

Development of an Acid-Base Chemistry Magazine Oriented toward Creative Thinking Skills

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ABSTRACT

The abstract nature of acid-base concepts can make them difficult for students to understand, although these concepts are closely related to everyday life. Therefore, learning media that present acid-base concepts in an interesting and contextual form are needed. This study aimed to develop an acid-base chemistry magazine oriented toward creative thinking skills and to determine its feasibility and students' creative thinking achievement after using the magazine. The study employed a Research and Development (R&D) method using the 4D model, consisting of Define, Design, Develop, and Disseminate stages. The developed magazine was evaluated by a content expert, a media expert, teachers, and students, and was tested with 20 eleventh-grade students of SMK Al-Falah Nagreg. The feasibility assessment showed an average score of 82.00%, which was categorized as very good. Students' creative thinking achievement after using the magazine reached an average score of 85.20, with fluency obtaining the highest score (92.00) and originality the lowest score (75.00). These results indicate that the developed acid-base chemistry magazine is feasible as a learning medium and provides learning activities oriented toward the four indicators of creative thinking: fluency, flexibility, originality, and elaboration.

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Introduction

Chemistry deals with substances, their properties, and the changes they undergo in natural and experimental processes (Keenan et al., 1999). Many chemistry concepts are related to everyday phenomena, but their explanation often involves abstract representations. Students are expected to understand chemical phenomena at macroscopic, submicroscopic, and symbolic levels. Difficulties in connecting these levels can lead to incomplete understanding and misconceptions, including in acid-base concepts (Mubarak & Yahdi, 2020).

Acid-base is one of the chemistry topics that combines theoretical concepts with applications in daily life. Students learn acid-base theories, ionization, acid and base strength, pH, indicators, and reactions. These concepts require students not only to remember information but also to interpret phenomena and apply concepts in different situations. Therefore, learning activities need to provide students with opportunities to explore chemical concepts through materials that are understandable, contextual, and interesting.

Learning media can support the interaction between learning materials, teachers, and students and can be used in both independent and teacher-guided learning (Sudjana, 2005). One form of print-based learning media is a magazine. Compared with conventional textbooks, a chemistry magazine can present scientific information through shorter texts, illustrations, contextual topics, and varied learning activities. Sari et al. (2019) reported the use of a chemistry magazine to support scientific literacy on colloid concepts. Print-based visual media also remain relevant in chemistry education because they can present chemical information in an accessible and engaging format (Cook & van Hest, 2025).

In addition to conceptual understanding, learning media can be designed to support students' creative thinking. Creative thinking involves the ability to generate ideas and develop different responses to a problem or situation (Munandar, 2002; Tawil & Liliasari, 2013). It is commonly described through four indicators: fluency, flexibility, originality, and elaboration (Alabbasi et al., 2022). These indicators can be incorporated into learning activities by providing questions, problems, and contextual tasks that allow students to produce more than one possible response.

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Several studies have developed digital learning media for acid-base chemistry. Tarawi et al. (2020) developed an interactive acid-base e-chemistry magazine, while Aeni et al. (2026) reported the validity and practicality of an acid-base e-magazine. Other studies have focused on creative thinking through different types of learning materials. For example, Hidayah et al. (2026) developed inquiry-based student activity sheets for acid-base electrochemistry that integrated creative-thinking indicators. These studies show the potential of both magazine-based media and learning materials oriented towards creative thinking. However, the previous studies addressed these aspects separately and mainly used electronic magazines or other learning materials.

Based on this background, this study developed a print-based acid-base chemistry magazine in which the four creative-thinking indicators were explicitly incorporated into its content and learning activities. The magazine consists of seven rubrics that present acid-base concepts through scientific information, contextual phenomena, practical activities, creative texts, and questions. Therefore, this study aimed to develop an acid-base chemistry magazine oriented toward creative thinking skills, determine its feasibility, and describe students' creative thinking achievement after using the magazine.

