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Interactive video-based e-worksheets to foster students' creative thinking skills in chemistry education

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ABSTRACT

The purpose of this study was to develop interactive learning video-based electronic worksheets for learning about hydrocarbons and to evaluate their validity, practicality, and effectiveness in fostering students' creative thinking skills. Using the ADDIE model, this development-oriented study involved 33 senior high school students at SMA Negeri 1 Driyorejo, Gresik, in a single-group pretest–posttest design. Data were collected through expert validation, student questionnaires, classroom observations, and tests assessing four indicators of creative thinking: fluency, flexibility, originality, and elaboration. Data were analyzed using descriptive statistics, normalized gain (N-gain), the Shapiro–Wilk test, and the Wilcoxon rank-sum test. The developed worksheets achieved an overall validity score of 89.08%, with content validity of 88.61% and construct validity of 97.22%. Practicality scores reached 86.27% based on student responses and 89.66% based on classroom observations. Students' average creative thinking scores increased from 34.18 on the pretest to 73.36 on the posttest, with an overall N-gain of 0.58, indicating moderate improvement. At the indicator level, the N-gain values were 0.67 for fluency, 0.48 for flexibility, 0.57 for elaboration, and 0.64 for originality. The difference between pretest and posttest scores was statistically significant ($p < 0.001$). These findings indicate that the developed electronic worksheets are highly valid and practical and show potential for improving students' creative thinking skills.

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Introduction

Science education aims to develop students' ability to interpret scientific information and apply it in new situations. According to the 2022 PISA report, only 34% of Indonesian students were reported to have achieved science literacy at Level 2 or above, while the average for OECD countries was 76%. (OECD, 2023). These results illustrate the challenges of science education in Indonesia, particularly in equipping students not only to memorize scientific facts but also to understand information, construct explanations, and develop solutions to scientific problems. Nevertheless, PISA results must be interpreted while considering the educational context and characteristics of participating countries, so they should not be used as the sole basis for assessing the quality of science education (Sjøberg, 2015). Therefore, a more contextual analysis of learning challenges in schools is needed to identify the needs for science education development.

This challenge is important for chemistry learners because studying chemical concepts requires students to connect three levels of representation: macroscopic, submicroscopic, and symbolic (Johnstone, 1991; Treagust et al., 2003). Difficulty in linking these three levels of representation can lead students to rely more on rote

memorization than on understanding (Hidayah et al., 2026). The topic requiring the most integration of these representations is hydrocarbons, which covers the classification and nomenclature of hydrocarbon compounds, the properties of hydrocarbon compounds, hydrocarbon isomers, and reactions of hydrocarbon compounds. This topic requires students to identify and name compounds, as well as understand the relationship between a compound's structure and formula, and the changes that occur during a reaction.

In addition to conceptual understanding, chemistry education must also provide opportunities for the development of creative thinking skills. Chemistry is a field of science that involves exploring various possibilities, developing ideas, and solving problems (Brederode, 2025). Scientific creativity is important because students are not only expected to arrive at the correct answer but also to develop diverse ideas and approaches to solving scientific problems (Nursiwan et al., 2025). In this study, creative thinking skills refer to four indicators according to Torrance: originality, fluency, flexibility, and elaboration (Torrance, 1968). Fluency is associated with the generation of ideas. Flexibility is associated with the development of ideas in relation to different perspectives. Originality is associated with the generation of ideas in relation to uniqueness. Elaboration is associated with the development and expansion of ideas. The four indicators mentioned above are relevant to the characteristics of hydrocarbon compounds. Students can be guided to generate various possible compound structures, use different methods to identify and name compounds, and explain the relationship between hydrocarbon structures and their reactions. Therefore, learning about hydrocarbons can serve as a context for simultaneously developing students' creative thinking skills and their understanding of chemistry.

This can be achieved through learning activities guided by student worksheets that require students to engage critically in building their understanding and ideas. The use of inquiry-based learning activity worksheets promotes the development of creative thinking skills, as demonstrated by Hidayah et al. (2026). In addition, formative feedback in chemistry worksheets can help students construct chemical concepts and regulate their learning (Rahma & Muchlis, 2026). Advances in educational technology provide opportunities to integrate learning materials into interactive and animated digital environments. The use of digital learning resources also has the potential to support higher-order thinking skills when designed with activities aligned with learning objectives (Falma & Putra, 2025; Miftahuddin & Perdana, 2026; Sarbaitinil et al., 2026). Therefore, integrating electronic worksheets with interactive instructional videos can serve as an alternative for presenting chemistry concepts in a more visual manner while providing students with opportunities to engage in activities that stimulate creative thinking.

A number of studies have developed digital media to support chemistry learning, including on the topic of hydrocarbons. Dheadema et al. (2023) demonstrated the use of animated videos as a learning medium for hydrocarbons, while Rossie et al. (2025) developed interactive video-assisted worksheets to support students' visual comprehension of this topic. Research by Zulfa et al. (2023) also highlights the potential of audiovisual media in fostering creative thinking skills, while Nugroho & Ary. (2026) developed audiobook media to enhance creativity in dance education. Although these studies contribute to the development of learning media and activities, research on the integration of interactive videos and electronic worksheets specifically designed to guide students in developing the four indicators of creative thinking within the context of hydrocarbon learning still needs to be strengthened. Furthermore, the relationship between presenting concepts through visual representations and activities that encourage students to generate, develop, and evaluate various ideas has not yet been a specific focus in the development of hydrocarbon learning media examined in this study.

