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Development of a Socio-Scientific Issues-Based Interactive E-Book on Acid-Base Chemistry : Validity and Practicality Analysis

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A B S T R A C T

This study developed and evaluated a Socio-Scientific Issues (SSI)-based interactive e-book for learning acid-base chemistry. The study employed a research and development approach based on the first five stages of the Borg and Gall model: research and information collection, planning, initial product development, preliminary product testing, and revision. The e-book integrates structured acid-base content, multimedia representations, interactive exercises, competency tests, feedback, and SSI contexts. Validation involved two content experts and two media experts, followed by a practicality test with chemistry students. The results showed Good content validity (8.31), Very Good media validity (3.56), and Good practicality (3.3). These findings indicate that the e-book is a valid and practical digital resource for further classroom implementation.

INTRODUCTION

Chemistry learning requires students to connect observable phenomena with particulate processes, chemical symbols, equations, and quantitative relationships. This challenge is particularly evident in acid-base chemistry, where students often experience difficulties in explaining acid-base processes, reasoning about acidity, interpreting titration phenomena, and connecting molecular representations with symbolic expressions and experimental evidence (Baldwin & Orgill, 2019; Czysz et al., 2020; Kim et al., 2019; Schmidt-McCormack et al., 2019; Shah et al., 2018). Studies have also shown that instructional approaches that explicitly connect representations and provide opportunities for conceptual reasoning can strengthen students' understanding of acid-base and pH concepts (Watson et al., 2020; Ye et al., 2019) . Therefore, acid-base learning should not focus solely on formulas and algorithmic calculations but should provide learning resources that support visualization and conceptual connections.

Digital learning resources provide opportunities to support these needs. Interactive materials can integrate text, images, animations, videos, exercises, feedback, and navigation within a single learning environment. Such features are relevant to chemistry because many chemical processes cannot be directly observed at the particulate level. Day & Pienta (2019) found that students valued e-book features that supported visualization and engagement, while Seibert et al. (2020) demonstrated that interactive digital resources could integrate information, learning activities, exercises, and supporting materials. Other chemistry education studies have similarly shown the value of simulations, video-based instruction, and student-centered digital environments for supporting conceptual learning and interaction (Groos et al., 2021; Pekdağ, 2020; Schwedler & Kaldewey, 2020; Watson et al., 2020) . However, Turner & Chung (2020) showed that students do not automatically adopt e-books simply because they are available, indicating that digital resources require purposeful integration into learning activities.

Digital interactivity alone, however, does not ensure meaningful chemistry learning. Chemical concepts also need to be connected with social, environmental, technological, and everyday contexts. Socio-Scientific Issues (SSI) provide a suitable framework for this purpose because they require learners to use scientific knowledge while considering evidence, multiple perspectives, values, and possible decisions. Högström et al. (2025) , through a systematic review of 157 empirical studies, showed that SSI teaching frequently combines science content with higher-order thinking and commonly addresses environmental, sustainability, health, and technological issues. Earlier empirical research also demonstrates that SSI can support students in considering knowledge, values, and experiences when constructing arguments and making decisions (Rundgren et al., 2016) , while SSI classrooms provide opportunities to connect school science with more contextual and socially embedded forms of scientific reasoning (Lee et al., 2020) .

SSI is particularly relevant to chemistry because chemical knowledge is closely connected with materials, products, health, environmental processes, and

technological decisions. López-Fernández et al. (2021, 2022) showed that chemistry-based socioscientific contexts can promote the consideration of scientific evidence, argumentation, decision making, and critical analysis. In the Indonesian context, Nida et al. (2021) found that students perceived SSI-based chemistry learning on palm-oil biodiesel as relevant and motivating for learning chemistry and participating in societal discussions. Wiyarsi et al. (2021) further demonstrated the potential of SSI-oriented inquiry in acid-base learning to support chemical literacy and scientific habits of mind. Recent evidence also continues to link socioscientific reasoning with argumentation and the evaluation of evidence (Khishfe, 2026) .

