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Development of an Interactive E-Module Based on *Google Sites* to Support Chemistry Learning on Molecular Shape Material

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Abstract

Students face difficulties visualizing abstract molecular geometry concepts because current teaching materials lack 3D modeling support. To overcome this, this research aims to develop a valid, practical, and effective *Google Sites*-based e-module for learning molecular geometry. This study applied the Research and Development (R&D) method using Thiagarajan's 4D model. Data collection instruments included expert validation questionnaires, teacher perception surveys, student response questionnaires, pretest-posttest assessments, and learning observation sheets. The e-module's feasibility was assessed by expert lecturers and chemistry teachers. Practicality data were gathered through chemistry teachers' perceptions, observer sheets, and questionnaires from 31 eleventh-grade students. Effectiveness data were collected involving the same 31 eleventh-grade subjects. Expert validation results showed average percentage s of 87.73% for media and 86.5% for material, indicating the e-module is valid with "very high" criteria. During the limited trial phase, teacher and student perceptions scored 90.5% and 85.73%, demonstrating the e-module's practicality with "very high" criteria. The product's effectiveness in learning is evidenced by an average student N-gain score of 0.54 (moderate category). Based on these results, the developed e-module is declared feasible, practical, and effective for use as an educational medium.

Keywords: *e-module, interactive, molecular geometry, google sites. 4D.*

Abstrak

Peserta didik mengalami kesulitan dalam memvisualisasikan materi bentuk molekul yang abstrak karena bahan ajar yang digunakan belum mendukung permodelan 3D. Untuk mengatasi permasalahan penelitian ini bertujuan untuk mengembangkan e-modul berbasis *Google sites* yang layak, praktis dan efektif pada materi bentuk molekul. Instrumen pengambilan data pada penelitian ini adalah angket validasi ahli, angket presepsi guru, angket respon peserta didik, pretest-postest, dan lembar keterlaksanaan pembelajaran. Penelitian ini menerapkan metode R&D dengan model 4D yang dikembangkan oleh Thiagarajan. Pada tahap pengumpulan data kelayakan e-modul dinilai oleh validator dosen ahli dan guru kimia. Data kepraktisan e-modul diperoleh melalui penilaian presepsi guru kimia, lembar observasi dari observer, serta angket respon dari 31 peserta didik kelas XI. Pengumpulan data keefektifan melibatkan 31 peserta didik kelas XI sebagai subjek. Berdasarkan validasi ahli diperoleh rata-rata persentase untuk media dan materi sebesar 87,73% dan 86,5% yang menunjukkan bahwa produk e-modul valid dengan kriteria "sangat tinggi". Pada tahap uji coba terbatas, presepsi guru dan peserta didik sebesar 90,5% dan 85,73% yang menunjukkan bahwa produk e-modul praktis dengan kriteria "sangat tinggi". Keefektifan produk e-modul dalam pembelajaran dapat dilihat dari rata-rata n-gain peserta didik sebesar 0,54 dengan kategori sedang. Berdasarkan hasil tersebut, e-modul dinyatakan layak, praktis dan efektif digunakan sebagai media pembelajaran.

Kata Kunci: e-modul, interaktif, bentuk molekul, *google sites*, 4D.

Introduction

Chemistry encompasses inherently abstract concepts that cannot be directly observed, touched, or seen. These abstract materials can primarily be understood through theoretical explanations, symbols, or models, thus requiring strong illustration and visualization skills to accurately conceptualize them. One specific topic that frequently presents learning challenges due to its abstract nature is molecular geometry (Wahdatillah et al., 2022). Comprehending molecular geometry necessitates excellent spatial visualization and a high capacity for abstraction (Shakina & Afrianis, 2021). In practice, many students struggle to depict molecular shapes; because these structures are not directly observable, students often fail to project accurate mental images of the molecules (Anshori, 2021). Therefore, educators must provide appropriate instructional facilitation to help students navigate the abstract nature of chemistry learning.

Interactive e-modules have emerged as an innovative solution to address the abstract nature of chemistry learning (Silaban et al., 2022). An e-module represents the digital transformation of a printed module's content, integrating text, images, videos, animations, and interactive elements such as quizzes, specifically designed to facilitate independent learning (Marta, 2019). Interactive multimedia featuring animations and user simulations has proven capable of visualizing abstract chemical concepts (Ainyn & Dwiningsih, 2022). Furthermore, the utilization of animations and simulations has been shown to effectively increase student engagement by enabling independent exploration (Penn & Ramnarain, 2019).

The use of website-based interactive e-modules has proven effective in enhancing students' comprehension of abstract chemistry concepts (Azizah & Ardhana, 2023). One platform that can be utilized to develop these e-modules is *Google Sites. Google Sites* is a user-friendly learning application as it only requires a smartphone and an internet connection; it eliminates the need to download additional applications and is easily accessible to both students and teachers via *Google* (Adzkiya & Suryaman, 2021). Furthermore, *Google Sites* is highly effective for developing educational media in senior high schools, achieving a teacher satisfaction rate of 95% due to its ease of collaboration and accessibility (Pitri et al., 2024).