This need is also supported by the results of a preliminary study conducted at the school. The findings indicate that 54.55% of students experienced difficulty understanding hydrocarbon material. These difficulties were specifically found in the concept of isomers (40.91%) and the nomenclature of hydrocarbon compounds (31.82%). These findings suggest that students still face challenges in understanding the relationship between the structure and naming of hydrocarbon compounds. In addition, 95.45% of students stated that they needed engaging learning media to support the learning process. These results indicate a need for learning media capable of presenting hydrocarbon concepts in a more easily understandable way while also involving students in meaningful learning activities. The development of learning media must be carried out systematically so that the resulting products align with learning needs and objectives (Nasution et al., 2025).

Based on these issues and previous research studies, this study developed interactive video-based e-worksheets on hydrocarbons to support the development of students' creative thinking skills. The e-worksheets were developed using the ADDIE model. This study aimed to develop interactive video-based e-worksheets on hydrocarbons and to evaluate their feasibility, practicality, and effectiveness in fostering students' creative thinking skills. The novelty of this study lies in the integration of interactive educational videos with activities in e-worksheets specifically designed based on the four indicators of creative thinking skills: fluency, flexibility, originality, and elaboration. Interactive videos are used to facilitate the presentation of hydrocarbon concepts through visual information, while the activities in the e-worksheets provide students with opportunities to

explore concepts, generate various ideas, develop alternative solutions, and elaborate on the ideas they have generated. This integration is expected to link the visual presentation of chemical concepts with activities that purposefully stimulate students' creative thinking skills. Thus, the contribution of this study lies not only in the use of digital media but also in the design of learning activities that integrate the presentation of hydrocarbon concepts and the development of the four indicators of creative thinking within a single learning product.

Method

Research Design

This study employs a research and development (R&D) approach to design and develop interactive video-based e-worksheets on hydrocarbons, as well as to assess their feasibility and practicality and the changes in students' creative thinking skills following their use. Product development involves the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation.



Figure 1. ADDIE Flowchart

The Analysis stage identified learning needs, student characteristics, barriers to learning hydrocarbon material, and the product's alignment with the curriculum and learning objectives. In the Design stage, the design process involved creating the E-LKPD and interactive instructional videos, as well as designing learning activities to practice the four indicators of creative thinking skills: fluency, flexibility, originality, and elaboration. The Development phase involves implementing the design by creating the E-LKPD, having the product validated by three validators, and revising the product based on their suggestions. The Implementation phase involves applying the product to students during learning activities. Next, the Evaluation phase analyzes the validation results, student responses, observations of student activities, and the results of creative thinking ability tests to evaluate the product's feasibility, practicality, and changes in students' abilities following its use. Changes in creative thinking skills were evaluated using a pre-experimental one-group pretest–posttest design. This design involved a single group of students who took tests before and after using the e-worksheets, without a control group. The research design is illustrated as follows:

$$O_1 \quad X \quad O_2$$

Explanation: O_1 is the pretest, X is learning using e-worksheets, and O_2 is posttest.

This design was chosen in consideration of limited access to a comparison class and the time constraints of the study. Therefore, the pretest and posttest results were used to identify changes in students' creative thinking skills following the use of the product. However, without a control group, these changes cannot yet be fully attributed to the use of e-worksheets.

Participant

This study involved 33 students from a single class selected using purposive sampling. The class was selected based on the chemistry teacher's recommendation and considerations regarding the feasibility of conducting the study. All students in the selected class participated in the study. The students had previously covered the hydrocarbons topic; therefore, the use of e-worksheets was intended to reinforce their understanding of the material and develop their creative thinking skills. The number of participants was determined based on the number of students in the class who were available during the study, rather than through an a priori statistical power analysis.

In addition to the students, product validation involved three validators: one chemistry education professor and two chemistry teachers. All three validators provided evaluations, comments, and suggestions regarding the product before it was implemented with the students.

Data Collection

Research data were collected through test and non-test techniques. Non-test data included product validation results, student responses, and observations of student activities while using the e-worksheets. Validation data were obtained through evaluation forms completed by the three validators. Student response data were obtained through a questionnaire administered after the product's implementation, while observations were conducted to assess student engagement in using interactive instructional videos and completing activities on the e-worksheets.

Test data were obtained through pre- and post-tests of creative thinking skills administered before and after the use of e-worksheets. The test instrument consisted of eight items measuring four indicators of creative thinking skills: fluency, flexibility, originality, and elaboration. Each indicator was measured using two items.

Instrument

Product validation sheet

The validation sheet was used by three validators to assess the suitability of the e-worksheets before implementation. The assessment was accompanied by comments and suggestions that served as the basis for product improvements. The assessment results were analyzed descriptively using percentages.

Student Response Questionnaire

The student response questionnaire consisted of 26 statements covering seven aspects of the practicality of using e-worksheets. The questionnaire used a four-point Likert scale. There are three negative statements related to difficulties in following the sequence of activities, using interactive features, and reading text in the e-worksheets. These three statements were reverse-scored before analysis.

Student Activity Observation Sheet

The observation sheet consists of 18 indicators used to observe student activities and engagement while using the e-worksheets. The aspects observed included student engagement in watching interactive instructional videos, responding to interactive quizzes, correcting answers based on feedback, and completing learning activities. Each indicator was rated using the options "Yes" and "No." Observations were conducted over two sessions, and the results were used as supporting data in evaluating the product's practicality.

Pretest-Posttest

The creative thinking ability test consists of eight items used in the pretest and posttest. Each item has a maximum score of four, resulting in a maximum total score of 32. The instrument was developed based on four indicators of creative thinking ability: fluency, flexibility, originality, and elaboration. Each indicator is represented by two items based on the test blueprint and scoring rubric that were developed.