Methods

This study employed a Research and Development (R&D) design adapted from the 4D model proposed by Thiagarajan et al. (1974), consisting of four stages: Define, Design, Develop, and Disseminate. The 4D model was selected because its sequential stages are suitable for developing and validating instructional products. The product developed in this study was a print-based chemistry magazine on acid-base concepts oriented toward four indicators of creative thinking skills: fluency, flexibility, originality, and elaboration. These four indicators have also been widely used as a framework for assessing creative thinking in learning activities (Hidayah et al., 2026; López Martínez et al., 2024).

The study involved eleventh-grade students of class XI-RPL at SMK Al-Falah Nagreg. The main field trial involved 20 students who used the developed chemistry magazine and completed a creative thinking test after the learning activity. Product feasibility was assessed by one content expert, one media expert, a chemistry teacher, and students.

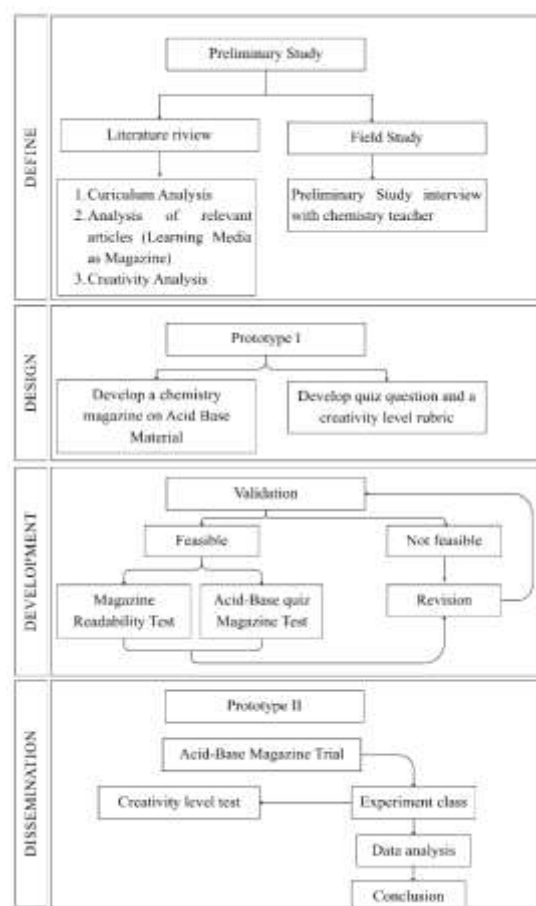


Figure 2. Design method

Define

The Define stage was conducted to identify the learning needs and determine the acid-base content to be included in the magazine. This stage consisted of a preliminary study, learner analysis, task analysis, concept analysis, curriculum analysis, and analysis of creative thinking indicators, in accordance with the initial stage of the 4D development model (Thiagarajan et al., 1974).

The preliminary study included an interview with a chemistry teacher to identify problems encountered in learning acid-base concepts and the learning media commonly used in the classroom. Previous studies have also reported that acid-base concepts are abstract and prone to misconceptions, indicating the need for contextual and alternative learning materials (Hidayah et al., 2026).

Curriculum and concept analyses were then conducted to determine the scope of the material. The concepts included the history of acid-base development, Arrhenius, Brønsted–Lowry, and Lewis theories, properties of acids and bases, ionization, degree of ionization, acidity, acid-base strength, indicators, and acid-base reactions. The material was then related to the four creative thinking indicators, namely fluency, flexibility, originality, and elaboration, so that each learning activity had a specific creative-thinking orientation (Hidayah et al., 2026; López Martínez et al., 2024).

Design

The Design stage was carried out to prepare the initial form of the chemistry magazine and the research instruments. The magazine was designed in B5 format, printed in full color, and organized into seven rubrics: History, Figures and Theories, Substance Study, Mini Lab, Art Chemist, Phenomena, and Quiz. Similar magazine-based learning media have previously been developed for acid-base chemistry and reported to be valid and practical for learning (Tarawi et al., 2020; Aeni et al., 2026).

Each rubric was prepared according to the acid-base concepts and the targeted creative thinking indicators. The History rubric introduced the development of acid-base concepts, while Figures and Theories presented the Arrhenius, Brønsted–Lowry, and Lewis's theories. Substance Study contained the main concepts of acid-base chemistry, Mini Lab provided simple practicum activities, and Art Chemist and Phenomena presented acid-base concepts through contextual and creative content. The Quiz rubric contained questions designed to assess fluency, flexibility, originality, and elaboration.

