



## Development of Interactive Google Sites-Based Learning Media to Improve Senior High School Students' Understanding of Stoichiometry

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**Abstract:** Development of Interactive Google Sites-Based Learning Media to Improve Senior High School Students' Understanding of Stoichiometry. Chemistry is a field of science characterized by abstract concepts and unique terminology, which often leads to it being perceived as a difficult subject. One of the challenging topics is stoichiometry due to its abstract nature. This study aims to develop and validate an interactive web-based learning media using Google Sites to support students' understanding of stoichiometry. The research employed a Research and Development (R&D) method, which includes the stages of needs analysis, design, development, and validation. Data were collected in both qualitative and quantitative forms, with quantitative data obtained through validation questionnaires using a 5-point Likert scale. The validation process involved two expert validators: a media expert and a subject matter expert. The results showed a validity score of 89% from the media expert and 90% from the subject matter expert, with an overall average of 90%, categorized as highly valid. These findings indicate that the developed learning media has achieved a high level of validity and is appropriate for use as a supporting tool in chemistry learning, particularly in stoichiometry. However, this study is limited to the validation stage; therefore, further research is required to examine the effectiveness of the media in improving students' learning outcomes.

**Keywords:** Interactive, Learning, Stoichiometry, Google Site.

**Abstrak:** Pengembangan Media Pembelajaran Interaktif Berbasis Google Sites untuk Meningkatkan Pemahaman Siswa Sekolah Menengah Atas terhadap Konsep Stoikiometri. Kimia merupakan salah satu bidang ilmu pengetahuan dengan konsep-konsep abstrak dan kosakata yang unik, sehingga sering dianggap sebagai mata pelajaran yang sulit. Salah satu materi yang menantang adalah stoikiometri karena sifatnya yang abstrak. Penelitian ini bertujuan untuk mengembangkan dan memvalidasi media pembelajaran berbasis web interaktif menggunakan Google Sites guna mendukung pemahaman siswa terhadap stoikiometri. Metode yang digunakan adalah Penelitian dan Pengembangan (R&D) yang meliputi tahap analisis kebutuhan, desain, pengembangan, dan validasi. Data dikumpulkan dalam bentuk kualitatif dan kuantitatif, dengan data kuantitatif diperoleh melalui kuesioner validasi menggunakan skala Likert 5 poin. Proses validasi melibatkan dua validator ahli, yaitu ahli media dan ahli materi. Hasil penelitian menunjukkan skor validitas sebesar 89% dari ahli media dan 90% dari ahli materi, dengan rata-rata keseluruhan 90% yang termasuk dalam kategori sangat layak. Dengan demikian, hasil penelitian ini menegaskan bahwa media pembelajaran yang dikembangkan telah memenuhi kriteria validitas yang tinggi dan layak digunakan sebagai sarana pendukung dalam pembelajaran kimia, khususnya pada materi stoikiometri.

*Namun, penelitian ini masih terbatas pada tahap validasi, sehingga diperlukan penelitian lanjutan untuk menguji keefektifan media dalam meningkatkan hasil belajar siswa.*

***Kata kunci:*** *Interaktif, Pembelajaran, Stoikiometri, Google Sites.*

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## ▪ INTRODUCTION

Education is the process of expanding knowledge, skills, and values through teaching and learning. Education encourages students to develop their potential, broaden their horizons, and acquire the skills needed to live and work in society. Apart from that, education also plays an important role in forming students, character and personality. Education is the main pillar in developing a country. The vision of national education is contained in law no. 20 of 2003 concerning the national education system explains that the aim of education is to develop the potential of students to become human beings who believe in and are devoted to God Almighty, have noble character, are healthy, knowledgeable, capable, creative, independent and become democratic and responsible citizens (Mautang et al, 2024).

Chemistry is a field of science that has a very special vocabulary and abstract concepts. This is what makes chemistry one of the subjects that is considered difficult. (Karimatunnisa, 2023). The Freedom to Learn program initiated by the Minister of Education and Culture is designed to overcome conventional education which is often referred to as Teacher Centered education. In the Merdeka Belajar program, freedom to innovate is one of the important points as a reference for implementing the program. In this program, students have the right to learn without having to be pressured and have the freedom to be creative so that the teaching and learning process will be enjoyable (Suryana et al, 2023). In the independent curriculum, students are expected to be more active and creative, where the teacher acts as a facilitator. As a facilitator, you are expected to be able to create a creative atmosphere through learning media that will be used during the teaching and learning process. Learning media is one of the factors that plays an important role in the learning and teaching process. The use of learning media in the teaching and learning process can develop new interests and desires, generate motivation and even have a psychological influence on learning (Wulandari et al, 2023).

