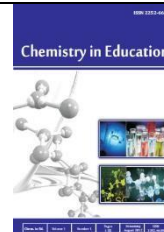




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Development of Google Sites-Based E-learning Using the Problem-Based Learning Model to Improve Student Learning Outcomes in Chemical Equilibrium

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ABSTRAK

Penelitian ini bertujuan untuk mengembangkan platform e-learning berbasis Google Sites yang terintegrasi dengan model Problem Based-Learning (PBL) untuk meningkatkan hasil belajar peserta didik pada topik keseimbangan kimia. Penelitian ini menggunakan metode Research and Development (R&D) dengan menggunakan model pengembangan 4D, melibatkan 35 siswa sekolah menengah atas kelas XI sebagai subjek penelitian. Instrumen penelitian meliputi lembar validasi ahli, skala respon siswa, dan tes prestasi belajar yang dilakukan melalui pretest dan posttest. Hasil validasi menunjukkan bahwa media yang dikembangkan memperoleh skor 85,3% dari pakar materi dan 86% dari pakar media, keduanya dikategorikan sangat valid. Respon siswa terhadap media e-learning juga sangat praktis, dengan persentase 88,7%. Efektivitas media ditunjukkan dengan peningkatan hasil belajar yang signifikan, dengan skor N-gain sebesar 0,72 dikategorikan tinggi. Oleh karena itu, e-learning berbasis Google Sites yang terintegrasi dengan model PBL dianggap valid, praktis, dan efektif digunakan sebagai media pembelajaran.

ABSTRACT

This study aims to develop an e-learning platform based on Google Sites That is integrated with The Problem Based Learning (PBL) model to improve student learning outcomes on the topic of chemical equilibrium. This study uses Research and Development (R&D) method using 4D development model, involving 35 eleventh grade high school students as research subjects. Research instruments include expert validation sheets, student response questionnaires, and learning achievement tests conducted through pretest and posttest. The validation results showed that the developed media obtained scores of 85.3% from material experts and 86% from media experts, both categorized as very valid. Student response to e-learning media is also very practical, with a percentage of 88.7%. The effectiveness of the media was shown by a significant increase in learning outcomes, with an N-gain score of 0.72 categorized as high. Therefore, Google Sites-based e-learning integrated with the PBL model is considered valid, practical, and effective, making it feasible to use as an alternative learning medium for teaching chemical equilibrium.

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INTRODUCTION

Education is one of the important elements that cannot be separated from human life, both in developed and developing countries (Lestari & Nuryanti, 2022). In developed countries, education serves as a means of improving the quality of life of the community, while in developing countries, education is used to catch up with developed countries at the international level (Yulianti *et al.*, 2023). Education plays a major role in developing high-quality and integrity-based human resources (Umiga, 2022). The development of information and communication technology has also encouraged various innovations in the world of education, including the use of digital technology that can be integrated into learning (Akhyar *et al.*, 2022).

In 21st-century learning requires the integration of technology in the teaching and learning process to respond to global challenges (Purba & Saragih, 2023). The use of appropriate technology allows teachers and students to reap positive benefits in the form of ease of access, flexibility, and a more interactive learning experience (Consoli *et al.*, 2024). In Indonesia, the implementation of the Mandiri curriculum provides more flexibility for educators to design learning that suits the characteristics of students, including the use of technology to support the learning process (Wisudariani *et al.*, 2024).

Observations at Bergas 1 Public High School show that chemistry learning, especially chemical equilibrium, still faces obstacles. The media used, in the form of printed teaching materials, tends to be simple and easily accessible, but lacks interactivity in explaining abstract concepts such as equilibrium shifts. This has implications for the low learning outcomes of students. In fact, the majority of students already have smartphones that have the potential to be used in learning, but have not been optimally utilized (Wati *et al.*, 2024).

Previous studies have shown that various e-learning platforms can improve the quality of chemistry learning (Alfirzan *et al.*, 2024). The use of Articulate Storyline has proven to be effective but requires high- specification hardware (Rati.F *et al.*, 2022). Padlet is considered valid and practical, but its features are still limited (Agustiningrum & Firda Khairunnisa, 2021). The PhET virtual laboratory can increase learning motivation, but it does not support collaboration (Hasna Fauziyah *et al.*, 2024). To overcome these limitations, Google Sites is a simpler, more accessible alternative that can integrate various learning formats, such as videos, quizzes, animations, and discussion forums (Pubian & Herpratiwi, 2022).

