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Development, Validation, and Practicality of a Wordwall-Based Educational Game for Senior High School Acid-Base Learning

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Abstract
This study aimed to develop and evaluate the validity and practicality of a Wordwall-based educational game for senior high school acid-base learning. The study employed a Research and Development (R&D) design using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The developed media integrated game-based quizzes, instant feedback, visual elements, and concept-based challenges to support joyful learning and deepen students' conceptual understanding of acid-base material. Data were collected through expert validation sheets, student response questionnaires, and a teacher interview. The product was validated by three expert validators and evaluated by one chemistry teacher. The implementation stage involved 29 students from class XI.F.1 and 31 students from class XI.F.2 at SMAN 10 Sijunjung. The validation results showed that the material aspect obtained a validity score of 80%, the language aspect obtained 75%, and the media design aspect obtained 95%, categorized as valid to highly valid. Student responses indicated that the media was very practical, with practicality scores of 86,75% in class XI.F.1 and 88,00% in class XI.F.2 in terms of ease of use, attractiveness, usefulness, and time efficiency. Teacher feedback also indicated that the media helped present acid-base concepts in a more interactive and engaging way. The findings indicate that the Wordwall-based educational game is feasible and practical for use as an alternative digital learning medium in acid-base instruction. Further research is recommended to examine its effectiveness on students' conceptual understanding, learning motivation, and learning outcomes.

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INTRODUCTION

Chemistry is a branch of science that studies the composition, structure, properties, and changes of matter, along with the energy involved in these processes (Nashyra et al., 2024; Hilda, 2020). In chemistry learning, two inseparable aspects are identified: chemistry as a product, which includes facts, concepts, principles, and laws, and chemistry as a process, which involves scientific inquiry and activities (Rostika, 2020). Therefore, chemistry learning should not only focus on conceptual understanding but also on the development of scientific thinking and problem-solving skills.

However, chemistry topics such as acid–base are often perceived as difficult by students due to their abstract and complex nature, requiring learning media that can concretize these concepts. Without appropriate learning media, students tend to experience difficulties in understanding the relationships between concepts, calculations, and chemical phenomena in daily life (Febriyanti & Siregar, 2025).

The development of digital technology provides opportunities to create more interactive learning media. Digital learning media enable the integration of text, images, audio, video, and

animation, which can enhance student engagement in the learning process (Yuniarti et al., 2023). One form of digital learning media is the educational game.

Educational games are game-based learning media designed to present content in an interactive and enjoyable way, thereby increasing students' active participation in learning (Ma'ruf, 2021). One platform that can be used is Wordwall, which provides various educational game templates that are easy to use and attractive for students. Previous studies have shown that Wordwall can improve students' motivation and learning outcomes across various subjects (Amalia et al., 2024). However, most of these studies focus on general learning motivation and do not specifically address Wordwall-based media development for acid–base material, which is abstract and hierarchical in nature.

In addition, most previous studies have not integrated Wordwall with other platforms such as Google Sites and Canva into a single structured learning system. Such integration has the potential to create a more systematic and engaging learning experience.

In this study, deep learning is defined as a learning process that promotes in-depth conceptual understanding through students' active engagement in analyzing, connecting, and applying concepts. Meanwhile, joyful learning is operationalized through enjoyable media design, including attractive visuals, simple navigation, and game-based activities that create a positive and engaging learning atmosphere.

Field observations in one senior high school revealed that chemistry learning was still dominated by conventional media such as whiteboards, although digital facilities such as projectors and smartphones were available. This condition resulted in less varied learning activities and low student engagement, particularly in understanding acid–base concepts.

Based on these conditions, this study aims to develop a Wordwall-based learning media for acid–base material integrated with Google Sites and Canva, and to examine its validity and practicality as a chemistry learning medium.

METHOD

This study employed a Research and Development (R&D) approach aimed at developing a Wordwall-based educational game as a learning medium for acid-base material at the senior high school level using the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation. The study was limited to validity and practicality testing of the developed media. The research was conducted at SMAN 10 Sijunjung involving 29 students from class XI.F.1, 31 students from class XI.F.2, and one chemistry teacher. The participants were selected using purposive sampling based on the suitability of the acid-base material and recommendations from the chemistry teacher.