The integration of creative-thinking indicators into different learning activities was based on the same general principle used in previous chemistry learning materials that explicitly incorporated the four creative thinking indicators into instructional tasks (Hidayah et al., 2026). The assessment items were also prepared with reference to the four constructs of verbal creative thinking described by López Martínez et al. (2024).

At this stage, the researchers also prepared the expert-validation questionnaire, teacher and student feasibility questionnaires, and the creative thinking test. The initial product produced at the end of this stage was referred to as Draft I.



Figure 2. Acid-base chemistry magazine cover

Develop

The Develop stage consisted of expert validation, product revision, a limited readability test, and the main field trial. Draft I was evaluated by one content expert and one media expert using a Likert-scale questionnaire. This process followed the expert appraisal and revision cycle of the 4D model (Thiagarajan et al., 1974) and was consistent with the validation approach used in previous acid-base learning-media development studies (Aeni et al., 2026).

The experts assessed the content, organization, presentation, and visual aspects of the magazine and also provided comments and suggestions for improvement. Based on the validation results, the magazine was revised, particularly in the sequence of the material and the presentation of the Substance Study and Mini Lab rubrics. The revised product was then referred to as Draft II.

A limited test was subsequently conducted to obtain responses regarding the readability and usability of the magazine. This stage was used to identify parts of the magazine that still required improvement before the main field trial. Limited practicality testing has also been used in comparable acid-base e-magazine development before wider implementation (Aeni et al., 2026).

The main field trial was conducted with 20 eleventh-grade students of SMK Al-Falah Nagreg. The students used the chemistry magazine during the learning activity and completed the creative thinking test after using the magazine. The test assessed the four indicators of creative thinking: fluency, flexibility, originality, and elaboration. The use of these four indicators is consistent with previous studies of creative thinking in chemistry learning (Hidayah et al., 2026; López Martínez et al., 2024).

Disseminate

The disseminate stage was conducted on a limited scale. the developed chemistry magazine was introduced to chemistry teachers within the school and the chemistry subject-teacher forum (mgmp). broader dissemination was not conducted because of limitations in time, cost, and distribution. in the 4d model, dissemination is intended to extend the use of the developed product after it has passed the development and validation stages (thiagarajan et al., 1974).

Data Analysis

The data obtained in this study consisted of feasibility data and students' creative thinking scores. Feasibility data from the media expert, content expert, teacher, and students were analyzed descriptively by converting the obtained scores into percentages of ideality. The calculation was performed using the following equation:

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

The resulting percentages were then interpreted into qualitative categories ranging from very poor to very good. This type of descriptive quantitative analysis is commonly used in instructional product-development studies to determine the feasibility of developed learning media (Aeni et al., 2026).

Students' creative thinking scores were analyzed descriptively for each indicator—fluency, flexibility, originality, and elaboration—and as an overall average score. Because the study did not use a pretest, control group, or comparison group, these scores were interpreted as students' creative thinking achievement after using the chemistry magazine rather than as evidence of improvement or causal effect.

Results and Discussion

The development process resulted in a print-based chemistry magazine on acid-base concepts entitled Chemistry. The magazine was designed using semi-scientific language, illustrations, contextual examples, and learning activities related to the four indicators of creative thinking: fluency, flexibility, originality, and elaboration. The final product consisted of seven rubrics: History, Figures and Theories, Substance Study, Mini Lab, Art Chemist, Phenomena, and Quiz.

Characteristics of the Chemistry Magazine

The History rubric introduces students to the historical development of chemistry through information about Jabir Ibn Hayyan and several important developments related to acid-base concepts (figure 3). The questions included in this rubric were designed to encourage students to give responses related to the originality indicator.



Figure 3. Rubric History of Jabir Ibnu Hayyan

The Figures and Theories rubric presents the development of acid-base theories proposed by Arrhenius, Brønsted–Lowry, and Lewis (figure 4). These theories were included to provide the conceptual basis needed for understanding the differences among the major acid-base definitions taught at the senior secondary level.