The factors that make chemistry difficult to study are due to several characteristics of chemistry, namely (1) chemistry requires the ability to think abstractly for study material, for example chemical bonds, atomic and molecular structures; (2) chemistry requires mastery of mathematics, for example in the study of thermochemistry, reaction rates and stoichiometry; (3) in studying chemistry, a strong memory and solid logic are required; (4) Chemistry consists of abstract concepts, where the concepts are tiered, developing from simple concepts to more complex concepts. The inability of students to understand a concept is due to the inability of students to understand other basic concepts correctly (Zakiyah et al, 2018). External factors also play a role, including the mismatch between students' skills and the teaching methods applied by teachers, which are often less effective, as well as the influence of peers and the limited time students have to study chemistry (Allo & Azrun, 2023).

One of the chemistry topics considered difficult due to its abstract nature is stoichiometry. Stoichiometry is still perceived as challenging because students are required to integrate chemical concepts with mathematical operations and apply analytical thinking in problem-solving processes (Ahmad, 2022). One of the main difficulties in learning stoichiometry is the instructional approach that tends to emphasize

mathematical procedures rather than conceptual understanding, which often leads to students' incomplete comprehension of chemical principles (Basuki, 2020). In addition, many students experience low engagement during classroom learning, often showing boredom and lack of attention, which negatively affects their learning outcomes. Therefore, the use of interactive and engaging learning media is essential to improve students' motivation and participation in learning activities (Sarif & Yunus, 2023).

Previous studies published in *Jurnal Pendidikan Kimia FKIP Universitas Lampung* have shown that the use of virtual laboratory-based learning media can improve students' understanding and learning outcomes in chemistry, particularly in abstract topics such as salt hydrolysis (Fadhilah et al., 2025). In addition, the development of web-based learning media has been shown to enhance student competence and learning engagement by providing structured and interactive learning environments (Sugiharti et al., 2024). Similar findings also indicate that web-based learning media such as electronic worksheets can improve students' learning outcomes in chemistry through problem-based learning approaches (Ramadhani Zain et al., 2025). These studies confirm that technology-based learning media, including virtual laboratories and web-based platforms, play an important role in supporting chemistry learning.

However, previous studies mostly focus on general web-based learning media without specifically integrating interactive features such as virtual laboratories and structured quizzes in stoichiometry learning. Therefore, such integration is considered important to provide a more comprehensive learning experience and to strengthen students' conceptual understanding.

Based on these gaps, this study aims to develop and validate an interactive web-based learning media using Google Sites that integrates virtual laboratories, instructional videos, and structured online quizzes specifically for stoichiometry learning to support conceptual understanding and enhance student engagement.

Previous studies have shown that the development of digital and web-based learning media has been widely implemented in chemistry education, including the development of interactive web-based e-modules (Sari et al., 2022) and the use of virtual laboratories to improve learning outcomes (Putri et al., 2023). However, most prior research has focused on web-based learning media in general and has not specifically integrated interactive features such as virtual laboratories, instructional videos, and structured quizzes within stoichiometry learning. This integration is crucial to support students in visualizing abstract concepts and systematically developing problem-solving skills.

Based on these issues, this study aims to develop and validate an interactive web-based learning media using Google Sites that specifically integrates virtual laboratories, instructional videos, and structured online quizzes in stoichiometry learning to support conceptual understanding and enhance student engagement. Therefore, creativity is needed from a teacher to create an interactive classroom atmosphere. Today's interactive learning media is digital media. There are currently many choices of information technology that can be used for learning. Some are in the form of platforms or applications, in every educational institution at school or college level, for example Google classroom, e-learning, YouTube, WhatsApp (WA) Group, Edmodo, Zoom, Google Meet and so on are used (Choirunnisa, 2023). A simple and easy way to build website-based learning media for educators is to use Google Sites. Learning using online media is an alternative so that the learning process can run well and create learning interactions and students can accept modern technology (Rachman et al., 2022). Therefore, this study aims to develop and validate an interactive web-based learning