Table 1. Item Analysis and Internal Consistency of the Creative Thinking Test

Item	Pearson's r	Significance
1	0.854	$p < 0.001$
2	0.776	$p < 0.001$
3	0.808	$p < 0.001$
4	0.522	$p < 0.001$
5	0.657	$p < 0.001$
6	0.785	$p < 0.001$
7	0.732	$p < 0.001$
8	0.482	$p = 0.005$
Cronbarch's Alpha = 0.852		

Item analysis using Pearson's correlation revealed correlation coefficients ranging from 0.482 to 0.854, with all significance levels below 0.05. Meanwhile, an internal consistency test using pretest data from 33 students yielded a Cronbach's Alpha value of 0.852. These results were used to assess the relationship between item scores and total scores, as well as the internal consistency of the instrument within the study group.

Data Analysis

Test Data Analysis

Pretest and posttest data were analyzed to identify changes in students' creative thinking skills following the use of e-worksheets, both overall and for each indicator. Improvements in ability were analyzed using the normalized gain (N-Gain) method with the following formula:

$$g = \frac{Posttest - Pretest}{100 - Pretest}$$

The N-Gain score were classified according to the following criteria.

Table 2. N-Gain Value Criteria

Index N-Gain (g)	Category
N-Gain ≤ 0,70	High
0,30 < N-Gain < 0,70	Medium
N-Gain ≤ 0,30	Low

(Lestari & Yudhanegara, 2017; 235)

An N-Gain analysis was also conducted separately for the four indicators of creative thinking ability: fluency, flexibility, originality, and elaboration. Pretest and posttest scores for each indicator were calculated to determine the level of improvement for each indicator.

Next, the Shapiro–Wilk normality test was performed on the differences between pretest and posttest scores. The test results indicated that the data were not normally distributed; therefore, score differences were analyzed using the Wilcoxon Signed-Rank test. All statistical analyses were performed using Jamovi software.

Analysis of Non-Test Data

Non-test data, consisting of product validation results, student response questionnaires, and observations of student activities, were analyzed descriptively using percentages calculated with the formula:

$$P = \frac{\sum x}{\sum x\, max} \times 100\%$$

Notes: (P) represents the assessment score percentage, ($\sum x$) is the total score obtained, ($\sum x\, max$) the maximum possible scores.

The validation results were analyzed to determine the product's suitability based on the assessments of three validators. Survey data were analyzed to determine students' responses regarding the practicality of the e-worksheets after applying reverse scoring to negative statements. Meanwhile, observational data were analyzed to determine students' activities and engagement while using the e-worksheets as supporting data for the product's practicality. The percentage results for each dataset were interpreted based on the evaluation criteria used in the study.

Results and Discussions

This development research produced interactive video-based e-worksheets on hydrocarbons to enhance students' creative thinking skills. The product was developed using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The results of each development stage are presented as follows.

Stage 1. Analysis

The analysis stage was conducted to identify learning needs, student characteristics, and the difficulties students faced in learning hydrocarbon material. An initial needs analysis was conducted by distributing a questionnaire to 22 students. The questionnaire consisted of 13 questions with yes/no and multiple-choice response options. The data were analyzed descriptively using response frequencies and percentages.

The analysis results showed that 12 out of 22 students (54.55%) reported experiencing difficulties in learning hydrocarbon material. In addition, 21 out of 22 students (95.45%) stated that they needed more engaging learning media. These results indicate a need for learning materials that can help students learn hydrocarbon material in a more engaging way.

Stage 2. Design

The design stage involved developing a preliminary draft of the E-Worksheets based on the results of the needs analysis and learning objectives for the hydrocarbons material. This design integrates learning objectives, the sequence of material, the structure of the e-worksheet, interactive instructional videos, learning activities, and creative challenges. The material is organized into four concepts: hydrocarbon classification, hydrocarbon nomenclature, hydrocarbon isomerism, and hydrocarbon reactions.

The purpose of the learning activities is to enable students to understand hydrocarbon concepts and to develop four indicators of creative thinking skills: fluency, flexibility, originality, and elaboration. The activities are designed to facilitate an increase in the complexity and depth of students' learning experiences. The e-worksheets are structured similarly to provide students with various opportunities for guided and self-directed learning. The e-worksheets include concept presentations through interactive instructional videos, followed by structured learning activities and creative challenges. The product design is shown in Figure 2.