In addition to media, learning models also play an important role. Problem-Based Learning (PBL) is one relevant model because it encourages students to actively solve contextual problems, think critically, and build concepts independently. Research by Susi & Yenti (2020) and Parbo Maulana *et al.* (2021) shows that PBL can improve learning outcomes in chemistry, especially in the subject of Chemical Equilibrium (Susilawati *et al.*, 2021).

Based on this description, this study aims to develop Google Sites-based e-learning with a Problem-Based Learning model for chemical equilibrium material. This development is expected to help students gain a more interactive learning experience, improve their understanding of abstract concepts, and have a positive impact on learning outcomes.

METHODS

This research is a development study, also known as *Research and Development* (R&D), using the 4D model, which consists of four stages: define, design, *develop*, and disseminate. The product developed in this study is Google Sites *e-learning* using the PBL model for chemical equilibrium material. This research was conducted at SMA Negeri 1 Bergas, Semarang Regency. This research was conducted to improve the media that had been created. The product to be developed by the researcher was Google Sites *e-learning* media. The product was tested to see and obtain the results of the effectiveness of using Google Sites *e-learning* media in classroom learning. The product validation stage aims to obtain data in the form of assessments, comments, and suggestions from experts on the learning media created so that the suitability of the product can be determined. The following are the expert validation instruments and student responses to the Google Sites *e-learning* media product:

a) Expert material assessment instrument

Table 1. Material Validation Scale Grid

No	Aspect	Indicator	Item Number
1	Curriculum	Alignment of materials with learning objectives	1, 2, 3
2	Material	Accuracy, consistency, completeness, and depth of the concepts presented	4, 5, 6, 7
		The suitability of the material to the characteristics of the students and the material is supported by appropriate media	8, 9, 10
3	Grammar	The use of language and the language used are appropriate for the characteristics of the students.	11, 12
Number			12

b) Expert media assessment instrument

Table 2. Media validation scale grid

No.	Aspect	Indicator	Item number
1	Display Design	Appearance design suitability	1, 2, 3, 4,
		Menu and button layout consistency	5, 6, 7, 8
		Font size, color, and type	9,10,11
2	Video	Video relevance to the material	12
3	Animation	Accuracy of animation	13, 14
4	Ease of use Media	Usefull	15, 16, 17
Number			17

c) Readability scale instrument

Table 3. Readability scale grid

No	Aspect	Indicator	Item number
1	Visual communication	Accuracy of font selection	1
		Accuracy of color selection	2
		Clarity of images/animations	3
2	Presentation of material	The material presented is clear	4
		The material presented is easy to understand	5
		The examples provided in the material are easy to understand	6
3	Motivating	Interactive learning media can motivate students	7
		Letters can be read clearly	8
Number			8

d) Student response instrument

Table 4. Student response scale grid

No	Aspect	Indicator	Item number
1	Attracting students' interest	Attractiveness of learning media display	1
		The attractiveness of the images displayed	2
		Clarity and appeal of the colors presented	3
2	Presentation of material	The material presented is clear	4
		The material presented is easy to understand	5
		The examples provided in the material are easy to understand	6
3	Increases student attention	Interactive learning media can increase student attention.	7
4	Motivating	Interactive learning media can motivate students	8
		Letters can be read clearly	9
Number			9

The research was conducted through several systematic steps. First, a preliminary analysis was conducted to identify problems that arose in the classroom learning process. The findings from this stage were then studied further to formulate relevant solutions. Second, information was collected through direct observation of teaching and learning activities and interviews with teachers and students as the main sources of data. Third, product design was carried out by preparing learning media designs tailored to the characteristics and needs of the students. Fourth, the designed products were validated by experts in the fields of materials, language, and design to assess their quality and suitability. Next, the fifth stage was revision based on suggestions from the validators to improve the product. In the sixth stage, a limited trial was conducted with 15 high school students. Grade XII with diverse characteristics to obtain initial input regarding the practicality of the media. The seventh stage is further revision based on the evaluation of limited trial results. Next, the eighth stage is a large-scale trial involving 35 Grade XI high school students to test effectiveness and obtain a broader user response. The final stage is the

final revision, where the media is improved according to the comments and input obtained during the implementation stage, so that the product is ready for use in learning..