media using Google Sites that integrates virtual laboratory simulations, instructional videos, and structured online quizzes for stoichiometry learning. The developed media is intended to enhance students' conceptual understanding, improve engagement in learning activities, and support independent learning (Pardosi & Dibyantini, 2025). In addition, this study focuses not only on the development stage but also on the validation of the media's feasibility based on expert judgment in terms of media design and content accuracy. The findings are expected to provide a valid and practical learning resource that can be used in chemistry classrooms, particularly for teaching abstract concepts in stoichiometry.

Google sites is one of the appropriate media in the process of creating teaching materials because this software is dynamic which gives teachers the opportunity to improve their abilities in utilizing today's technology. This software also gives teachers the opportunity to manipulate objects, create simple visualizations about abstract materials, and helps teachers open up their knowledge about technology (Pratama et al, 2023). Google Sites is a Google service that functions to make it easier for Google users to create sites. Google Sites is a structured wiki application for creating personal or group websites or blogs, for personal and corporate purposes (Setiawan, et al, 2022). Google Sites is an online feature provided by Google to create websites that contain information and can be shared according to user needs.

The advantage of Google sites is that it is easy to access the information you need quickly, because you can add attached files and other Google information such as Google Docs, Sheets, From, Calendar, Awesome Table, videos from YouTube and others that can be shared according to user needs (Ferismayanti, 2020). The benefits of Google Sites are that it makes students more interesting and fun, provides learning materials that can be downloaded so that students can learn from the materials wherever and whenever, provides materials that from the beginning to the end of the meeting, students can re-read the materials provided by the teacher because the materials are not automatically disappear, can upload tasks that have been given a separate task place, and provide separate announcements regarding tasks, or other information (Rosiyana, 2021).

The benefits of implementing web-based learning include: (a) Students can learn independently, the existence of a website prepared and managed by teachers for learning will have an impact on the flexibility of learning time and place for students. Students not only learn with the teacher in class, but can also learn before and after learning. This will certainly increase students' understanding of the material, because the material can be opened repeatedly; (b) increasing students' knowledge about the technology used in learning (Rasapta et al, 2022).

## ▪ **METHOD**

In this research, the method used is the Research and Development (R&D) method. This method aims to produce a product through the process of identifying potential problems, designing, developing, and validating a product as a solution. The development model used in this study refers to the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). However, in this research, the stages were limited to the Analysis, Design, Development, and Evaluation (validation) stages.

This study focuses on the development of web-based learning media using Google Sites designed to improve students' understanding of stoichiometry material. The research begins with a needs analysis through surveys, interviews, and literature studies

to identify students' learning difficulties. Based on the analysis results, an interactive learning media was developed by integrating updated features such as virtual laboratory simulations and online quizzes. The media also includes learning videos and visual illustrations designed to increase students' interest and motivation in learning stoichiometry.

The media developed in this study was validated by two expert validators, namely a media expert and a material expert. The validation instrument used in this study consisted of two questionnaires, namely a media validation questionnaire and a material validation questionnaire. Each questionnaire contains indicators assessing aspects of feasibility, including content accuracy, instructional design, language clarity, interactivity, and visual presentation. The data used in this development research consist of qualitative and quantitative data. Qualitative data are in the form of descriptive feedback such as comments, suggestions, and revisions from the validators regarding the developed Google Sites media. Quantitative data refer to measurable data obtained from validator assessments using a Likert scale ranging from 1 to 5. The level of validity of the product is determined based on percentage scores and is categorized into five criteria: very invalid, invalid, fairly valid, valid, and very valid (Riduwan, 2015). A product is considered feasible for use if it reaches the category of valid or very valid. The quantitative validation data were analyzed by calculating the percentage score of each aspect and the overall average score from both validators. This process aims to determine the feasibility level of the developed learning media before being used in classroom learning.

### **Subject, Object and Time Of Research**

The test subjects used by the author in the development of google site-based android application media on Stoichiometry learning for class XI SMA are validation subjects. The validation subjects in this study consisted of material experts and media experts. The object of this development research is a google site-based android application on Stoichiometry learning for class XI SMA. The development research time was carried out on August 22, 2024 to October 09, 2024.