The implementation of interactive e-modules in Indonesia remains uneven, particularly for topics such as molecular geometry. The utilization rate of interactive educational media in chemistry learning is still considered low and suboptimal (Widarti et al., 2022). This aligns with the findings of Hijriansyah et al. (2024), who identified a significant shortage of interactive instructional media. These conditions underscore the need to develop digital-based learning tools capable of fostering active student engagement in chemistry education. Previous research by Pitri et al. (2024) successfully developed a *Google Sites*-based chemistry e-module for hydrocarbon compounds that enhanced student motivation; however, this development was limited to hydrocarbons, with a primary focus on nomenclature and 2D structures. This contrasts significantly with molecular geometry, which inherently demands 3D visualization. Consequently, the development of a *Google Sites*-based interactive e-module for molecular geometry is anticipated to effectively support chemistry instruction by incorporating essential elements like 3D animations and interactive assessments tailored for eleventh-grade senior high school students.

Based on a questionnaire administered to 31 students at SMA Negeri 1 Abung Semuli, an overview was obtained regarding the classroom chemistry learning conditions and students' needs for digital instructional media. The data indicate that the classroom learning process has not fully integrated technology as supplementary learning material. A majority of students (61.3%) feel that the current learning resources are ineffective in aiding comprehension, while 64.5% consider them visually unappealing. This ineffectiveness stems from the use of teaching materials that lack digital technology integration, thereby failing to present three-dimensional (3D) molecular modeling. Consequently, students experience misconceptions when required to translate two-dimensional (2D) structures into three-dimensional (3D) forms. This poses a significant problem, as 83.9% of students find the molecular geometry topic difficult to understand, primarily due to its abstract nature and high demand for visualization. Conversely, there is a strong learning preference for digital media, with 90.3% of students expressing a preference for interactive platforms. A substantial gap exists, however, as students reported never having used an e-module previously. The need for this instructional innovation is fully supported by the students, with 93.5% believing that such media would help them understand the material more effectively.

Teachers stated that e-modules had never been utilized in the eleventh-grade learning process. This absence is attributed to a lack of time for developing independent instructional media, as well as insufficient technical skills required to create e-modules. Consequently, the utilization of digital technology in learning remains suboptimal. As a result, students' learning interest declines, and they encounter difficulties in visualizing abstract concepts. Nevertheless, all teachers agreed that the implementation of *Google Site*s-based interactive e-modules holds significant potential for increasing student engagement. The educators assessed that interactive media featuring molecular geometry visualizations would greatly assist students in comprehending abstract concepts that are difficult to visualize solely through traditional textbooks.

Based on the aforementioned rationale, this research aims to develop a *Google Sites*-based interactive e-module to support chemistry learning on the topic of molecular geometry for eleventh-grade senior high school students. The results of this development are expected to serve as a reference for teachers and schools in fostering an innovative and inclusive learning environment. Consequently, this background leads to the formulation of the research problems to be further investigated, specifically regarding the validity, practicality, and effectiveness of the developed product.

Method

This research is a developmental study utilizing the Research and Development (R&D) method with the 4D model, which consists of four stages: Define, Design, Develop, and Disseminate. The Define stage was conducted to analyze the needs of students and teachers regarding digital instructional media. The Design stage involved planning the visual layout and structure of the *Google Sites*-based interactive e-module. The Develop stage encompassed the product creation process and validation testing by material and media experts, as well as readability testing. The Disseminate stage is the phase where the developed product is distributed (Thiagarajan et al., 1974). The strength of the 4D model lies in the Develop stage, which relies on expert appraisal to ensure the media and materials achieve a valid status. The product is then revised based on the expert validators' suggestions before being tested to determine its practicality and potential effectiveness within a limited single-class trial (Taufik et al., 2022).

This research was limited to the third stage, the Develop phase. This limitation was established because the study focused on producing a valid and feasible product based on the results of expert validations and a limited trial. The Disseminate stage was not conducted, as the research has not yet reached the phase of broad product distribution to users on a large scale. Furthermore, constraints regarding research time and implementation scope were primary considerations in restricting the developmental stages. The developmental research method was employed to produce a specific instructional product; in this study, the developed product is a *Google Sites*-based interactive e-module designed to support chemistry learning on the topic of molecular geometry.

Research Procedures

Define

The define stage aims to establish the fundamental learning requirements through a comprehensive series of analyses. This process begins with a preliminary analysis to identify essential problems in chemistry instruction using questionnaires distributed to teachers, followed by a student analysis to map the cognitive characteristics and learning motivation of 31 students at SMA Negeri 1 Abung Semuli. Subsequently, a task analysis is conducted to specify the skills required by students, alongside a concept analysis that systematically structures the molecular geometry material, encompassing VSEPR theory, electron domain theory, and hybridization. The findings from these analyses culminate in the formulation of learning objectives, which serve as a strategic foundation for designing achievement indicators, evaluation instruments, and the specifications for developing the instructional materials.