Figure 4. Rubric Figures and Theories

The Substance Study rubric contains the main concepts of acid-base chemistry, including the properties of acids and bases, ionization, degree of ionization, acidity, acid-base strength, and indicators (figure 5). This rubric provides the conceptual foundation for the other activities presented in the magazine.



Figure 5. Rubric Substance Study: a) Acid-Base Solution, b) Acid-Base Strongest, c) Indicator

The Mini Lab rubric contains simple experimental activities related to acid-base reactions (figure 6). The activities are presented in sequential steps so that students can follow the procedure and explain the observations in more detail. This rubric was mainly oriented toward the elaboration indicator of creative thinking.



Figure 6. Rubric Mini Lab

The Art Chemist rubric presents acid-base concepts in more varied forms (figure 7). The contents include the short story “Ke-Galau-an H_2O ,” the illustrated story “Kesengsaraan Neng Siti Terjebak di Pulau Asam,” and the poem “Asam Basa Kehidupan.” These materials were used to connect chemistry concepts with creative forms of expression and were mainly related to the originality indicator.



Figure 7. Rubric Art Chemis: a) Ke-Galau-an H_2O , b) Kesengsaraan Neng Siti Terjebak di Pulau Asam, c) Asam Basa Kehidupan

The Phenomena rubric connects acid-base concepts with situations encountered in daily life (figure 8). The topics include “Semut Imut Beracun,” which discusses acidic substances associated with ant venom; “Kisah Lime,” which relates acids to everyday health contexts; “Acid Bath Killer,” which is used as a contextual example of the hazardous misuse of a strong acid; and “Si Kunyit Penyelamat,” which discusses acid-base concepts in a health-related context. The discussion of hazardous chemical use was presented only to relate chemical properties to safety and responsible chemical handling, without providing procedural information that could encourage harmful use.



Figure 8. Rubric Phenomena: a) Kisah Lime, b) Acid Bath Killer, c) Semut Imut Beracun

The Quiz rubric contains questions related to the acid-base concepts presented throughout the magazine. The questions were designed to obtain students’ responses based on the four creative thinking indicators.



Figure 9. Rubric Quiz

Feasibility of the Chemistry Magazine

The feasibility assessment was conducted to determine the suitability of the developed chemistry magazine before and during its use with students. The assessment involved a media expert, a material expert, a chemistry teacher, and students. The results are presented in Table 1.

Table 2. Percentage of ideality and quality of each assessment aspect of the acid-base chemistry magazine oriented to creative thinking skills

Assessor	Ideality Percentage (%)	Category
Media Expert	81.40	Very Good
Material Expert	80.66	Very Good
Teacher/Educator	82.00	Very Good
Student	83.37	Very Good
Total Average Score	82.00	Very Good

The overall feasibility score of the chemistry magazine was 82.00%, which was classified as very good according to the assessment category used in this study. Among the four assessments, students gave the highest score at 83.37%, followed by the teacher at 82.00%, the media expert at 81.40%, and the material expert at 80.66%. Although the scores were relatively close, they indicate that both expert and user assessments placed the developed magazine in the same feasibility category.

The media expert gave a score of 81.40%. This assessment considered aspects related to the visual presentation and physical characteristics of the magazine, including layout, readability, use of illustrations, printing quality, and organization of the content. The magazine was produced in B5 format with full-color printing and contained supporting visual elements in each rubric. The use of visual and print-based formats is consistent with previous studies reporting that chemistry magazines and other visual print media can provide an attractive alternative to conventional learning materials (Sari et al., 2019; Cook & van Hest, 2025).

The material expert gave the lowest score, although it remained in the very good category, at 80.66%. Feedback from the material expert mainly concerned the organization and sequencing of the content. Based on this feedback, several parts of the magazine, particularly the Substance Study and Mini Lab rubrics, were revised so that the material was presented more systematically from simpler to more complex concepts. Revision based on expert judgment is an important part of the development stage in the 4D model before the product is used in a field trial (Thiagarajan et al., 1974).