Product validation was carried out by three expert validators consisting of a content expert, namely a Chemistry Education lecturer, a language expert, namely an Indonesian Language lecturer, and a media expert, namely a Chemistry Education lecturer. The research instruments included expert validation sheets, student response questionnaires, and teacher interview guidelines. The validation sheets and student response questionnaires used a 1–4 Likert scale consisting of strongly disagree, disagree, agree, and strongly agree categories. The aspects assessed in the validation process included material feasibility, language, and media design, while the student response questionnaire covered ease of use, attractiveness, usefulness, and time efficiency.

Data were analyzed using descriptive quantitative analysis by calculating the percentages of validity and practicality scores. This study obtained permission from the school prior to implementation, and all participants voluntarily participated in the study. The confidentiality of the research data was maintained and used solely for research purposes.

Analysis Stage

The analysis stage aimed to identify problems and learning needs in acid-base learning at SMAN 10 Sijunjung through classroom observations and interviews with one chemistry teacher and ten grade XI students. Observations focused on the learning process, the use of learning media, student participation, and students' difficulties in understanding acid-base concepts. Interviews were conducted to identify the learning methods used, students' learning motivation, the need for digital learning media,

and the use of smartphones in learning activities. The interview results showed that the school allowed the use of smartphones in learning activities under teacher supervision. The analysis results indicated that chemistry learning was still dominated by conventional methods, causing students to experience difficulties in understanding acid-base concepts and reducing their interest in learning. Students also showed greater interest in game-based and interactive digital learning. Based on these findings, the learning media was developed by integrating visual illustrations, learning videos, animations, and Wordwall-based evaluation activities that could be accessed through smartphones to support student engagement and conceptual understanding.

Design Stage

The design stage focused on designing the structure and specifications of the learning media in the form of a Wordwall-based educational game integrated through Google Sites. Google Sites was selected because it is easily accessible through smartphones and laptops and is capable of integrating various learning components into one platform, while Wordwall was used for interactive game-based evaluation activities that could increase students' motivation and participation. At this stage, a media flowchart and storyboard were developed consisting of the home page, menu selection page, learning outcomes page, learning objectives page, learning materials, learning videos, and interactive game-based evaluation activities. The learning objectives included understanding acid-base theories, the general properties of acids and bases, the concept of pH and pH scale, and acid-base indicators. The materials were presented through text, visual illustrations, learning videos, and Wordwall-based evaluation activities. The media design also considered accessibility aspects, such as simple navigation, text readability, and compatibility with smartphones. This stage resulted in the initial prototype of the developed learning media.

Development Stage

The development stage included expert validation and product revision. The developed learning media were validated by three expert validators consisting of a content expert, a language expert, and a media expert using validation sheets with a 1–4 Likert scale. The validation was conducted in one stage to assess aspects of content appropriateness, language, and media design. The validation results indicated that the media was categorized as valid to highly valid. In addition to providing assessment scores, the validators also gave suggestions for improvement. The content expert suggested adding more questions to the Wordwall game, the language expert suggested using more standard and appropriate language, and the media expert suggested adding usage instructions. Based on these suggestions, revisions were made by adding more questions to the Wordwall game, improving the language used, and adding a user instruction page. The validation and revision results were used as the basis for improving the media before implementation in the learning process.

Implementation Stage

The implementation stage was conducted to test the practicality of the developed learning media involving 29 students from class XI.F.1, 31 students from class XI.F.2, and one chemistry teacher at SMAN 10 Sijunjung. The implementation was carried out in two meetings with a duration of 2 × 45 minutes for each meeting. During the learning activities, the teacher explained the learning objectives and guided students in accessing the media individually through their smartphones. Students then studied the materials, watched learning videos, and completed Wordwall-based game and evaluation activities. At the end of the lesson, students completed response questionnaires to assess the practicality of the media based on aspects of ease of use, attractiveness, usefulness, and time efficiency. Interviews with the chemistry teacher showed that the media helped increase student participation, supported the explanation of acid-base concepts, and made the learning process more interactive. The results obtained at this stage were used to determine the practicality of the developed learning media.