Design

The design stage focuses on formulating the instructional media design based on the fundamental needs established during the define stage. This stage includes outlining product criteria to ensure the e-module meets interactive standards and integrates 3D visualizations, as well as selecting the media, which establishes the use of a *Google Sites*-based e-module for the molecular geometry topic. The process proceeds with selecting a presentation format that systematically organizes the material hierarchy, visual elements, and evaluation instruments to optimize the potential improvement in student learning outcomes. This design stage concludes with the preparation of the initial draft (Draft I), which is refined through supervisor reviews, alongside the formulation of data collection instruments including validation sheets, practicality questionnaires, observation sheets, and test instruments—to be implemented in the develop stage.

Develop

The develop stage aims to produce a final instructional material product whose feasibility has been rigorously tested through expert validation and empirical trials. This phase initiates with validation testing conducted by expert lecturers assessing both material and media aspects alongside educational practitioners (teachers) to evaluate the e-module's feasibility. The assessment outcomes serve as the fundamental basis for revisions, refining Draft I into Draft II. The revised prototype is subsequently implemented in a limited trial to measure the product's practicality based on teacher observation results and student response questionnaires. Finally, this stage concludes by evaluating the e-module's potential effectiveness using a One-Group Pretest-Posttest Design without a control group. Within this specific design, the estimated improvement in students' cognitive understanding is quantitatively analyzed by calculating the score difference (N-gain) between the pretest and posttest.

Data Collection and Analysis Techniques

The data collection techniques used in this research are:

Table 1. Data Collection Techniques

Research Data	Data Source	Instrument	Implementation in the 4D Stage
Validity	Expert lecturers and high school chemistry teachers	Validity questionnaire	*Develop*
Practicality	High school chemistry teachers, eleventh-grade students, and observers	Observation sheet and practicality questionnaire	*Develop*
Effectiveness	Eleventh-grade students	Test	*Develop*

a. Validity

Data regarding the validity of the product an interactive e-module created using *Google Sites* for the molecular geometry topic in chemistry learning were collected using material and media expert assessment questionnaires modified from Ramadanti et al. (2021). These questionnaires were administered to three expert lecturers at Universitas Lampung and two chemistry teachers at SMA Negeri 1 Abung Semuli. The validation results guided the researcher in revising the instrument to ensure its feasibility for use. Data were obtained from the completed questionnaires utilizing a Likert scale with a score range of 1 to 4, modified from Arikunto (2016). The questionnaire results were subsequently analyzed through calculations using an equation adapted from Sudjana (2005).

$$\%J_{in} = \frac{\sum J_{in}}{N} \times 100\%$$

The resulting assessment scores (p) were subsequently converted to determine the quality level of the developed product. This score conversion was adapted from Arikunto (2016) as presented in Table 2.

Table 2. Practicality Score Conversion

Percentage Score	Criteria
0% - 20%	Very low validity / Invalid
20,1% - 40%	Low validity / Less valid
40,1% - 60%	Moderate validity / Fairly valid
60,1% - 80%	High validity / Valid
80,1% - 100%	Very high validity / Very valid

b. Practicality

Data collection to determine the product's practicality was conducted using observation sheets and by distributing two questionnaires, namely a teacher perception questionnaire and a student response questionnaire.

1) Analysis of Learning Implementation Observation Sheet Data

In the product practicality analysis stage, the assessment was based on observation sheets. The observation score data for learning implementation were tabulated by assigning a score of 1 for "Yes" and 0 for "No". The observation results of learning implementation were calculated as a percentage using a formula adapted from Sudjana (2005)

$$k = \frac{score\ of\ each\ aspect}{maximum\ score\ of\ each\ aspect} \times 100\%$$

The learning implementation score (k) results were then converted to determine the quality level of the developed product.

2) Data Analysis of Teacher and Student Perceptions

Students and teachers were asked to fill out a questionnaire using a modified Likert scale with a score range of 1 to 4. This scale was used to measure indicators for every aspect of practicality and perception, which evaluates the extent to which the e-module learning medium is considered practical. The completed questionnaire results were then analyzed as a percentage based on calculations using an equation adapted from Sudjana (2005).

$$p = \frac{\sum Obtained\ score}{\sum Total} \times 100\%$$

The assessment score (p) results were then converted to determine the quality level of the developed product. The assessment score conversion was adapted from Arikunto (2016) in Table 3.