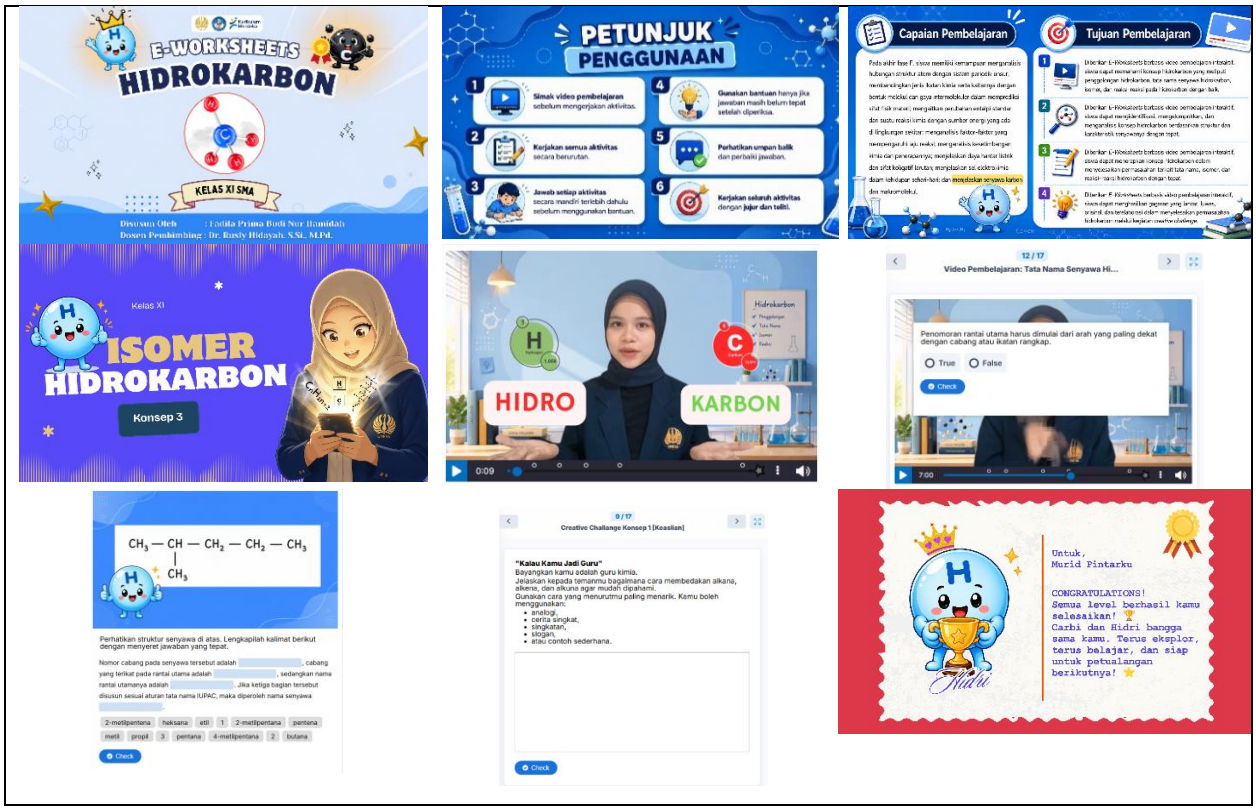


Figure 2. Results of Design E-Worksheets

Stage 3. Develop

The development stage focuses on product development and validation of interactive video-based E-Worksheets on hydrocarbons. The product was developed by integrating content, interactive instructional videos, learning activities, creative challenges, and help and feedback features. Product refinements were made based on validator feedback, including correcting the writing of chemical formulas, expanding quiz answer choices to five options, adding keywords for essay answer grading, standardizing the use of Indonesian, and clarifying the instructions for use. The instructions for use also emphasize that students should try to answer questions on their own before using the help feature.

Table 3. Results of the Subject Matter Expert Validation

Indicator	Percentage (%)	Category
Content Alignment	95,37	Very Feasible
Interactive Videos	88,88	Very Feasible
Learning Activities	81,25	Very Feasible
Creative Thinking Activities	81,63	Very Feasible
Help and Feedback	91,66	Very Feasible
Total	88,61	Very Feasible

Table 4. Results of the Media Expert Validation

Indicator	Percentage (%)	Category
Interactivity	91,66	Very Feasible
Presentation and Navigation	86,11	Very Feasible
Language	91,66	Very Feasible
Design and Layout	91,66	Very Feasible
Total	90,27	Very Feasible

Based on the validation results, the total percentage for subject-matter expert validation was 88.61% and for media expert validation was 90.27%; both were categorized as highly acceptable. The validators' feedback was used as the basis for refining the presentation of the material and chemical formulas, the comprehensiveness of the quizzes, the user instructions, and the interactive features of the E-Worksheets.

Stage 4. Implementation
The implementation stage involved using interactive video-based E-Worksheets in one class that served as the research subject. Instruction took place over two sessions. In the first session, students learned about the classification of hydrocarbons and the nomenclature of hydrocarbon compounds. In the second session, students learned about hydrocarbon isomers and reactions involving hydrocarbons. Students used the E-Worksheets step by step according to the sequence of activities that had been designed.

In the first session, students took a pretest before using the E-Worksheets. Next, students used the E-Worksheets during the learning activities. In the second session, after completing the activities on the third and fourth concepts, students took a posttest to assess changes in their creative thinking skills. Student responses to the medium and observations of student activities during the use of the E-Worksheets were also collected as data on the product's practicality.



Figure 3. Documentation of E-Worksheets Implementation

Stage 5. Evaluation
The Evaluation stage focused on examining the practicality and effectiveness of the developed interactive video-based E-Worksheets. Their effectiveness was determined by analyzing changes in students' creative thinking skills based on pretest and posttest scores, while practicality was analyzed based on student feedback and the feasibility of using the media during instruction. The effectiveness analysis was conducted using a normality test, the Wilcoxon Signed-Rank Test, and the N-Gain.

To examine changes in students' creative thinking skills following the use of the E-Worksheets, the pretest and posttest scores were initially subjected to a normality assessment. Normality was evaluated using the difference between the two sets of scores to identify the appropriate statistical test for subsequent analysis. The results of the Shapiro–Wilk test are presented in Table 5.

Table 5. Normality Test Results with Shapiro-Wilk

Data	Shapiro-Wilk (W)	p-value
Pretest-Posttest Difference	0.927	0.029

As shown in Table 5, the Shapiro–Wilk test yielded a W statistic of 0.927 and a p-value of 0.029, which is below the (<0.05) significance threshold. This finding indicates that the pretest–posttest difference scores were not normally distributed. Accordingly, the Wilcoxon Signed-Rank Test was used to analyze changes in students' creative thinking skills before and after the implementation of the E-Worksheets. The results of this analysis are presented in Table 6.