## **▪ RESULT AND DISCUSSION**

### **Needs Analysis Stage**

Stoichiometry is one of the fundamental topics in chemistry that requires students to understand and integrate multiple interrelated concepts and mathematical procedures, such as chemical reaction equations, reaction stoichiometry, equilibrium concepts, and concentration calculations. A solid understanding of molecular relationships and chemical interactions is essential; however, these abstract and quantitative characteristics often pose significant challenges for students who are newly introduced to the topic. Previous studies have shown that 63.8% of students perceive stoichiometry as a difficult subject due to the large number of formulas and complex calculations involved in solving problems (Rahayu & Yerimadesi, 2022).

In addition, learning achievement on stoichiometry concepts remains relatively low, as reflected in students' performance across several indicators. One study reported that most conceptual indicators in stoichiometry were achieved at levels below 55%, with the lowest achievement found in indicators related to determining mass or volume based on reaction illustrations and chemical equations, which reached only 41.16% (Karimatunnisa, 2022). These findings indicate that students experience significant

difficulties in translating macroscopic representations into mathematical and symbolic forms, which are essential in stoichiometric problem-solving.

The low level of conceptual understanding suggests that students tend to memorize formulas without fully comprehending the underlying concepts and their applications. This condition highlights the need for instructional approaches that emphasize conceptual visualization, step-by-step problem solving, and meaningful learning experiences. Therefore, teachers are required to provide clear, structured, and simplified explanations, while also facilitating gradual concept mastery to bridge students' understanding from abstract chemical concepts to mathematical representations in stoichiometry.

### **Media Analysis Stage**

Learning media has an important role in the educational process. The selection of media that is not varied and less attractive will certainly make students less enthusiastic and can become saturated (Pratama et al., 2023). Through the proper use of media, be it visual, audio, or interactive, teachers can bridge the gap between abstract concepts and students' concrete understanding.

The development of learning media is carried out using the type of R&D or Research and Development research. Development research resulted in a product, namely in the form of web-based learning media google site (Firmansyah et al, 2023). Google sites can be a forum as a Building on these conditions, an instructional innovation is required to bridge the gap between abstract concepts and students' mathematical understanding in stoichiometry learning. One relevant solution is the use of web-based learning media that is interactive and easily accessible, such as Google Sites. This platform enables the systematic presentation of learning materials through a combination of text, visual representations, instructional videos, and online quizzes, allowing students to learn more independently and flexibly (Sugiharti et al., 2024)

Furthermore, the integration of virtual laboratory features within the learning media is essential to help students visualize abstract stoichiometric concepts, such as the relationships between reactants and products as well as quantitative calculations based on chemical equations. Virtual laboratories allow students to conduct simulated experiments without the limitations of physical laboratory equipment and materials, thereby transforming abstract concepts into more concrete and interactive learning experiences (Fadhilah et al., 2025). In addition, structured quiz activities further support students in reinforcing their conceptual understanding in a gradual and systematic manner.

Thus, the use of Google Sites integrated with virtual laboratories, instructional videos, and interactive quizzes is expected to serve as an innovative solution to improve students' understanding of stoichiometry, overcome learning difficulties, and create a more active, engaging, and meaningful learning experience. learning medium that provides space for interactive materials, assignments and learning resources. With the help of this learning media website, students will easily access pages that support students to learn independently and collaboratively. The application of Google Sites learning media is a potential solution to improve student understanding (Syalsabillah, 2024).