Table 3. Practicality Score Conversion

Score Persentage	Criteria
0% - 20%	Very low practicality / Impractical
20,1% - 40%	Low practicality / Less practical
40,1% - 60%	Moderate practicality / Fairly practical

Score Persentage	Criteria
60,1% - 80%	High practicality / Practical
80,1% - 100%	Very high practicality / Very practical

c. Effectiveness

This stage was conducted to observe how the use of the e-module facilitates students in learning through pretest and posttest instruments. The comparison of these two test results is used as an indicator to examine the initial impact of using the e-module. The pretest and posttest scores are converted into grades, which are then used to calculate the N-gain in order to determine the magnitude of the difference between the students' pretest and posttest scores. The N-gain is obtained by subtracting the pretest score from the posttest score, divided by the maximum score minus the pretest score, which, if written as an equation according to Hake (2002).

$$N - gain = \frac{Pretest - Postest}{Ideal\ maximum\ score - Pretest\ score} \times 100\%$$

The obtained N-gain results were then converted into the N-gain effectiveness interpretation category, thus yielding a standardized improvement score. The assessment score conversion was adapted from Hake (2002) in Table 4.

Table 4. N-gain Category

N-gain	Categoy
N-gain ≥ 0,7	High
0,3 ≤ *N-gain* < 0,7	Moderate
N-gain < 0,3	Low

Results and Discussion

This development research utilized the 4D model, limited to the Develop stage, to produce instructional material in the form of a *Google Sites*-based interactive e-module for the molecular geometry topic. Aligned with the Merdeka Curriculum, the e-module integrates 3D visualization and discovery learning syntax. Based on Thiagarajan’s (1974) framework, the product's feasibility was evaluated through validity, practicality, and potential effectiveness indicators. Results from the limited trial confirmed that the product is not only valid and practical in terms of material presentation and user-friendliness but also demonstrates good potential effectiveness in supporting student learning.

Figure 1. Cover *Google Sites*-Based Interactive E-Module

a. Validity of the *Google Sites*-Based Interactive E-Module

The validation of this product in the media section consists of the user interface, graphics, and ease of use, while the material section comprises the aspects of Self-Instruction, Self-Contained, Stand Alone, Adaptive, and User Friendly.

1) Media validation

In media validation, there are three assessed aspects: user interface, graphics, and ease of use, with the recapitulation based on validators as follows.

Table 5. Media Validation Results

No.	Aspect	Average Score	Average Percentage	Criteria
1.	User Interface	17,71	88,55%	Very Valid
2.	Graphics	17,43	87,15%	Very Valid
3.	Ease of Use	17,5	87,5%	Very Valid
	Average Score	**17,55**	**87,73%**	**Very Valid**

Based on the recapitulation of assessments by the validators, the developed media has met high-level validity criteria and is declared highly feasible for use. The assessment indicates that all media components, from the visual appeal of the interface and graphic design quality to the operational ease of navigation for users, have been very well-designed and optimally integrated. Although quantitatively the media design is categorized as highly feasible, follow-up actions in the form of product refinement were still conducted based on the notes and suggestions for improvement from the validators. This qualitative refinement process is an essential part of the development stage to ensure that the resulting educational media is truly optimal and free from technical constraints before broader use.

2) Material validation

In material validation, there are five assessed aspects: Self-Instruction, Self-Contained, Stand Alone, Adaptive, and User Friendly, with the recapitulation based on validators as follows

Table 6. Material Expert Validation Resultsi

No.	Aspect	Average Score	Average Percentage	Criteria
1.	*Self-Instruction*	17	85%	Very valid
2.	*Self-Contained*	17,75	88,75%	Very valid
3.	*Stand Alone*	16	80%	Very valid
4.	*Adaptive*	16,67	83,35%	Very valid
5.	*User friendly*	20	100%	Very valid
	Average Score	**17,30**	**86,5%**	**Very valid**

The data in Table 6 shows the scores for each assessment aspect, comprising the Self-Instruction aspect at 85%, Self-Contained at 88.75%, Stand Alone at 80%, Adaptive at 83.35%, and the User Friendly aspect reaching 100%. Overall, the assessment resulted in an average score of 17.30 with an average percentage of 86.5%, falling into the "very valid" criteria.

To provide a visual overview of the evaluation results, a summary of both the media and material expert validations is presented in Figure 1. The bar chart illustrates the final average percentages achieved in each validation category, further confirming the high feasibility of the developed e-module.

