk test and a homogeneity test using the Levene test. The results of the pretest-posttest data analysis for both groups were normally distributed and homogeneous, with a significance value greater than 0.05.

**Table 6.** Independent sample T-test

Test type	t	df	Sig. (2-tailed)	t	Sig. (2-tailed)
Pretest (eksperiment-control)	0.921	58	0.361	8.364	0.000

The t-test of the pretest scores in Table 6 indicates that the experimental and control groups have equal initial ability levels, with a significance value of 0.361 ( $>0.05$ ). After learning using interactive e-modules in the experimental group, there was a significant



difference in creative thinking ability between the two groups, as evidenced by the T-test results of posttest values. The significance value obtained is 0.000 ( $<0.05$ ), indicating that the treatment significantly improves students' creative thinking skills.

**Table 7.** N-Gain score results

Class	N-Gain score	Categori
Eksperiment	0.50	Moderate
Control	0.15	Low

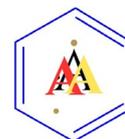
The results of the N-Gain test, which measures increases in creative thinking skills in the experimental and control groups, are shown in Table 7. The experimental group obtained an N-Gain of 0.5021, placing it in the moderate category, while the control group obtained an N-Gain of 0.1551, placing it in the low category. This shows a difference in the level of ability improvement between the two groups. Therefore, using interactive e-modules to learn IPA mixture materials has been proven to be an effective way to improve students' creative thinking skills compared to conventional learning.

**Table 8.** N-Gain score results on each creative thinking indicator

Indicators of creative thinking	N-Gain score	Categori
Fluency	0.62	Moderate
Flexibility	0.47	Moderate
Originality	0.58	Moderate
Elaboration	0.39	Moderate

Using interactive e-modules during the learning process has been shown to improve students' creative thinking skills in the experimental group. Using interactive e-modules facilitates the delivery of material and accelerates the provision of feedback and evaluation, thereby allowing students to optimally improve their competence (Mutia et al., 2025). Related research on e-modules using PDF flip-based in biology learning shows that this method can enhance students' creative thinking skills (Fahru et al., 2024). Interactive e-modules also foster student independence in learning by presenting content in an engaging manner using a combination of media, such as videos, images, text, evaluations, and instructions for use (Sidiq et al., 2021).

The implementation of learning with interactive e-modules at school is supported by teachers. The teacher accompanies students during problem analysis and investigation through online simulation activities. During these activities, students are required to find various solutions and relate them to theory. The improvement in students' creative thinking skills after utilising interactive e-modules during learning is supported by activities that include open-ended questions. These questions can train students' ability to generate a large number of ideas (Treffinger et al., 2002). Open-ended questions consist of a problem with more than one correct solution. The activities in the e-module contain open-ended problems that allow students to explore, identify, and solve problems in various ways. Open-ended problems play an important role in



training students' creative thinking skills, because they give them the freedom to explore various ideas and solutions (Ariani et al., 2024).

The questions in the e-module encourage students to generate multiple ideas related to the mixture. The activities in the e-modules encourage students to generate more than one answer idea when solving the problems given. In Table 8, students' fluency has increased after using interactive e-modules during learning, with an N-Gain of 0.6282, classified as moderate improvement. Students' flexibility ability also increased at a moderate level. The N-Gain value for the flexibility aspect after learning with interactive e-modules is 0.4744. Student worksheet activities in interactive e-modules that train this ability include problems that require students to find various solutions. This statement aligns with Treffinger et al. (2002), who suggested that flexibility includes students' ability to seek diverse ideas, enabling them to produce varied solutions to a single problem. Originality refers to the ability to generate new ideas.

After using the interactive e-module, this ability has increased, with an N-Gain of 0.5833, and is classified as moderate improvement. Activities in the e-module that can train students' originality skills are found in the student worksheet menu. This activity requires students to design innovative solutions to a problem in the surrounding environment. Questions related to complex contextual problems can develop students' creative potential in solving problems (Zaiturrahmah et al., 2024). Elaboration ability is the ability to add details or expand ideas (Treffinger et al., 2002). In this e-module, activities encourage students to present answers systematically and in detail. Students' detailing ability has increased after learning using interactive e-modules. This improvement is reflected in the N-Gain value of 0.3910 and is categorised as moderate. The test results show that the use of interactive e-modules based on Google Sites in a blended format can improve students' creative thinking skills. The activities in this interactive e-module encourage students to practice these abilities when solving various problems. This finding is consistent with the results of Mutia et al.'s (2025) study, which showed that interactive e-modules can facilitate the development of students' creative thinking skills.

## CONCLUSIONS

The interactive e-module based on Google Sites is considered feasible for implementing in learning IPA mixture materials with an almost perfect agreement category. The results of the independent T-test showed a significant difference in students' post-test scores on creative thinking skills between the experimental and control groups. Using interactive e-modules for learning improved the students' creative thinking skills in the experimental group. This statement is supported by the N-Gain value for the experimental group, which is classified as moderate improvement, whereas the N-Gain value for the control group is classified as low improvement. Thus, the interactive e-module on Google Sites is considered valid and effective for improving students' creative thinking skills.



## AI-ASSISTED TECHNOLOGY STATEMENT

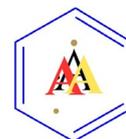
In the preparation of this work, the writers utilised Grammarly to detect grammatical errors and ChatGPT to create the graphical abstract. Following the use of these tools, the authors meticulously evaluated and revised the content as necessary, assuming full accountability for the publication's material.

## ACKNOWLEDGEMENT

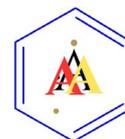
We thank the school staff for their assistance with this research.

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