Table 6. T-Test Results (Wilcoxon Signed-Rank Test)

			Statistic	p
Pretest	**Posttest**	**Wilcoxon W**	0.00	<.001

Note. H_a μMeasure 1 - Measure 2 ≠ 0

The Wilcoxon Signed-Rank Test results in Table 6 revealed a W statistic of 0.00 and a p-value of less than 0.001, demonstrating a statistically significant difference in students' creative thinking skills before and after the implementation of the E-Worksheets. The mean score increased from 34.18 on the pretest to 73.36 on the posttest, suggesting an improvement in students' creative thinking skills following the use of the interactive video-based E-Worksheets.

Furthermore, an N-Gain analysis was performed to quantify the extent of improvement in students' creative thinking skills after the implementation of the E-Worksheets. The results of the N-Gain analysis are presented in Table 7.

Table 7. N-Gain Results of Students' Creative Thinking Ability

Indicator	Pretest	Posttest	N-Gain	Category
Fluency	2.81	6.27	0.67	Moderate
Flexibility	3.65	5.72	0.48	Moderate
Originality	2.03	5.84	0.64	Moderate
Elaboration	2.87	5.78	0.57	Moderate
Overall	**34.18**	**73.36**	**0.58**	**Moderate**

The results in Table 7 show that the N-Gain score was 0.58, placing the improvement in the moderate category. This finding suggests that the interactive video-based E-Worksheets contributed to enhances students' creative thinking skills regarding hydrocarbons.

In addition to effectiveness, an evaluation was also conducted to assess The practicality of the E-Worksheets was assessed through student response questionnaires completed after the learning sessions and observation sheets used to document students' activities throughout the learning process. A questionnaire was used to gauge students' responses regarding the media, learning activities, creative challenges, help features, ease of use, appearance and design, as well as independence and interest. Meanwhile, Observation sheets were used to evaluate the implementation of student activities during two sessions involving the E-Worksheets. The findings from the student response questionnaires regarding the use of the E-Worksheets are presented in Table 8.

Table 8. Results of Students Response Questionnaire

Aspect	Obtained Score	Maximum Score	Percentage (%)	Category
Interactive Learning Video	467	528	88.45	Very Practical
Learning Activities	452	528	85.60	Very Practical
Creative Challange	457	528	84.94	Very Practical
Help Features	346	396	87.37	Very Practical
Ease Of Use	434	528	82.19	Very Practical
Appereance And Design	459	528	86.93	Very Practical
Independence And Interest	346	396	87.37	Very Practical
Total	**2961**	**3432**	**86.27**	**Very Practical**

Based on Table 8, student responses regarding the use of E-Worksheets yielded a percentage of 86.27% and fell into the "very practical" category. All aspects received a percentage above 80%, with the highest percentage—88.45% for the interactive instructional videos. These results indicate that E-Worksheets are well-received and easy for students to use in learning about hydrocarbons.

Table 9. Results of Student Observation

Aspect	Obtained Score	Maximum Score	Percentage (%)	Category
Engagement in Interactive Video	187	198	94.44	Very Practical
Engagement in Activities	125	132	94.69	Very Practical
Concept Aplication	131	132	99.24	Very Practical
Creative Thinking Activities	222	264	84.09	Very Practical
Use of Assistance	95	132	71.97	Practical
Learning Independence	64	66	96.96	Very Practical
Interaction with E-Worksheets	182	198	91.91	Very Practical
Total	**1006**	**1122**	**89.66**	**Very Practical**

Based on Table 9, the results of observations of student activities during the use of E-Worksheets showed a percentage of 89.66% and fell into the "very practical" category. The observational data is a summary of student activities over two class sessions. Most aspects showed very good implementation, particularly in the application of concepts, which reached 99.24%. These observational results reinforce the findings from the student response questionnaire, indicating that E-Worksheets are practical for use in hydrocarbon instruction.

Interactive video-based e-worksheets achieved a content validity of 88.61% and a media validity of 90.27%, both of which fall into the highly feasible category. Regarding content validity, the highest percentage was obtained for content alignment (95.37%), while the lowest was for learning activities (81.25%). Regarding media validity, the aspects of interactivity, language, and design and layout scored 91.66%, while presentation and navigation scored 86.11%. These results indicate that the product meets the criteria for both content and media validity.

These findings align with those of Furqon & Novita. (2021), who developed inquiry-based e-worksheets to foster creative thinking skills in the topic of chemical equilibrium, as well as Lestari & Muchlis. (2021), who developed e-worksheets oriented toward Contextual Teaching and Learning to foster critical thinking skills in the topic of thermochemistry. Unlike those studies, these e-worksheets integrate interactive videos, guided activities, creative challenges, as well as assistance and feedback to support the four indicators of creative thinking: fluency, flexibility, originality, and elaboration. The use of visual and verbal elements is also consistent with the principles of multimedia learning described by Mayer (2021).

The development of these creative activities is linked to the research by Ernawati et al. (2022) on problem-based learning with scaffolding strategies, Hervyanti & Muchlis. (2021) on collaborative creativity, and Widodi et al. (2026) on inquiry-based digital worksheets. These studies highlight the importance of structured learning activities in supporting the development of students' ideas. Thus, the contribution of e-worksheets lies in the integration of various digital learning components specifically aimed at fostering creative thinking skills in hydrocarbon-related material. However, the contribution of each individual component cannot yet be determined separately because all components are used in an integrated manner.

The results of the student response questionnaire showed a percentage of 86.27% in the very practical category. The "interactive learning video" aspect received the highest percentage 88.45%, while "ease of use" received the lowest percentage at 82.19%. Meanwhile, the results of the observation of learning implementation reached 89.66%, falling into the "very practical" category. The "concept application" aspect received the highest percentage 99.24%, while "use of assistance" received the lowest percentage 71.97% and was categorized as "practical." These results indicate that e-worksheets received a positive response and can be used in learning activities, although the utilization of the assistance feature still needs to be improved.