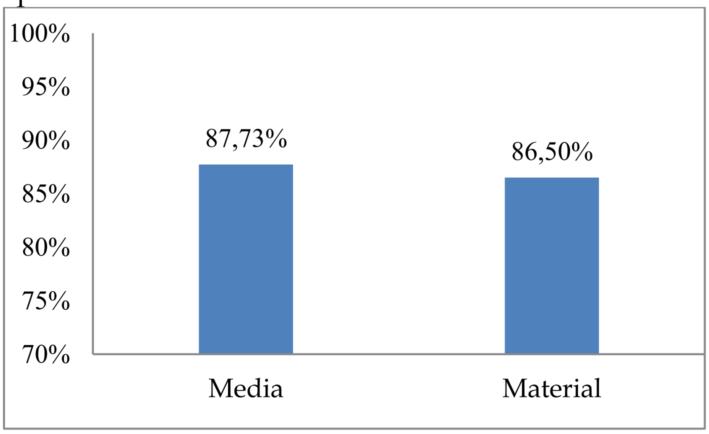

Figure 1. Recapitulation of Expert Validation

Regarding validity, the assessments from media and material experts achieved averages of 87.73% and 86.5%, respectively, classifying it as a highly feasible medium (Arikunto, 2016). Although the quantitative criteria for "very valid" were met, the validators still provided several suggestions for refinement to perfect the e-module's quality. Suggestions from media experts focused on refining the interface and interactivity, such as improving the visual cover, harmonizing layout colors, and adding a feature for answer verification. Meanwhile, material experts provided feedback regarding conceptual and pedagogical accuracy, including adjusting the *discovery learning* syntax, correcting the notation of chemical symbols, providing a discussion rubric in the evaluation section, and stipulating the necessity to accurately visualize Lone Pairs (PEB) on the central atom in the molecules' 3D representation. Following up on this feedback, a comprehensive refinement phase was conducted, encompassing design responsiveness to support learning engagement (Dermawanti & Saino, 2026).

b. Practicality of the *Google Sites*-Based Interactive E-Module

After improvements were made based on the validators' suggestions during expert validation, a limited trial was subsequently conducted. This practicality test or limited trial was carried out to determine the e-module's practicality based on feedback from teachers and students.

1) Learning Implementation

The implementation of learning using the *Google Sites*-based interactive e-module can be measured through observation sheets completed by observers during the learning process. This observation was conducted by two observers: one chemistry teacher and one chemistry education university student, tasked with directly observing the progress of the learning activities. The recapitulation results of this learning implementation can be seen in Table 7.

Table 7. Learning Implementation Results

No.	Aspect	Average Score	Percentage	Kriteria
1.	Implementation of Learning Steps	0,9	90%	Very Practical
2.	Implementation of the Learning Social System	1	100%	Very Practical
3.	Implementation of Learning Reaction Principles	0,8	80%	Practical
	Average	**0,9**	**90%**	**Very Practical**

The data in Table 7 concerns the results of learning implementation focusing on the assessment of three aspects. The aspect of learning steps implementation obtained an average score of 0.9 with a percentage of 90% and criteria of "very practical". Furthermore, the aspect of the learning social system implementation reached an average score of 1 with a percentage of 100%, which is also categorized as "very practical". The aspect of learning reaction principles implementation obtained an average score of 0.8 with a percentage of 80% and "practical" criteria. Overall, the average assessment of these three aspects reached a score of 0.9 with a percentage of 90%. Based on this average score, it can be concluded that the results are very practical and this *Google Sites*-based interactive e-module can be used to support student learning on the topic of molecular geometry.

2) Teacher Perception and Student Response Results

The results of the teacher's perception toward the e-module can be seen as follows.

Table 8. Teacher Perception Results

No.	Aspect	Average Score	Percentage	Criteria
1.	Ease of Use	11	91,6%	Very practical

2.	Presentation	10,9	90,8%	Very practical
3.	Usefulness	10,67	88,9%	Very practical
	Average	**10,86**	**90,5%**	**Very practical**

Based on the data analysis results, it can be concluded that the developed e-module received highly positive responses and was considered very practical by teachers. The evaluation, which focused on three aspects namely ease of use, presentation, and usefulness demonstrated a consistently high level of satisfaction. The highest appreciation in the ease of use aspect indicates that this e-module features an intuitive and user-friendly interface design, thus causing no technical issues during operation. Concurrently, the excellent assessment in the presentation and usefulness aspects proves that the enclosed material is structured clearly and is relevant to learning needs. Overall, these results confirm that the interactive e-module has met excellent practicality standards, making it a viable educational medium to support the effectiveness of teaching and learning activities.

The results of student responses to the developed e-module were obtained by filling out a questionnaire that covered the aspects of ease of use, attractiveness, and usefulness. The average percentages of these assessment results are presented in Table 9.

Table 9. Recapitulation of Student Response Results

No.	Aspect	Average Score	Percentage	Criteria
1.	Ease of Use	100,8	81,29%	Very practical
2.	Attractiveness	110,5	88,87%	Very practical
3.	Usefulness	107,8	86,93%	Very practical
	Average	**106,3**	**85,73%**	**Very practical**

Based on the assessment recapitulation results, the developed e-module proved to be highly practical and received positive feedback from students across all measured aspects. The primary strengths of this e-module are sequentially demonstrated by the high scores achieved in the aspects of attractiveness, usefulness, and ease of use. The high score in the attractiveness aspect emphasizes that the e-module possesses a strong appeal for its users. Furthermore, the achievement in this aspect, coinciding with high assessments in the usefulness and ease of use aspects, highlights the harmony between the e-module's visual design and functionality. This proves that the e-module not only excels in terms of visual presentation appeal but is also balanced with highly adequate functionality. Overall, these results indicate that the e-module can be easily operated by students, both independently and during learning activities.