Nevertheless, SSI implementation in everyday classrooms remains challenging. Chen & Xiao (2021) identified difficulties associated with teacher preparation, pedagogical knowledge, students, curriculum conditions, and instructional support, while Lee et al. (2020) showed that students may experience tensions when moving between conventional school science and the more uncertain and multidimensional nature of SSI. Embedding SSI within a structured interactive learning resource may therefore provide practical support for bringing socioscientific contexts into chemistry instruction.

Although previous studies have examined interactive digital resources and SSI-oriented chemistry learning, these two areas are commonly investigated as separate strands. Digital-resource studies mainly emphasize visualization, interaction, accessibility, and learning support, whereas SSI research often focuses on scientific literacy, argumentation, reasoning, and decision making. The contribution of the present study lies in integrating these dimensions within an interactive e-book specifically designed for acid-base chemistry and evaluating the resulting product through content validity, media validity, and user practicality. Accordingly, this study aimed to develop a Socio-Scientific Issues-based interactive e-book for acid-base chemistry and evaluate its validity and practicality as a digital learning resource.

THEORETICAL REVIEW

Interactive E-Books in Chemistry Learning

Interactive e-books extend conventional electronic texts by integrating multimedia and interactive components, including written explanations, images, animations, videos, exercises, navigation tools, and feedback. These features are particularly relevant to chemistry because conceptual understanding requires students to coordinate macroscopic observations, submicroscopic processes, and symbolic representations. Research has consistently shown that students may struggle to move between these representational forms, including in acid-base and titration contexts (Baldwin & Orgill, 2019; Czysz et al., 2020; Wang & Lewis, 2020) . Multiple and digitally supported representations can facilitate connections among these levels when they are deliberately integrated into instruction (Schwedler & Kaldewey, 2020; Ye et al., 2019) .

Research on digital chemistry resources also indicates that the value of an e-book depends on how its interactive functions support learning. Day & Pienta (2019) found that students valued e-book features that supported visualization

and engagement. Franco & Provencher (2019) reported positive responses to an interactive chemistry book combining text, videos, figures, and self-quizzing, while Seibert et al. (2020) demonstrated how information, exercises, and interactive tasks can be integrated within one digital learning environment. Groos et al. (2021) further emphasized individuality, interactivity, and realism as important considerations when designing digital chemistry environments. At the same time, (Turner & Chung, 2020; Weng et al., 2018) indicate that digital format or increased interactivity alone does not guarantee better learning or adoption. The interactive elements must serve clear pedagogical purposes.

Socio-Scientific Issues in Chemistry Education

SSI refers to complex issues in which scientific knowledge interacts with social, environmental, technological, ethical, economic, or health considerations. SSI-oriented learning requires students not only to understand scientific concepts but also to examine evidence, consider alternative perspectives, construct arguments, and make informed judgments. Högström et al. (2025) found that the most common goals of SSI instruction include higher-order thinking and science content knowledge. Rundgren et al. (2016) further demonstrated that SSI decision making involves an interaction among scientific knowledge, values, and previous experiences, while Leung & Cheng (2020) showed that sustained SSI instruction can broaden the perspectives students use to explain complex societal problems.

Chemistry provides particularly suitable contexts for SSI because chemical knowledge directly relates to environmental pollution, materials, food, health, energy, and technological products. Nida et al. (2021) demonstrated that an Indonesian chemistry SSI involving palm-oil biodiesel was perceived by students as relevant and motivating. López-Fernández et al. (2021) reported that a chemistry-based role-playing activity involving single-use plastics enabled students to construct arguments and consider evidence before making decisions. Their later work further emphasized the potential contribution of SSI to critical thinking in chemistry education (López-Fernández et al., 2022) . In acid-base learning specifically, Wiyarsi et al. (2021) found that SSI-oriented inquiry supported chemical literacy.