Evaluation Stage

The evaluation stage was conducted as a formative evaluation aimed at improving and refining the developed learning media rather than measuring learning effectiveness. This stage

used practicality data obtained from student response questionnaires and supported by teacher interviews. The evaluation focused on ease of use, attractiveness, usefulness, and time efficiency. Feedback from students and the teacher was used to make minor revisions, particularly in improving navigation clarity and enhancing the Wordwall game activities. The revised product was then finalized as a feasible learning media for implementation.

Data Collection and Analysis

Data were obtained through expert validation sheets, student practicality questionnaires, and teacher interviews. Quantitative data were analyzed using percentage scores to determine the levels of validity and practicality using the following formula.

$$\text{Percentage} = \frac{\text{obtained score}}{\text{maximum score}} \times 100\%$$

Table 1. Summarizes the Data Collection Instruments and Analysis Techniques Applied in This Study.

Score Interval	Criteria
0 – 20%	Not valid/ Practical
21 – 40%	Less valid/ Practical
41 – 60%	Fairly valid/ Pratical
61 – 80%	Valid/ Practical
81 – 100%	Highly Valid/ Practical

Source (Septiani & Okmarisa, 2023)

Qualitative data from teacher interviews and expert comments were analyzed through data reduction, categorization, and interpretation to support media revision. The research instruments were validated by experts in chemistry education, language, and instructional media to ensure their appropriateness for measuring validity and practicality.

RESULTS AND DISCUSSION

Analysis and Design Stages

The observation results at SMAN 10 Sijunjung indicate that chemistry learning has not been optimally supported by interactive digital learning media and still dominated by conventional media such as whiteboards. Digital media such as PowerPoint and YouTube are used only to a limited extent. As a result, instructional delivery remains largely textual and provides limited support for students in visualizing abstract chemistry concepts, particularly in acid–base material.

The interview results with students show that they prefer learning activities involving animations, images, audio, and interactive activities compared to learning that relies solely on textbooks and whiteboards. In addition, students already own personal smartphones that could support the learning process; however, their use in classroom learning has not been fully optimized

Based on the analysis results, there is a need to develop digital learning media that can enhance concept visualization, student engagement, and more active learning processes. This is in line with the principles of multimedia learning, which state that the combination of text, images, audio, and interactivity can improve conceptual understanding compared to text-based learning alone.

Based on these needs, the learning media were developed in the form of a Wordwall-based educational game integrated through Google Sites with visual design created using Canva. The selection of these platforms was based on their ability to integrate text, images, videos, and interactive activities within a single digital learning system.

The learning components were arranged progressively to guide students from understanding basic acid–base concepts to the evaluation stage. To provide a clear illustration of the designed concept, the interface display of the educational game-based learning media using Wordwall is presented in Figure 1.

Home page

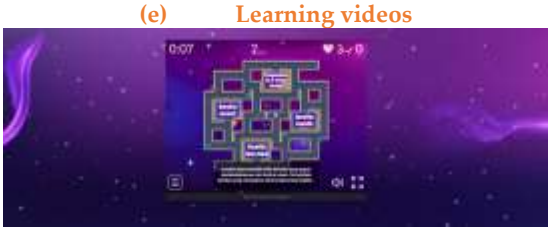
(a) Menu selection page

(b) Learning outcomes page,

(c) Learning objectives page

(d) Learning materials

(e) Learning videos



(f) Educational Game

Figure 1. Design of the Wordwall-based Educational Game

The structure of the learning media was systematically designed, consisting of a home page, menu selection page, learning outcomes page, learning objectives page, learning materials, learning videos, and interactive game-based evaluation activities.

Figure 1 shows the design of the Wordwall-based learning media developed through the integration of Google Sites, Canva, and Wordwall. The media consists of several systematically organized pages to support the learning process, including the home page, menu selection page, learning outcomes page, learning objectives page, learning materials page, learning videos page, and interactive game-based evaluation activities. This structure is designed to support systematic, visual, and interactive learning in understanding acid–base concepts. The difference in interface language (Indonesian) and the language used in the manuscript (English) is due to the adaptation of the media design to the target users, namely Indonesian students.