To provide a comprehensive overview of the overall practicality test, the average percentage scores from the three main evaluation aspects namely learning implementation, teacher perception, and student responses were synthesized into a final summary. The compiled data indicates that the overall learning implementation reached 90%, the teacher perception aspect scored 90.50%, the student response aspect achieved 85.73%. The visual representation comparing these three practicality aspects is summarized in Figure below.

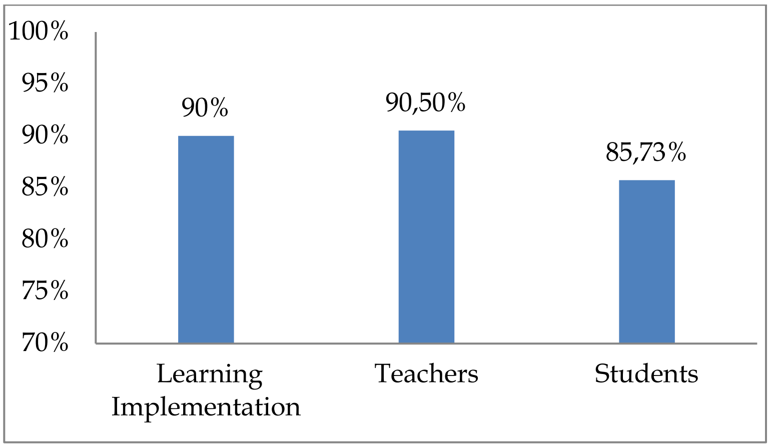

Figure 2. Recapitulation of Practicality Results

Regarding practicality, the limited trial at SMA Negeri 1 Abung Semuli proved that this product is highly applicable in the field. The overall practicality achieved the "very practical" category, supported by a learning implementation percentage of 90%, educator responses of 90.50%, and student responses of 85.73%. When evaluated comprehensively, these figures strongly confirm that the developed *Google Sites*-based interactive e-module for molecular geometry is not only highly feasible but also exceptionally user-friendly for both educators and learners in actual classroom environments**.** This high level of practical application is closely tied to the media's design. The visual appeal of this e-module proved to be a key factor in sparking student interest (Murdianti, 2024). Furthermore, the combination of an intuitive interface, straightforward navigation, and interactive visualization successfully reduced students' cognitive load in studying abstract concepts (Rusli et al., 2024).

c. Effectiveness of the *Google Sites*-Based Interactive E-Module

This effectiveness test was conducted using a One-Group Pretest-Posttest Design, where the evaluation focused on a single experimental group without involving a control class for comparison. The comparison of scores obtained by students from the pretest and posttest was then analyzed to observe the significance of the students' score improvement using N-gain. This N-gain analysis serves to quantitatively measure the extent of improvement in students' understanding and learning outcomes, allowing conclusions to be drawn regarding the product's level of effectiveness when implemented in learning activities.

1) Student Pretest and Posttest Results

The students' pretest and posttest score results can be seen in Table 10.

Table 10. Pretest and Posttest Results of Students

Aspect	Average	Lowest Score	Highest Score
Pretest	55,08	29	81
Posttest	79,73	45	100

During the pretest, the students' initial ability showed an average score of 55.08, with the lowest score at 29 and the highest score reaching 81. After the learning process or treatment was applied, the posttest results demonstrated a positive improvement across all assessment indicators. The students' average score increased to 79.73. Correspondingly, the lowest student score also increased to 45, and the highest score successfully reached the maximum score of 100. The improvement across these three aspects (average, lowest score, and highest score) indicates an upward trend in students' initial understanding of the molecular geometry material, and the effectiveness level of this treatment will be further analyzed using the N-gain test.

2) Student N-gain Results

The N-gain test is used to measure the magnitude of the improvement in students' comprehension before and after utilizing the *Google Sites*-based interactive e-module for molecular geometry material. Through the calculation of this test, the category of learning outcome improvement achieved during the trial stage can be determined. This provides a more objective overview of how well the developed product supports the learning process. The results revealed that the average student pretest score was 55.08, which increased to 79.73 on the posttest. The N-gain calculation result shows a value of 0.54, which falls into the "moderate" category. These results demonstrate that the use of the developed interactive e-module is capable of enhancing student learning outcomes on the Molecular Geometry topic with an improvement level classified within the moderate category.