These findings are consistent with the research by Lestari & Muchlis. (2021) on E-LKPD and by Aprilia & Lutfi. (2023) on the Chemistry Tricky Test Game regarding hydrocarbons. Although they employ different formats and approaches, these studies demonstrate the use of digital learning resources in chemistry education. In this study, student responses and observations showed that the integration of videos, guided activities, creative challenges, and help features can be effectively applied in the context of the hydrocarbon learning studied.

Students' average creative thinking skill scores increased from 34.18 on the pretest to 73.36 on the posttest. The results of the Wilcoxon signed-rank test indicated a significant difference between the two scores ($p < 0.001$), with an N-Gain of 0.58, classified as moderate. These results indicate an increase in creative thinking skill scores following instruction using e-worksheets.

These findings are consistent with those of Furqon & Novita. (2021), Ernawati et al. (2022), and Mulyasari & Mitarlis. (2025), who developed chemistry learning activities to support creative thinking skills. Widodi et al. (2026) also demonstrated the relevance of using guided-inquiry-based e-worksheets to develop creative thinking skills. Nevertheless, this study takes a different approach by integrating interactive videos and creative challenges into the hydrocarbon material.

At the indicator level, fluency achieved the highest N-Gain of 0.67, followed by originality (0.64), elaboration (0.57), and flexibility (0.48). All indicators fell within the moderate improvement category. These results indicate that improvements in students' ability to generate ideas were relatively higher than their ability to explore alternative approaches or perspectives. Therefore, activities that provide students with opportunities to compare various structures, consider alternative answers, and explain the reasons for their choices need to be strengthened, particularly to support the flexibility indicator.

Although there was an increase in scores, these results cannot yet be fully attributed to the use of e-worksheets. This study used a single-group pretest-posttest design without a comparison group; thus, the effects of the pretest experience, the learning process, and other external factors cannot yet be separated from the contribution of the product. Consequently, the research results are more appropriately interpreted as an increase in scores following the implementation of e-worksheets, rather than as evidence of a direct cause and effect relationship.

The use of interactive digital media is relevant to the characteristics of hydrocarbon material, which involves molecular structures, nomenclature, isomers, and chemical reactions. Pratama & Sukarmin. (2021) developed the HACE medium to address misconceptions about hydrocarbons, while Aprilia & Lutfi. (2023) examined the Chemistry Tricky Test Game on the same topic. Nora et al. (2025) also investigated interactive media based on socioscientific issues for hydrocarbon learning. Meanwhile, Sari et al. (2025) developed an E-LAPD based on the 7E Learning Cycle, focusing on chemical representation and critical thinking skills. Unlike these studies, these e-worksheets specifically focus hydrocarbon learning activities on four indicators of creative thinking.

The potential of interactive E-Worksheets to improve chemistry learning has been well-documented. Azizah & Dwiningsih. (2025) structured activities to illustrate how the use of interactive E-Worksheets enabled learners to represent multiple aspects of a chemical substance. Ferdiansyah & Hapsari. (2025) developed an interactive activity book for learning of hydrocarbons. Mahardhika et al. (2025) demonstrated the potential of interactive E-LKPD to enable learning independence of students. Digital worksheets are useful to support conceptual learning and may facilitate creative thinking, if the activities are planned based on the creativity indicators (Irawan et al., 2024). This approach is used by Janah & Hidayah. (2025) when integrating project-based activities in their E-Worksheets to promote creative thinking in green chemistry. Jamal et al. (2025) suggested that the use of electronic worksheets for chemistry learning improves students' creative thinking by showing fluency, flexibility, originality and elaboration. Based on their study, further research should adopt stronger designs, like a quasi-experimental design. Although the E-Worksheets incorporated in the present study facilitated students' creative thinking, its single-group pre-test/post-test design limited causal understanding.

Several limitations should be noted. First, the study was conducted on a single group without a control group, so generalizations and causal conclusions remain limited. Second, the use of pretests and posttests may introduce a test effect. Third, the study was conducted within a limited context of participants and subject matter. Furthermore, the contributions of videos, creative activities, and assistance and feedback have not been tested separately. Therefore, future research is recommended to include a control group, participants from more diverse school contexts, and independent testing of individual components. Follow-up assessments are also needed to determine the sustainability of improvements in creative thinking skills and the application of these products to other chemistry topics.

Overall, interactive video-based e-worksheets met the criteria for being highly feasible and practical in the context of hydrocarbon learning as studied. The increase in pretest-posttest scores and N-Gain indicates the development of creative thinking skills following implementation, although a causal relationship cannot yet be confirmed. The relatively lower N-Gain flexibility score also provides a basis for refining the learning activities. Thus, e-worksheets can serve as an alternative digital learning resource for teaching hydrocarbons, though further research is still needed to test the effectiveness and contribution of each component.