Research data was collected using various methods. First, interviews were conducted in person or through digital media to obtain information from teachers and students regarding learning needs. Second, observations were made by systematically observing learning activities using the senses, as described by Suciarti (2021). Third, questionnaires were used as instruments to capture respondents' responses, opinions, and perceptions of the developed media. Fourth, documentation was used as a source of supporting data to reinforce the research findings, for example in the form of activity notes and learning outcome archives.

The data were analyzed using qualitative and quantitative approaches. Qualitative analysis was used to describe the results of observations, interviews, and comments and suggestions obtained through questionnaires. Meanwhile, quantitative analysis was used to process data in the form of expert validation scores, product test results, and usage tests. The assessment instrument was designed in the form of a Likert scale with checklist answer options. This scale is commonly used to measure a person's attitude, perception, or opinion towards a social phenomenon (Azura *et al.*, 2024). The following are the formulation and score intervals:

$$\text{Feasibility percentage (\%)} = \frac{\sum \text{score}}{\text{maksimum score}} \times 100\%$$

The validation categories based on the following criteria (Arikunto, 2017) can be seen in Table 5.

Table 5. Validation percentage criteria

Score (%)	Validation criteria
81 – 100%	Very valid
61 – 80 %	Valid
41 – 60 %	Less valid
21 – 40 %	Invalid
<21%	Very invalid

RESULT AND DISCUSSION

Result

The results of the needs analysis show that the chemical equilibrium learning process at SMA Negeri 1 Bergas still faces a number of obstacles. The media used by teachers generally only consists of PowerPoint presentations without visualization, simulation, and supporting videos, making it difficult for students to understand abstract concepts. From the interviews conducted, it was also found that students expect more interactive and contextual media that utilizes their digital devices. Based on these conditions, it is necessary to develop Google Sites-based e- learning media that is integrated with the

Problem-Based Learning (PBL) model and contains materials, videos, E-LKPD, virtual laboratories, and exercises.

The media design stage was carried out by referring to the results of needs identification, material analysis, and learning objectives. The product was developed in the form of a website with various main menus, including learning instructions, concept maps, materials, E-LKPD, videos, virtual laboratories, practice questions, quizzes, and glossaries. The research instruments used included learning outcome tests in the form of pre-tests and post-tests, readability questionnaires, and student response questionnaires.

The media was then validated by three media expert validators and three material expert validators. The validation results showed that the media aspect scored 86% and the material aspect scored 85.3%, both of which are highly valid categories. The readability test involving 15 students resulted in a score of 88.7% in the excellent category. The media expert validators provided assessments by filling out the validation scale provided. The results obtained an average score of 86% with the criteria of highly valid. Based on the scores obtained, the Google Sites- based e-learning media can be used in the learning process with several revisions. The validation results by media experts can be seen in Table 6.

Table 6. Summary of media expert validation results

Validator	Number of score	Percentage	Criteria
Validator 1	57	83%	Very valid
Validator 2	68	100%	Very valid
Validator 3	51	75%	Valid
Rata-rata	58	86%	Very valid

Subject matter experts provided assessments by filling out the validation sheet provided. In this assessment, subject matter experts gave a percentage of 85.3% with the criteria of highly valid. Based on the scores obtained, the Google Sites-based e-learning media can be used in the learning process with some revisions. The results of the validation by media experts can be seen in Table 7.

Table 7. Summary of material expert validation results

Validator	Number of score	Percentage	Criteria
Validator 1	59	86%	Very valid
Validator 2	65	95%	Very valid
Validator 3	51	75%	Valid
Average	59	85,3%	Very valid

The validation results from subject matter and media experts show that Google Sites-based e-learning with the PBL model falls into the highly valid category, with scores of 85.3% and 86%, respectively. This indicates that the content, clarity of language, visual design, and navigation media have met learning quality standards. This feasibility is also supported by the integration of various features, such as learning videos, virtual laboratory simulations, interactive quizzes, and E- LKPD that comply with PBL syntax. These findings are in line with the research by Ade et al. (2021), which states

that expert validation is an important indicator in determining the quality of learning media developed. Thus, it can be confirmed that this media can be an alternative learning resource in line with the characteristics of an independent curriculum that prioritizes flexibility and learning innovation. The readability scale of Google Sites e-learning media was given to 15 grade XII.4 students as respondents. The readability scale was filled out by the students after the researcher tested the e- learning on 15 students. The accumulation of the e-learning media readability scale can be seen in Table 8.