Table 11. N-gain Category Distribution

N-gain Category	Number of Students	Percentage
High	9	29,03%
Moderate	17	54,8%
Low	5	16,13%

Based on the N-gain calculation conducted on 31 students, the details of the improvement category distribution can be seen in the table. The data distribution reveals that 9 students, equivalent to 29.03%, are in the "high" category, and the majority, namely 17 students with a percentage of 54.8%, are in the "moderate" category. Meanwhile, there are 5 students, or 16.13%, whose achievements fall into the "low" category. Overall, these achievements align with the upward trend in the students' average scores, moving from 55.08 during the pretest to 79.73 on the posttest. The fact that the majority of students reached the moderate to high category ranges indicates a positive increase in understanding following the treatment.

The effectiveness evaluation of the e-module, conducted using a One-Group Pretest-Posttest Design, revealed a meaningful transformation in students' material mastery. The average score significantly increased from 55.08 to 79.73. Based on Hake's (2002) criteria, the N-gain test recorded a score of 0.54 (moderate category), with 84.7% of students achieving improvement in the moderate to high ranges. This finding aligns with Maharani (2025), which states that flexible visual information assists students in better retaining knowledge and learning independently. However, consistent with the limitations of the 4D model's Develop stage and the absence of a control class, these results primarily serve as an empirical indication of the product's potential effectiveness rather than an absolute measure. Overall, the accumulated data convincingly demonstrates that the developed *Google Sites*-based interactive e-module is highly valid, practical, and possesses strong potential to effectively support chemistry learning on the topic of molecular geometry.

Conclusion

Based on the research results, the *Google Sites*-based interactive e-module on the molecular geometry topic is declared very valid (media expert 87.73%; material expert 86.5%) and very practical (learning implementation 90%; teacher perception 90.5%; student response 85.73%). Furthermore, this product is also proven to be effective as an initial indicator of improving student comprehension during the *Develop* stage, demonstrated by the increase in the average score (from a pretest of 55.08 to a posttest of 79.73) with an achieved N-gain of 0.54 (moderate category).

References

Adzkiya, D. S., & Suryaman, M. (2021). Penggunaan Media Pembelajaran Google Site dalam Pembelajaran Bahasa Inggris Kelas V SD. *Educate: Jurnal Teknologi Pendidikan, 6*(2). https://doi.org/10.32832/educate.v6i2.4891

Ainyn, Q., & Dwiningsih, K. (2022). Interactive Multimedia by Stimulating Visual-Spatial Intelligence Trial. *THABIEA : Journal Of Natural Science Teaching, 5*(1), 34. https://doi.org/10.21043/thabiea.v5i1.9820

Anshori, A. F. J., Priyasmika, R., & Purwanto, K. K. (2021). Hubungan Kecerdasan Spasial-Visual dan Prestasi Belajar pada Materi Bentuk Molekul. *Jurnal Kependidikan, Pembelajaran, dan Pengembangan, 3*(2), 102–107. https://doi.org/10.55273/karangan.v3i2.134

Arikunto, S. (2016). *Dasar-dasar Evaluasi Pendidikan Edisi 2*. Jakarta: Rineka Cipta.

Azizah, A. L., & Ardhana, I. A. (2023). Pengembangan Elektronik Modul (EModul) interaktif berbasis web dengan pendekatan saintifik pada materi ikatan kimia. *Jurnal Riset Pendidikan Kimia, 13*(1), 8–15. https://doi.org/10.21009/JRPK.131.02

Dermawanti, P. E., & Saino. (2026). Pengembangan Media Pembelajaran Interaktif Berbasis Genially Untuk Meningkatkan Pemahaman Materi Siswa Elemen Pengelolaan Bisnis Ritel Fase F Siswa Kelas XI di SMK Labschool Unesa 1 Surabaya. *Jurnal Ilmiah Wahana Pendidikan, 12*(2.C), 26-45. https://jurnal.peneliti.net/index.php/JIWP/article/view/12510

Hake, R. R. (2002). Relationship of individual student normalized learning gains in mechanics with gender, high-school physics, and pretest scores on Mathematics and Spatial Visualization. *Physics Education Research Conference*, 1-14.

Hijriansyah, R., Aisyah, R., Sunarya, R. R., & Purliantoro, D. (2024). Implementation of Problem Solving-Based Electron Configuration E-Modules tao Improve Student Learning Outcomes. *Jurnal Pendidikan Kimia Indonesia, 8*(1), 11–20. https://doi.org/10.23887/jpki.v8i1.70029

Maharani, A. (2025). Pemanfaatan pengembangan e-modul IPA interaktif berbasis Android untuk siswa SMP. *JSE: Journal Sains and Education, 3*(1), 24–30.