### **Validation Stage of Website-based Learning Media (Google Sites)**

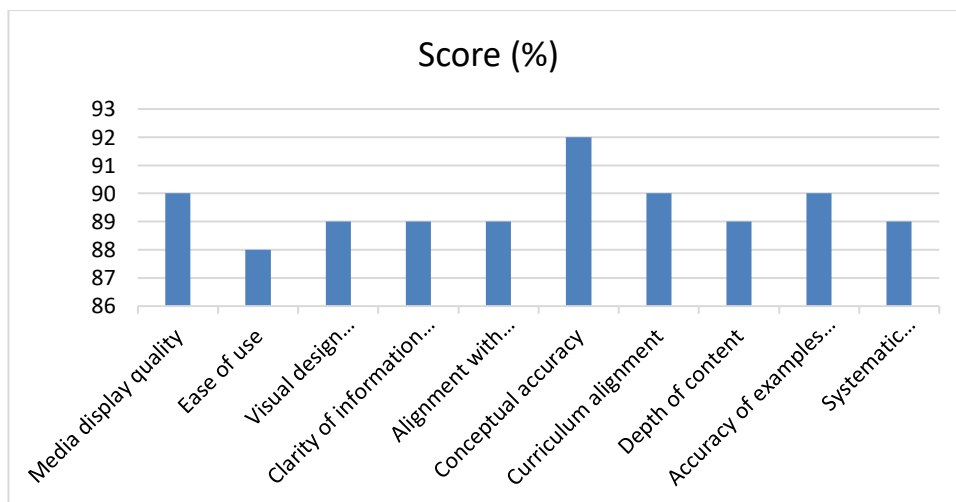
The validation stage needs to be carried out to measure and see the feasibility of the learning media produced. The website-based media contains stoichiometry material that has been produced in the previous stage will be validated by several validators who are

experts in their fields. This validation is conducted by media experts, as well as material experts. The instrument used in this validation test is a questionnaire.

**Table 1.** Recapitulation of Media Validity Assessment Results

No.	Assesment	Percentage of Grades (%)	Category
1.	<b>Media Experts</b>		
	Media display quality	90	Highly Feasible
	Ease of use	88	Highly Feasible
	Visual design attractiveness	89	Highly Feasible
	Clarity of information presentation	89	Highly Feasible
	Alignment with learning objectives	89	Highly Feasible
	<b>Average</b>	89	Highly Feasible
2.	<b>Material Experts</b>		
	Conceptual accuracy	92	Highly Feasible
	Curriculum alignment	90	Highly Feasible
	Depth of content	89	Highly Feasible
	Accuracy of examples and illustrations	90	Highly Feasible
	Systematic organization of content	89	Highly Feasible
	<b>Average</b>	90	Highly Feasible

Based on the results of validation that has been carried out by media experts and also material experts, a percentage rate of 89% was obtained with a very feasible category for the media created. Meanwhile, the percentage level produced is 90% with a very decent category for the material contained in the media. In validity testing with media experts and material experts, there are several things that need to be reviewed better and need to be improved, namely the placement of subheadings that are more considered, writing reactions with the addition of phases, and optimizing the quiz feature. The data in the table above can also be represented in the graph shown in the Figure 1.



**Figure 1.** Validity Results Graph

The validity results show that the website-based media produced in this stoichiometry material is feasible to use with the improvement of several features. A learning medium will be said to be good and effective if it has good planning (Islanda &

Darmawan, 2023). Web-based media that has gone through a design process both in terms of materials, media and additional features can support stoichiometry learning in students. The existence of virtual laboratory features and practice questions will motivate students in learning stoichiometry. Therefore, it can be concluded that this learning media is valid and effective so that it can be used as a learning medium. This combines new innovations for the world of education and involves the latest technology. Based on this, the learning media developed in this study has gone through a planned and developed planning process so that it is suitable as a learning medium.

These results are consistent with previous studies showing that Google Sites-based learning media generally achieve very high validity levels due to its structured presentation, accessibility, and ease of use (Laili, et al., 2025). In addition, research on virtual laboratory implementation in chemistry learning reports that such media significantly improve students' conceptual understanding of abstract chemical concepts and are categorized as highly valid and effective for learning, similar findings indicate that web-based interactive learning media can enhance student engagement and motivation in chemistry learning (Sinaga et al., 2021). Furthermore, technology-based learning media have been widely recognized as effective tools in chemistry education because they support visualization of abstract concepts and promote active learning experiences (Sugiharti et al., 2024). These findings strengthen the results of this study, confirming that the integration of Google Sites, virtual laboratories, and interactive quizzes is feasible and appropriate for stoichiometry learning.