Table 8. Accumulation of readability scale

No.	Indicator	Number of question	ΣScore
1.	Subject	3	162
2.	Practicality of media	3	158
3.	Format	5	266
	Number		586
	Average		39
	Percentage		88,7%
	Category		Very good

The cumulative readability score was 611 with a percentage of 88.7%, which means that *Google Sites e-learning* has high readability.

A questionnaire on student responses to the use of *Google Sites e-learning* was given to 35 students in class XI.5 as respondents. The questionnaire was filled out after the researcher had completed a large-scale product trial. This questionnaire consisted of 3 indicators and 11 questions. The accumulated student response questionnaire can be seen in Table 9.

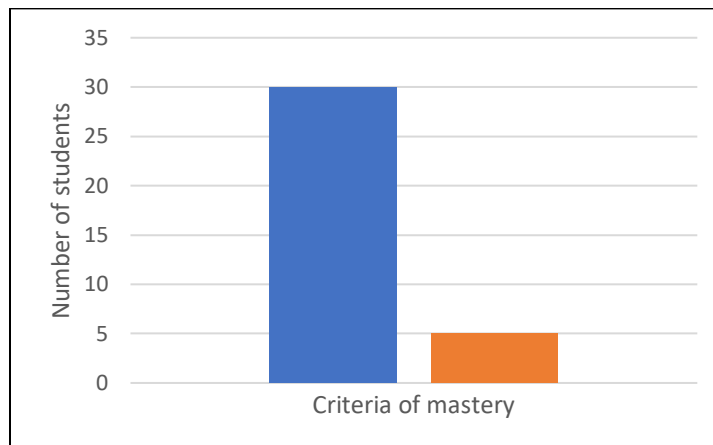
Table 9. Accumulation of student response questionnaires

No.	Indicator	Number of question	ΣScore
1.	Attracting students' interest	3	375
2.	Presentation of material	3	381
3.	Motivating	5	621
	Percentage		89%
	Category		Very good

Based on the collected survey results, student responses to the use of Google Sites-based e-learning received an average score of 39, equivalent to a percentage of 89%. This score places the developed media in the "very good" or "very practical" category. This indicates that the digital e-learning product designed by the researcher is considered feasible and practical for supporting the learning process in the classroom.

The effectiveness of the media was also tested through learning outcomes in the form of pre-tests and post-tests. The pre-test was conducted before students used the learning media, while the post-test was conducted after the use of Google Sites-based *e-learning*. These tests aimed to measure the improvement in student learning outcomes before and after using the media. The instrument used consisted of 20 multiple-choice questions. In the post-test, there were 30 students who had

completed the test, while 5 students had not. The level of student learning completeness on the material of chemical equilibrium is shown in Picture 1.

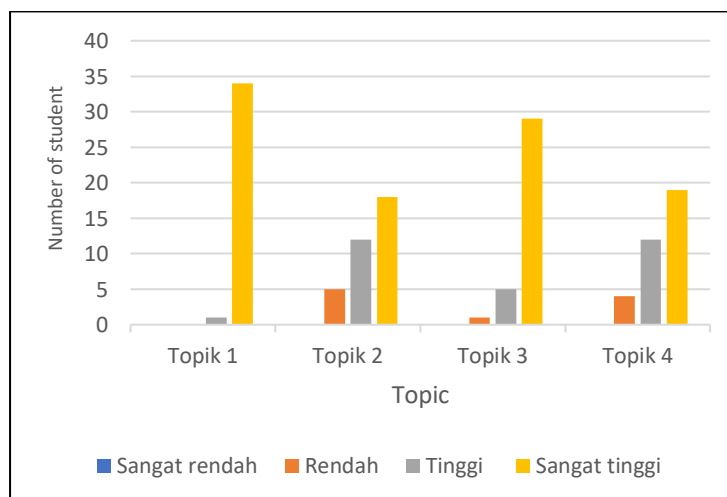


Picture 1. Graph of student learning achievement

Analysis of improvements in student learning outcomes divided into 4 topics, including:

- 1) Topic 1: The concept of dynamic equilibrium
- 2) Topic 2: Equilibrium constants K_c and K_p
- 3) Topic 3: Factors affecting equilibrium shifts
- 4) Topic 4: Application of equilibrium in industry.