Marta, L. C. (2019). The Integration of Digital Devices into Learning Spaces According to the Needs of Primary and Secondary Teachers. *TEM Journal*, 8(4), 1351-1358. https://doi.org/10.18421/TEM84-36

Murdianti, W. (2024). Inovasi Media Pembelajaran Digital untuk Meningkatkan Minat Belajar di Era Digital. *Innovative: Journal Of Social Science Research, 4*(1), 13200–13212. https://doi.org/10.31004/innovative.v4i1.16565

Pamungkas, A., Dewantari, T., Tohir, A., ., S., & Soraya, R. (2026). The Effectiveness of the Flipped Classroom Model in Improving English Reading Comprehension of Seventh-Grade Junior High School Students. Journal of Cultural Analysis and Social Change, 11(1), 999–1006. https://doi.org/10.64753/jcasc.v11i1.4009

Pamungkas, A.,& Tohir, A. (2026). Evaluating the Effectiveness of Technology-Based Learning through an Evidence-Based Education Framework. (2026). EduTech Journal, 2(3), 1-12. https://doi.org/10.62872/4zkfbq42

Penn, M. & Ramnarain, U. (2019). A Comparative Analysis of Virtual and Traditional Laboratory Chemistry Learning. *Perspectives in Education, 37*(2), 80-97. https://doi.org/10.18820/2519593x/pie.v37i2.6

Pitri, D., Musdansi, D. P., & Murwindra, R. (2024). Pengembangan Media Pembelajaran Interaktif Google Sites pada Sub Materi Tata Nama Senyawa Hidrokarbon di SMA/MA. *JOM FTK UNIKS, 4*(2), 425–432.

Putra, H. S., Tohir, A., & Mashari, A. (2025). Analysis of Teacher' Digital Literacy Competencies as Support for Teachers' Skills at SDN 7 Gunung Agung. Jurnal Evaluasi dan Pembelajaran, 7(2), 206–216. https://doi.org/10.52647/jep.v7i2.400

Ramadanti, F., Mutaqin, A., & Hendrayana, A. (2021). Pengembangan E-Modul Matematika Berbasis PBL (Problem Based Learning) pada Materi Penyajian Data untuk Siswa SMP. *Jurnal Cendekia: Jurnal Pendidikan Matematika, 5*(3), 2733-2745. https://doi.org/10.31004/cendekia.v5i3.759

Rusli, T. S., Ali, A., Ristiani, R., Sukmawati, & Yuliana, C. (2024). Pelatihan pembuatan media pembelajaran interaktif di SD Inpres Pir II. *J-DEPACE, 7*(1), 26–33. https://doi.org/10.34124/jpkm.v7i1.165

Shakina, A. & Afrianis, N. (2021). Desain dan Uji Coba Media Pembelajaran Berbasis Videoscribe Sebagai Sumber Belajar pada Materi Bentuk Molekul Kelas X IPA SMA. *Jurnal Eksakta Pendidikan, 5*(1), 17-24. https://doi.org/10.24036/jep/vol5-iss1/550

Silaban, R., Elvia, R., & Solikhin, F. (2022). Pengembangan E-Modul Kimia Berorientasi Literasi Sains pada Materi Kesetimbangan Kimia di SMA Negeri 3 Bengkulu Tengah. *Alotrop, 6*(2), 180–189. https://doi.org/10.33369/alo.v6i2.25515

Singagerda, F.S., Tohir, A., Timotius, E., Fibrila, F., Asad, I., Rahim, R. (2026). A TOPSIS-Based Decision Support System for Selecting the Best Online Learning Platform. In: Bhateja, V., Hoong, A.L.S., Kong, J.D., Jena, J.J. (eds) Smart Computing Paradigms: Advanced Data Mining and Analytics. SCI 2025. Lecture Notes in Networks and Systems, vol 1683. Springer, Cham. https://doi.org/10.1007/978-3-032-08243-5_4

Sudjana, N. (2005). *Metode Statistika*. Bandung: Tarsito.

Taufik, M., Dwijayanti, I., dan Rasiman. (2022). Pengembangan Media Pembelajaran Aplikasi Android Berbasis Problem Posing Untuk Meningkatkan Hasil Belajar pada Materi Bangun Ruang bagi Siswa Kelas VI. *Jurnal Ilmiah Pendidikan Dasar*. Vol. 7(2), 2477-2143. https://doi.org/10.23969/jp.v7i2.6849

Thiagarajan, S., Semmel, D. J., & Semmel, M. I. (1974). *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook*. ERIC.

Wahdatillah, B., Noer, A. M., & S., L. (2022). Pengembangan E-LKPD Berbasis PBL-MR Menggunakan Aplikasi Flip Builder pada Materi Bentuk Molekul dan Interaksi Antar Molekul. *Edusains, 14*(1) : 72-83. https://doi.org/10.15408/es.v14i1.2565

Widarti, H. R., Triwidiastuti, D., & Rokhim, D. A. (2022). Profile of Interactive Learning Media Based Digital Literacy Needs on Elemental Chemistry Concepts. *JTK (Jurnal Tadris Kimiya), 7*(2), 277–286. https://doi.org/10.15575/jtk.v7i2.20921