The teacher assessment reached 82.00%, while the students gave a score of 83.37%. These results show that the magazine was positively received not only by experts but also by its intended users. Similar findings have been reported in the development of acid-base magazine-based learning media, in which expert validation and user responses were used to determine whether the developed product was appropriate for classroom use (Aeni et al., 2026; Tarawi et al., 2020).

Taken together, the feasibility results indicate that the developed chemistry magazine was suitable for use as a learning medium on acid-base concepts. However, the feasibility scores should be interpreted as evidence of the quality and acceptability of the developed product, rather than as evidence that the magazine improves students' creative thinking skills.

Students' Creative Thinking Skills

Students' creative thinking skills were assessed after using the acid-base chemistry magazine. The assessment covered four indicators: fluency, flexibility, originality, and elaboration (Alabbasi et al., 2022). The trial involved 20 eleventh-grade students of SMK Al-Falah Nagreg. The results are presented in Table 2.

Table 2. Score of each creative-thinking-skill indicator on the acid-base concept through the chemistry magazine

Indicator	Score	Category
Fluency	92.00	Very Good
Flexibility	85.00	Very Good
Originality	75.00	Good
Elaboration	88.75	Very Good
Average Total Score	85.20	Good

The average creative thinking score was 85.20, which was categorized as good. Among the four indicators, fluency obtained the highest score at 92.00, followed by elaboration at 88.75, flexibility at 85.00, and originality at 75.00. These results show that students performed differently across the four creative thinking indicators after using the magazine.

The high fluency score indicates that students were able to generate several relevant responses to the questions and activities presented in the magazine. Fluency is generally associated with the ability to produce a number of ideas or possible responses to a given problem (Alabbasi et al., 2022). A similar pattern was reported by Dewi and Mashami (2019), who found that fluency showed a relatively strong performance compared with several other creative thinking indicators in chemistry learning.

Elaboration also obtained a relatively high score at 88.75. This indicator reflects students' ability to develop or add detail to an idea. In the developed magazine, activities in rubrics such as Mini Lab were designed to provide opportunities for students to explain observations and develop their responses in a more detailed form.

Flexibility reached a score of 85.00. This result shows that students were able to provide different responses or consider more than one way of explaining a problem. The variety of content presented in the magazine, including scientific information, contextual phenomena, practical activities, and creative texts, was intended to expose students to different forms of acid-base problems.

Originally obtained the lowest score at 75.00, although it was still classified in the good category. Compared with the other indicators, this result suggests that producing uncommon or original responses was more difficult for students. Originality generally requires students to produce ideas that are not only relevant but also less common than the responses produced by others (Alabbasi et al., 2022). A lower performance in originality compared with fluency has also been reported in previous studies of creative thinking in chemistry learning (Dewi & Mashami, 2019).

The relatively lower originality score indicates that the activities specifically targeting this indicator still need further development. Future revisions of the magazine may include more open-ended tasks that allow students to construct their own ideas, representations, or visual relationships among concepts. Previous work has suggested that activities such as mind mapping can provide opportunities for students to organize and express ideas more freely in chemistry learning (Sari, 2014).

Overall, the results show that students achieved good creative thinking scores after using the acid-base chemistry magazine. However, because this study did not employ a pretest or a comparison group, the results cannot be interpreted as evidence of an increase in creative thinking skills. The scores describe students' creative thinking achievement after using the developed magazine.

Conclusions

The development of the acid-base chemistry magazine produced a learning medium that integrates four indicators of creative thinking—fluency, flexibility, originality, and elaboration—across seven rubrics. The magazine presents acid-based concepts through scientific information, contextual phenomena, simple practical activities, creative texts, and assessment questions.

The feasibility assessment conducted by a media expert, a material expert, a chemistry teacher, and students resulted in an average score of 82.00%, which was classified in the very good category. This result indicates that the developed chemistry magazine is feasible for use as a learning medium on acid-based concepts.

After using the magazine, the 20 students obtained an average creative thinking score of 85.20, classified in the good category. Fluency showed the highest score at 92.00, while originality showed the lowest score at 75.00. These results describe students' creative thinking achievement after using the magazine. Further studies using pretest-post test or comparative designs are needed to determine whether the developed magazine can improve students' creative thinking skills.

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Conflici of Interest

The authors declare no conflict of interest.

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