Conclusions

The interactive video-based E-Worksheets on hydrocarbons have been developed successfully using the ADDIE model. This resource contains instructional videos, structured learning activities, guidance, feedback and creative challenges to foster the learning of chemistry and provide students opportunities to creatively think across four dimensions, namely fluency, flexibility, originality, and elaboration. Expert judgment evaluated the content and the media used in developing the E-Worksheets and found them to be highly feasible with a score of 88.61% and 90.27% respectively. Student's feedback also rated the E-Worksheets highly practical with a score of 86.27%. After its use, mean score of creative thinking improved from pretest score of 34.18 to 73.36 on the posttest. Wilcoxon Signed-Rank test showed the improvement was significant ($p < 0.001$), and the N-Gain score was 0.58 showing an improvement of moderate level. Results of the E-Worksheets testing showed that it has the potential to improve creative thinking of students learning hydrocarbons. Results should be interpreted carefully, as the study utilized a single-group pretest-posttest design. Therefore, the observed changes cannot be solely attributed to the E-Worksheets. Other factors, including maturation, testing effects, and historical events, cannot be excluded. Additionally, the estimated effect size (approximately 2.40) should be considered with caution when other researchers plan studies in the field, as the current study is unable to determine the effect size related to the E-Worksheets in a comparative condition. Future studies should utilize a quasi-experimental design to better understand the effects of the E-Worksheets, and, if feasible, a randomized controlled design. Additional research should use a participant sample from multiple educational settings and predetermine the appropriate sample size using an a priori power analysis. For planning purposes, a two-tailed independent samples comparison, with a assumed medium effect size ($d = 0.50$), a significance level of 0.05, and statistical power of 0.80 would require approximately 64 students in each group. A more conservative planning scenario was assumed, as relying only on the preliminary effect-size estimate would provide less guidance. Future research should provide multiple opportunities for students to engage in activities to generate, explore and elaborate on varying possibilities.

References

Azizah, A. N., & Dwiningsih, K. (2025). Interactive E-worksheets for critical thinking in chemistry: A three-level representation approach to voltaic cells. Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran, 11(1), 387–396. https://doi.org/10.33394/jk.v11i1.14799

Aprilia, D. D., & Lutfi, A. (2023). The effectiveness of Chemistry Tricky Test game in online learning when Covid-19 pandemic. Journal of Chemistry Education Research, 7(1), 152–159. https://doi.org/10.26740/jcer.v7n1.p152-159

Brederode, M. E. van. (2025). Teaching chemistry as a creative subject. *Chemistry Education Research and Practice*, *26*(3). https://doi.org/10.1039/d5rp00068h

Dheadema, S. A., Muharini, R., Rasmawan, R., Enawaty, E., & Lestari, I. (2023). Video animasi sebagai media pembelajaran pada materi hidrokarbon. *Jurnal Inovasi Pendidikan Kimia, 17*(2), 116–123. https://doi.org/10.15294/jipk.v17i2.40212

Ernawati, M. D. W., Sudarmin, S., Asrial, A., Muhammad, D., & Haryanto, H. (2022). Creative thinking of chemistry and chemistry education students in biochemistry learning through problem based learning with scaffolding strategy. Jurnal Pendidikan IPA Indonesia, 11(2), 282–295. https://doi.org/10.15294/jpii.v11i2.33842

Falma, F. O., & Putra, A. H. (2025). Correlation between academic self-efficacy and digital competence: An empirical study on first year students. Journal of Counseling, Education and Society, 6(1), 1–9. https://doi.org/10.29210/08jces540300

Ferdiansyah, N. N., & Hapsari, N. D. (2025). Development of interactive chemistry activity book on hydrocarbon topics. Jurnal Penelitian Pendidikan IPA, 11(4), 996–1002. https://doi.org/10.29303/jppipa.v11i4.7587

Furqon, H. M., & Novita, D. (2021). Implementation of electronic student worksheet based on guided inquiry learning model on chemical equilibrium material to improve the students' creative thinking skills. JPPS (Jurnal Penelitian Pendidikan Sains), 11(1), 73–89. https://doi.org/10.26740/jpps.v11n1.p73-89

Hervyanti, R. A. F., & Muchlis. (2021). Pengembangan LKPD berbasis collaborative creativity untuk meningkatkan creative thinking skill pada materi asam basa. UNESA Journal of Chemical Education, 10(1), 66–75. https://doi.org/10.26740/ujced.v10n1.p66-75

Hidayah, R., Dwiningsih, K., Lutfi, A., & Sukarmin. (2026). Enhancing creative thinking skills in acid–base and electrochemistry: The development of inquiry-based student activity sheets integrated with practical kits. *Multidisciplinary Science Journal, 8*(11), 2026717. https://doi.org/10.31893/multiscience.2026717

Irawan, N. Z. P., Anwar, S., & Munawaroh, H. S. H. (2024). Designing chemistry teaching materials and worksheets to promote students' creative thinking skills: A systematic literature review. JIPI (Jurnal IPA dan Pembelajaran IPA), 8(4), 350–366. https://doi.org/10.24815/jipi.v8i4.41761

Jamal, S. N., Ibrahim, N. H., Abd Halim, N. D., Surif, J., Saputra, A., Tania, L., & Sunyono. (2025). Problem-based learning integrated with the direct creative thinking process (PBL-DCT) module in enhancing creativity in chemistry. Journal of Chemical Education, 102(10), 4289–4304. https://doi.org/10.1021/acs.jchemed.3c01237

Janah, S. N., & Hidayah, R. (2025). Development of E-Worksheet Project-Based Learning on green chemistry materials to improve students creative thinking skills. *Jurnal Pijar MIPA, 20*(3), 488–493. https://doi.org/10.29303/jpm.v20i3.8891

Johnstone, A. H. (1991). Why is science difficult to learn? Things are seldom what they seem. *Journal of Computer Assisted Learning, 7*(2), 75–83. https://doi.org/10.1111/j.1365-2729.1991.tb00230.x

Lestari, K. E., & Yudhanegara, M. R. (2017). Penelitian Pendidikan Matematika. Bandung: PT Refika Aditama.