The average *post-test* scores for each topic can be seen in Picture 2.



Picture 2. student learning outcomes divided into 4 topics

The dissemination stage was carried out by distributing products in the form of Google Sites-based e-learning that had been developed in the previous phase. The initial disseminate through validation by experts, consisting of lecturers who are subject matter experts and media experts from Semarang State University, as well as chemistry teachers from Bergas 1 Public High School. After passing the validation stage, the product was then given to 11th grade chemistry teachers at the

school where the research was conducted to assess the practicality of the media in supporting the learning process. After obtaining results that showed that the media was practical to use, the Google Sites-based e-learning was then implemented for grade XI.5 students at SMA Negeri 1 Bergas in chemistry lessons, specifically on the topic of chemical equilibrium

Discussion

The validation results from subject matter and media experts show that Google Sites-based e-learning with the PBL model falls into the highly valid category, with scores of 85.3% and 86% respectively. This indicates that the content, clarity of language, visual design, and navigation media have met learning quality standards. This validity is also supported by the integration of various features, such as learning videos, virtual laboratory simulations, interactive quizzes, and E- LKPD that are in accordance with PBL syntax. These findings are in line with the research by (Harahap & Imelda, 2025), which states that expert validation is an important indicator in determining the quality of learning media developed. Thus, it can be confirmed that this media can be an alternative learning resource that is in line with the characteristics of an independent curriculum that prioritizes flexibility and innovation in learning.

The effectiveness of the media can be seen from the improvement in student learning outcomes. The average pretest score of 52.57 increased to 82.73 on the posttest with an N-gain of 0.74 in the high category. In addition, classical mastery increased significantly from 8.6% on the pretest to 85.7% on the posttest. This improvement shows that Google Sites-based e-learning is able to bridge students' difficulties in understanding abstract concepts of chemical equilibrium, especially equilibrium shifts that require visualization. These findings are in line with the research by Masfufah *et al.* (2023), which shows that the use of e-learning can improve conceptual understanding through visual and interactive representations. Furthermore, the results of this study also reinforce the statement by Sihotang *et al.* (2024) that web-based learning can help students build connections between theory and real phenomena, thereby making conceptual understanding more meaningful.

The students' response to the media also showed very positive results. The readability questionnaire scored 88.7% and the large-scale trial scored 89%, both of which are in the excellent category. This shows that students consider this media to be practical, easy to use, and interesting to follow. Interactive features in the media, such as online E-LKPD and discussion forums, encourage active student involvement in the learning process. This positive response is in line with the findings of Mayasri *et al.* (2023), who states that Google Sites as a learning medium provides a flexible, enjoyable learning experience and is able to increase learning motivation. In addition, the availability of smartphones, which almost all students have, is a major supporting factor in the use

of this medium.

Although the results of the study show the feasibility, practicality, and effectiveness of the media, there are still several obstacles. Some students reported limited internet networks and device capacity, which hindered optimal access to the media. In addition, the topic of applying chemical equilibrium in industry is still difficult to understand even though the media is equipped with visual explanations. This indicates the need to enrich contextual material through case studies or industry-based projects so that students can relate chemical concepts to real-world phenomena. A broader implication of this study is that teachers can utilize Google Sites as a learning medium that is easy to create, inexpensive, and can be updated flexibly according to class needs. Overall, this discussion confirms that Google Sites-based e-learning with the PBL model is valid, practical, and effective in improving learning outcomes, motivation, and student engagement. This medium not only provides a solution to the limitations of print media in explaining abstract concepts but also opens up opportunities for more adaptive and sustainable technology-based learning.

CONCLUSION

Based on the research results, it can be concluded that Google Sites-based e-learning with the Problem-Based Learning (PBL) model, equipped with interactive E-LKPD, is very suitable for use in teaching chemical equilibrium, as evidenced by expert validation and readability tests that fall into the very good category. The application of this media shows high effectiveness with a significant increase in student learning outcomes, as reflected in the N-gain value of 0.72 in the high category, which means that e-learning is effective as a medium for chemistry learning. Additionally, student responses to the learning media were very positive, leading to the conclusion that PBL-based e-learning integrated with Google Sites is not only valid and effective but also practical and well-appreciated by students as an alternative learning medium.

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