Development Stage

The development stage was conducted through expert validation and product revision to ensure that the Wordwall-based educational game learning media met appropriate learning quality standards before implementation. Validation was carried out by three experts who assessed three main aspects, namely content validity, language validity, and media/design validity. The overall results indicated that the developed media was categorized as valid to very valid, and therefore feasible to be used as a chemistry learning medium for acid–base material.

Table 2. Validation Results of the Wordwall-Based Learning Media

Aspect	Score (%)	Category
Content validity	80%	Valid
Language validity	75%	Valid
Media design validity	97%	Highly valid

Content validity obtained a score of 80% and was categorized as valid. This indicates that the acid–base material was systematically developed based on Learning Outcomes (CP) and Learning Objectives (TP), resulting in a structured and well-directed learning sequence aligned with expected competencies. This finding is consistent with the constructive alignment theory proposed by John Biggs, which emphasizes that alignment among learning objectives, instructional content, and assessment can enhance learning effectiveness (Alfiyansyah, 2026). In addition, the material was conceptually accurate and supported by visualizations and videos that helped concretize abstract acid–base concepts, making them easier for students to understand. This is in line with Lestari et al. (2026), who state

that visual and video media can strengthen conceptual understanding by transforming abstract concepts into more concrete representations.

Language validity obtained a score of 75% and was also categorized as valid. This result indicates that the language used in the learning media was generally clear and communicative for Grade XI students; however, several revisions were still required. The revisions included simplifying overly complex sentences, improving word choice consistency, and adjusting terminology to enhance readability and clarity. This is consistent with Panjaitan et al. (2021), who state that concise and communicative language improves students' comprehension of learning materials, and is further supported by Asyhari & Silvia (2016), who emphasize that proper use of standardized Indonesian language enhances students' understanding of instructional content.

Meanwhile, media design validity obtained the highest score of 95%, categorized as very valid. This indicates that the media design was highly attractive, characterized by consistent color use, well-organized layout, and clear typography that improved readability and visual appeal. In addition, the media included clear navigation, relevant images and videos, and interactive game-based evaluation features through Wordwall. The media is also accessible across various devices such as smartphones, laptops, and tablets, supporting flexible learning without spatial and temporal limitations. This aligns with the advantages of Google Sites-based learning media, which are flexible and easily accessible anytime and anywhere (Nurlatifah & Suprihatiningrum, 2023).

Overall, the validation results show that the Wordwall-based educational game learning media for acid–base material falls into the valid to very valid category, with content validity at 80%, language validity at 75%, and media design validity at 95%. The differences in these categories indicate that media design is the strongest aspect, while language is the aspect requiring the most revision. However, all aspects have met the minimum feasibility criteria, indicating that the media is suitable for use in chemistry learning. These findings also emphasize that instructional media development should not only focus on general feasibility, but also on the balance between content, language, and design as an integrated learning system.

Implementation Stage

In this stage, the Wordwall-based educational game learning media, which had been revised and validated, was implemented in classroom instruction. The practicality test involved one chemistry teacher, 29 students from class XI.F.1, and 31 students from class XI.F.2. Data were collected through student response questionnaires and teacher interview guidelines. The practicality of the media was assessed based on four aspects: ease of use, attractiveness, usefulness, and time efficiency (Annisa & Darussyamsu, 2023).

Table 3. Practicality Results of Student Responses

Aspect	XI.F.1 (%)	XI.F.2 (%)	Category
Ease of use	83%	87%	Highly practical
Attractiveness	86%	86%	Highly practical
Usefulness	87%	87%	Highly practical
Time efficiency	91%	92%	Highly practical
Average	**86,75%**	**88,00%**	**Highly practical**

Based on teacher interview results, the practicality of the Wordwall-based learning media can be described through three main themes: ease of material delivery, student engagement, and time efficiency. First, regarding ease of material delivery, the teacher stated that the media helped simplify abstract acid–base concepts through structured and visually supported content, making the material easier to explain and understand. Second, in terms of student engagement, the teacher observed that the game-based learning approach increased students' attention and participation.