Lestari, D. D., & Muchlis. (2021). Pengembangan e-LKPD berorientasi Contextual Teaching and Learning untuk melatihkan keterampilan berpikir kritis siswa pada materi termokimia kelas XI SMA. Jurnal Pendidikan Kimia Indonesia, 5(1), 25–33. https://doi.org/10.23887/jpk.v5i1.30987

Mahardhika, S. R., Dwiningsih, K., Arzety, T. N. I., Nuryanti, R., & Fathoni, R. (2025). Interactive E-LKPD based on CTL (Contextual Teaching Learning) assisted Wizer.me to train students' learning independence in hydrocarbons. Journal of Innovation in Educational and Cultural Research, 6(4). https://doi.org/10.46843/jiecr.v6i4.2351

Mayer, R. E. (2021). *Multimedia learning* (3rd ed.). Cambridge University Press. https://doi.org/10.1017/9781316941355

Miftahuddin, M., & Perdana, M. R. (2026). Integration of Islamic education and digital literacy in twenty-first century learning. Journal of Counseling, Education and Society, 7(1), 139–148. https://doi.org/10.29210/08jces682700

Mulyasari, Y., & Mitarlis. (2025). Pengembangan LAPD berbasis project-based learning dengan strategi mind mapping untuk meningkatkan keterampilan berpikir kreatif peserta didik pada materi kimia hijau. Jurnal Penelitian Pendidikan Matematika dan Sains, 9(1), 1–11. https://doi.org/10.26740/jppms.v9n1.p1-11

Nasution, I., Faeyza, A., Lestari, I., & Aini, N. (2025). Evaluasi program pendidikan. Journal of Counseling, Education and Society, 6(1), 23–32. https://doi.org/10.29210/08jces569000

Nora, M., Sholahuddin, A., Humaira, N., Rosita, F., & Rezani, M. I. (2025). Development and Evaluation of Articulate Storyline-Based Interactive Media : Integration of Socio-Scientific Issues in Hydrocarbon Learning to Enhance Students ' Critical Thinking Skills. *Jurnal Kimia Dan Pendidikan Kimia*, *10*(2), 421–444. https://doi.org/10.20961/jkpk.v10i2.105973

Nugroho, G. F., & da Ary, D. (2026). Development of ecosystem dance audiobook media to enhance the creativity of elementary school students. *Jurnal Eduscience, 13*(3), 970–980. https://doi.org/10.36987/jes.v13i3.9224

Nursiwan, W. A., Hanri, C., & Ibrahim, N. H. (2025). Scientific creativity in chemistry education: How is it measured? *International Journal of Research and Innovation in Social Science, 9*(7), 480–493. https://doi.org/10.47772/IJRISS.2025.90700038

Organisation for Economic Co-operation and Development. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Pratama, E. Y., & Sukarmin. (2021). Pengembangan media interaktif HACE (Hydrocarbon) dalam mereduksi miskonsepsi peserta didik dengan strategi conceptual change text pada materi hidrokarbon. Jurnal Teknologi Pendidikan, 14(1), 41–50. https://doi.org/10.24114/jtp.v14i1.22641

Rahma, J. N., & Muchlis, M. (2026). Embedded formative feedback in chemistry worksheets: A self-regulation approach to conceptual learning of the periodic table of elements. Journal of Counseling, Education and Society, 7(1), 168–177. https://doi.org/10.29210/08jces686200

Rossie, K., Dwiningsih, K., Setiyanti, A., & Setiawan, M. W. (2025). Development of interactive video-assisted worksheets: Enhancing students' visual intelligence. *Jurnal Eduscience, 12*(2), 437–449. https://doi.org/10.36987/jes.v12i2.6955

Sarbaitinil, S., Wardhani, R. D. K., Putranti, N., Latuconsina, A., & Rifai, M. (2026). Digital literacy-based learning strategies in shaping media-wise characters in the modern young generation. Journal of Counseling, Education and Society, 7(1), 299–307. https://doi.org/10.29210/08jces686700

Sari, R. F., Maulidiah, S. S. F., Agustin, L. N. D., & Novita, D. (2025). Validity of E-LAPD based on the Learning Cycle 7E model to improve critical thinking skills oriented to multiple chemical representations in reaction rate factors submaterial. Journal of Chemistry Education Research, 9(1), 21–28. https://doi.org/10.26740/jcer.v9n1.p21-28

Sjøberg, S. (2015). PISA and global educational governance: A critique of the project, its uses and implications. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(1), 111–127. https://doi.org/10.12973/eurasia.2015.1310a

Torrance, E. P. (1968). Examples and rationales of test tasks for assessing creative abilities. *The Journal of Creative Behavior, 2*(3), 165–178. https://doi.org/10.1002/j.2162-6057.1968.tb00099.x

Treagust, D. F., Chittleborough, G., & Mamiala, T. L. (2003). The role of submicroscopic and symbolic representations in chemical explanations. *International Journal of Science Education, 25*(11), 1353–1368. https://doi.org/10.1080/0950069032000070306

Van Brederode, M. E. (2025). Teaching chemistry as a creative subject. *Chemistry Education Research and Practice, 26*, 594–602. https://doi.org/10.1039/D5RP00068H

Widodi, B., Dwandaru, W. S. B., & Nyirahabimana, P. (2026). Developing a guided inquiry electronic student worksheet to foster students' creative thinking and collaboration skills. JPPS (Jurnal Penelitian Pendidikan Sains), 15(1), 1–16. https://doi.org/10.26740/jpps.v15n1.p1-16

Zulfa, M., Muliani, M., Sakdiah, H., Idris, S., & Ginting, F. W. (2023). Development of Powtoon-based audio-visual learning media to improve students' creative thinking ability on straight-motion materials. *Jurnal Eduscience, 10*(1), 8–18. https://doi.org/10.36987/jes.v10i1.3939