### **Product Development (Web Media based on Google Sites)**

Educators can use Google Sites as an effective learning platform in the teaching-learning process. Students can also access Google Sites independently. Some of the advantages of Google Sites include: 1) Free and easy to operate, 2) Flexible, accessible from anywhere and anytime, 3) Attractive interface design, 4) Ability to integrate various types of content such as text, video, images, audio, presentations, and other media through links, 5) Integrated with other Google services, including Google Forms, Google Slides, Google Drive, and so on. The Google sites-based website media developed helps overcome problems in class xi chemistry subjects on stoichiometry material. With the development of this media, it is hoped that students will have a great interest in the learning process. So that students can identify stoichiometric material and learning objectives can be achieved.

The initial stage of designing a website using Google Sites involves setting specifications that provide a comprehensive overview of the features of the site to be created. This process includes content selection, cover design, image selection, menu organization, and determining font type, size and color. The main page of the site was designed with a number of menus, including general information, user guide, learning objectives, materials, video content, practice questions, laboratory simulations, reference list, and developer profile. After going through the validation stage by media experts, some improvement suggestions were accepted and implemented. The end result of this development process was the final design of the Google Sites-based website that had been refined based on these inputs.

The following is the final design of the google sites-based website media developed.

#### **a. Main Page**

The main page or Home menu is the initial appearance of the website. It consists of a cover, instructions for use, general information, learning objectives, and a list of menus. There are ten menus available on this media which include materials about stoichiometry, practice questions, and a bibliography. The Home view can be described as follows.



Figure 2. Main page view

b. Instructions for use

Instructions for use are a guide for students to know how to use Google site media contained on the website. The display of instructions for use can be described as follows



Figure 3. Instructions for use view

c. General information and Objectives

General information includes students' understanding of stoichiometry material, learning objectives are KD, indicators and learning objectives to be achieved. The display of general information and learning objectives can be described as follows



Figure 4. General information and Objectives view

d. Materials

The content of the material display is a form of hangout that is packaged in the form of posters and videos. This material page aims to increase students' cognitive knowledge. There are seven materials along with videos on each page, the materials in question include introduction to stoichiometry, chemical reaction equations, the concept of moles, calculations based on chemical equations, theoretical results real

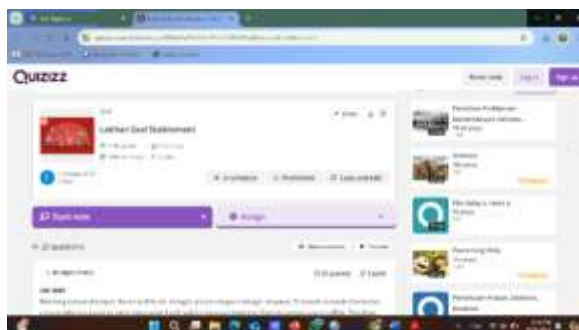
results & percentage of results, and gas stoichiometry. The material display can be described as follows.



**Figure 5.** Materials view

e. Exercise

Exercise is a post-test sheet that students must do. The form of the exercise uses Quizizz which amounts to 20 questions, and the questions have been compiled based on validated national exam questions. The exercise display can be described as follows.



**Figure 6.** Exercise view

f. Laboratory Simulation

Laboratory Simulation is used as a virtual testing stage for students related to the material that has been studied. On this page, the laboratory simulation used is an application that can be accessed from the web called Phet Colorado. On the page, instructions for using the web are displayed. The laboratory simulation display is described as follows.



Figure 7. Laboratory Simulation view

g. Bibliography

On this page, citations and reference sources are entered sequentially to ensure the quality of the website that has been provided.



Figure 8. Bibliography view

▪ CONCLUSION

This study demonstrates that the web-based learning media developed for stoichiometry material has been validated by expert judgment and is categorized as highly feasible for use in the learning process. The validation results indicate that the media meets the required criteria in terms of content accuracy, instructional design, and media presentation. However, several aspects still require revision and refinement based on feedback from the validators to improve the overall quality of the product.

These findings highlight that the developed media is appropriate for use as a learning resource in terms of validity, particularly for supporting stoichiometry instruction in chemistry education. Nevertheless, since this study is limited to the validation stage, no claims can be made regarding its effectiveness in improving student learning outcomes. Therefore, further research is needed to implement and evaluate the media in classroom settings to examine its impact on student understanding and learning performance.

This study contributes to the development of digital learning media by providing a validated web-based platform that has the potential to be further refined and tested in

future research. It also opens opportunities for the development of similar interactive learning media for other chemistry topics in order to support the improvement of science education in the digital learning era.

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