Recent studies also indicate that SSI should not be reduced to the simple presentation of real-world examples. Successful SSI learning requires students to engage with uncertainty, conflicting perspectives, evidence, and argumentation. Lee et al. (2020) identified tensions that may emerge when students accustomed to conventional science learning encounter these features, while Khishfe (2026) found meaningful associations between students' understanding of the nature of science and components of argumentation within SSI contexts. These findings strengthen the rationale for embedding SSI within structured learning resources that provide both scientific information and opportunities to engage with contextual issues.

Integration of SSI and Interactive E-Books for Acid-Base Learning

The integration of SSI into an interactive e-book combines two complementary functions. The interactive digital format provides multimedia representations, flexible access, exercises, and feedback, while SSI provides meaningful contexts in which chemical knowledge can be interpreted and applied. This combination allows an e-book to function not only as a source of chemical information but also as a structured environment for linking concepts with societal and environmental situations.

Such integration is also relevant to practical classroom implementation. Although SSI has strong potential in science education, teachers still encounter difficulties related to pedagogical knowledge, curriculum conditions, student readiness, and instructional resources Chen & Xiao (2021) . Högström et al. (2025) similarly identified a continuing need to translate the extensive theoretical foundation of SSI into practical classroom approaches. Embedding SSI contexts directly within a structured interactive learning resource may help address part of this implementation challenge by providing teachers and students with organized content, contexts, and learning activities within the same medium.

Based on this theoretical foundation, the interactive e-book developed in the present study integrates acid-base concepts, multimedia representations, interactive learning activities, feedback, and SSI contexts. The development process therefore considers two essential dimensions of product quality. First, validity concerns the appropriateness and accuracy of the content and media design. Second, practicality concerns the extent to which the developed resource can be accessed, understood, operated, and positively used by learners. These dimensions provide the basis for evaluating whether the developed e-book is sufficiently appropriate for further implementation in chemistry learning.

METHODOLOGY

This study employed a Research and Development (R&D) approach to develop a Socio-Scientific Issues (SSI)-based interactive e-book for acid-base chemistry. The development procedure was adapted from the Borg and Gall model and limited to five stages : research and information collection, planning, development of the initial product, preliminary product testing, and product revision. These stages were used to produce and evaluate the interactive e-book in terms of content quality, media quality, and practicality.

Research and Information Collection

The first stage focused on identifying the instructional requirements for the e-book. Curriculum analysis was conducted to determine the competencies and learning indicators related to acid-base concepts. Relevant chemistry textbooks were also reviewed to ensure the scientific accuracy and scope of the content. The learning materials included acid-base concepts, acid and base strength, ionization equilibrium, pH calculations, indicators, and applications of acid-base chemistry in everyday contexts. The curriculum analysis generated ten learning indicators that guided the organization of the e-book content.

Planning and Product Development

During the planning stage, the content structure and interactive components of the e-book were organized in a storyboard. The storyboard specified the sequence and placement of textual explanations, illustrations, videos, examples, exercises, animations, and competency tests. It also guided the integration of SSI contexts into the learning materials.

The initial product was developed as an online interactive flipbook that could be accessed through laptops and smartphones. The e-book incorporated multimedia and interactive components, including videos, illustrations, practice activities, navigation features, competency tests, scoring, and immediate feedback. SSI contexts were embedded into the content by connecting acid-base concepts with issues and applications related to everyday life, technology, the environment, and society.

Expert Validation

The developed e-book underwent expert validation involving two content experts and two media experts. Content validation examined the appropriateness and accuracy of the learning indicators, concepts, theories, chemical equations, molecular representations, and other instructional components. Media validation focused on visual design, typography, background use, image placement, navigation, functionality of interactive features, readability, and language use.

The experts provided quantitative ratings and qualitative comments. Their recommendations were used to revise the e-book. Validation data were summarized by calculating the mean score for each criterion, followed by the mean score for each aspect and the overall validation score. The resulting values were then interpreted using the predetermined validity categories.