The learning environment became more interactive and enjoyable, encouraging active student involvement. Third, in terms of time efficiency, the teacher explained that the use of the media accelerated the learning process due to automatic scoring and immediate feedback features. These functions reduced the time required for manual correction and repeated explanations, thereby improving instructional efficiency. These findings are consistent with Syahro et al. (2025), who stated that Wordwall facilitates material delivery and enhances

student engagement. by Lodi (2026) also emphasized that Wordwall creates interactive and enjoyable learning experiences. In addition, digital learning media have been shown to improve learning efficiency and reduce misconceptions (Khairunnisa & Ilmi, 2020).

Student responses further support these findings. In the ease of use aspect, scores of 83% (XI.F.1) and 87% (XI.F.2) indicate that the media is easy to access and operate, supported by clear instructions and simple navigation (Murdianti 2024). In the attractiveness aspect, both classes obtained 86%, indicating that the media successfully increased students' interest, motivation, and participation. The use of colorful visuals, videos, and game-based activities created a more engaging learning environment Dotutinggi et al. (2023) . In the usefulness aspect, both classes obtained 87%, showing that the media supports conceptual understanding and promotes student learning independence. This aligns with Dahlani & Afdaliyah (2024), who reported that Wordwall enhances student learning autonomy.

In the time efficiency aspect, the highest scores were obtained (91% in XI.F.1 and 92% in XI.F.2). This indicates that learning activities became more time-efficient. This result can be attributed to automatic scoring, instant feedback, and structured learning flow, which minimize time spent on manual grading and repeated explanations.

Overall, the average practicality scores were 86.75% for class XI.F.1 and 88.00% for class XI.F.2, categorized as very practical. These findings indicate that the developed Wordwall-based educational game media is feasible and practical for use in chemistry learning on acid–base topics.

Evaluation Stage

The evaluation stage aims to assess the Wordwall-based educational game learning media that has been developed, focusing on practicality analysis as a basis for product improvement and refinement. The results of the students' response questionnaire indicate that the media received positive responses with a high level of interest and learning motivation, as its interactive features and attractive design help facilitate understanding of acid–base material. This is in line with the theory of learning motivation, which states that attractive and interactive learning media can enhance student engagement and motivation in learning (Kusnadi & Azzahra, 2024). In addition, Wordwall as an interactive learning platform provides various features that can improve the learning experience and encourage active student participation (Ardila et al., 2023)

Novelty and Contribution to Chemistry Education

The novelty of this study lies in the development of an acid–base learning media that integrates Google Sites, Canva, and Wordwall based on joyful learning principles. The novelty is reflected in the use of Google Sites as an integration platform, Canva for visual design, and Wordwall for interactive game-based evaluation to support student engagement.

Joyful learning is implemented through interactive navigation, attractive visual design, learning videos, and game-based activities in Wordwall that make learning more engaging and enjoyable. These features are designed to support students' active participation and create a more meaningful learning experience in acid–base topics. The contribution of this study is the development of a valid and practical learning media that can be used as an alternative tool in chemistry learning. This study is limited to one school with a relatively small sample size and does not measure learning effectiveness, but focuses on validity and practicality testing as part of product development.

CONCLUSION

Based on the results of the study, the Wordwall-based educational game learning media on acid–base material was validated by three experts with validity results of 80% from the content expert, 75% from the language expert, and 95% from the media expert, indicating valid to highly valid categories. The practicality test results showed positive responses from students in class XI.F.1 at 86.75% and XI.F.2 at 80,00%, which were categorized as highly practical.

These results indicate that the developed media is feasible to be used in chemistry learning, particularly in acid–base topics. Students and teachers provided positive responses and considered the media easy to use, engaging, and helpful in supporting the learning process.

However, this study has limitations, as it was conducted in only one school with a relatively small sample size and focused only on validity and practicality testing without examining learning effectiveness. Therefore, further research is recommended to investigate the effectiveness of the media on students' learning outcomes and conceptual understanding.

RECOMMENDATION

Future research is recommended to use a pre-test/post-test control group experimental design to examine the effectiveness of the Wordwall-based media on acid-base material. The measurement may include learning outcomes, conceptual understanding, learning motivation, and critical thinking skills using validated instruments.

In addition, broader implementation is suggested across different schools with diverse student characteristics. Further development may integrate augmented reality and virtual laboratories as a future extension to enhance the visualization of abstract chemistry concepts.

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