Practicality Testing

Following expert validation and product revision, a limited practicality test was conducted with first-semester students in the Chemistry Department. The participants used the interactive e-book and then completed a response questionnaire concerning its practicality.

The questionnaire evaluated twelve aspects, including the attractiveness of the cover and content, clarity of instructions, ease of use, accessibility, interactive features, multimedia presentation, contribution to active participation, support for independent learning, and the usefulness of feedback provided through exercises. Student responses were summarized by calculating the mean score for each aspect and the overall mean practicality score.

Data Analysis

The study generated two main types of quantitative data: expert validation scores and student practicality responses. Expert validation data were analyzed descriptively by calculating mean scores at the criterion, aspect, and overall levels. The validity results were subsequently classified using the validity criteria established in the research protocol. Practicality data were also analyzed descriptively by calculating the mean response for each evaluated aspect and the

overall mean score. Qualitative comments from the experts were used as the basis for product revision.

RESULTS

Development and Characteristics of the SSI-Based Interactive E-Book

The development of the interactive e-book began with curriculum analysis to determine the scope of acid-base chemistry and the learning indicators that should be accommodated in the learning material. The analysis resulted in ten learning indicators covering the identification of acidic and basic substances in everyday life, acid-base theories according to Arrhenius, Brønsted-Lowry, and Lewis, calculations involving strong and weak acids and bases, acid-base indicators, and the use of natural materials as indicators. These indicators became the basis for organizing the content and learning activities presented in the e-book.

The development process was also supported by a review of university-level chemistry textbooks to ensure the scientific accuracy and appropriate scope of the concepts presented. The selected references were used to construct the conceptual content, examples, exercises, illustrations, and supporting explanations included in the e-book.

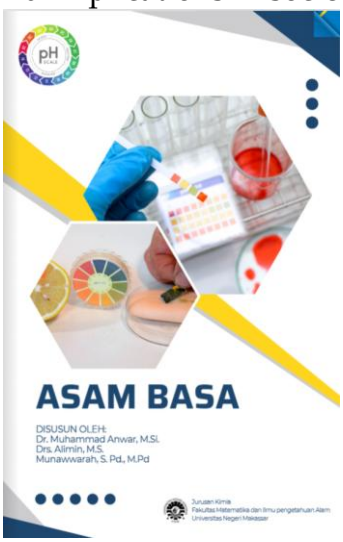
The resulting product was an SSI-based interactive e-book on acid-base chemistry developed using an online flipbook platform. The e-book could be accessed through laptops and smartphones, allowing users to open the material through the provided link. The product was designed with a simple interface and navigation structure to facilitate student access to different parts of the learning material.

The e-book contains several main components, including the cover, learning competencies and indicators, preface, table of contents, acid-base learning materials, illustrations, learning videos, interactive exercises, competency tests, and SSI-based contextual content. The table of contents was designed interactively so that users could directly select the desired section without browsing each page sequentially.

One of the main characteristics of the product is the integration of multimedia and interactive learning features. Videos were embedded to provide audiovisual explanations of acid-base concepts and their applications in everyday life. The e-book also included the "Mari Berlatih" feature, which allowed students to complete exercises online. After completing the questions, students could access the answers and feedback provided through the activity.
Another interactive feature was the competency test located at the end of the learning material. The test consisted of ten multiple-choice questions covering the acid-base content presented in the e-book. Students could select questions, submit their responses, and receive immediate notifications indicating whether their answers were correct or incorrect. The competency test also included a time limit, automatic scoring, and access to the answer key after completion.

In addition to its multimedia features, the e-book incorporated Socio-Scientific Issues (SSI) within the learning content. The SSI components linked acid-base concepts and chemical reactions with products, environmental

conditions, technology, and issues encountered in everyday life. These contextual materials were integrated into the conceptual explanations to provide opportunities for students to connect acid-base chemistry with its applications and implications in society.



(a) e-book cover



(b) learning competencies and indicators



(c) preface and interactive table of contents



(d) multimedia and contextual learning feature



(e) interactive competency test

Figure 1. Main characteristics of the SSI-based interactive e-book on acid-base chemistry

Thus, the developed product was characterized by four major components: structured acid-base content, multimedia representations, interactive learning and assessment features, and the integration of SSI contexts.

Expert Validation Results

The developed e-book was evaluated by two content experts and two media experts. Content validation focused on the appropriateness and accuracy

of the learning content and its presentation, whereas media validation examined the design, navigation, and operation of the digital learning resource.
The results of expert validation are presented in Table 1.

Table 1. Expert Validation Results of the SSI-Based Interactive E-Book

Validation	Aspect	Mean Score	Category
Content	Content feasibility	8.20	Good
Content	Presentation components	8.42	Good
Content overall		8.31	Good
Media	Media design	3.57	Very Good
Media	Navigation and operation	3.56	Very Good
Media overall		3.56	Very Good

The content validation results showed an overall mean score of 8.31, categorized as Good. The presentation component obtained a mean score of 8.42, while content feasibility obtained a mean score of 8.20. These results indicate that the content and its presentation met the validity criteria established in the study.

The media validation produced an overall mean score of 3.56, categorized as Very Good. The media design aspect obtained the highest score of 3.57, followed by navigation and operation with a mean score of 3.56. These results indicate that the appearance and operational functions of the interactive e-book met the predetermined media quality criteria.

The expert validation process also generated several recommendations for product improvement. The suggested revisions included improving sentence structure to minimize potential misconceptions, correcting punctuation, providing identification or numbering for equations, adding examples of acidic and basic products to relevant illustrations, improving the systematic presentation of tables and sources, and ensuring the accuracy of the chemistry concepts presented.

The e-book was revised based on these recommendations before the practicality test was conducted. Following the revision, the product met the validity standards for both content and media.

Practicality of the SSI-Based Interactive E-Book

After expert validation and revision, the e-book was subjected to a limited practicality test involving first-semester students in the Chemistry Department. The practicality questionnaire evaluated twelve aspects related to the appearance, clarity, usability, accessibility, multimedia features, interactivity, support for learning participation, independent learning, and feedback provided by the e-book. The results of the practicality test are presented in Table 2.

Table 2. Practicality Results of the SSI-Based Interactive E-Book

No.	Practicality Aspect	Mean Score
1	The cover and content design are attractive	3.3
2	Sentences and instructions are easy to understand	3.2
3	The interactive e-book is easy to use and user-friendly	3.4
4	The e-book supports active participation in learning	3.1
5	The e-book is easy to access continuously	3.0
6	The features provide opportunities to access broader knowledge	3.2
7	Concepts are attractively supported by animations, images, and videos	3.6
8	Thematic presentation integrates concepts, contextual content, examples, images, and videos	3.4
9	The e-book supports students' knowledge of information and communication technology	3.5
10	The e-book provides more concrete information and supports independent learning	3.3
11	Images, videos, and animations help clarify the concepts being studied	3.2
12	Exercises and feedback support and encourage continued learning	3.2
	Overall Mean	3.3
	Category	Good

The overall mean practicality score was 3.3, which was classified as Good. The highest score was obtained for the integration of concepts with animations, images, and videos, with a mean score of 3.6. This was followed by the contribution of the e-book to students' knowledge of information and communication technology, which obtained a mean score of 3.5.

The ease-of-use aspect obtained a mean score of 3.4, indicating a positive response to the operational characteristics of the e-book. The thematic presentation supported by contextual content, examples, images, and videos also obtained a score of 3.4. The attractiveness of the cover and content and the support provided for independent learning each obtained a mean score of 3.3.

The aspects related to clarity of instructions, access to broader information, concept clarification through multimedia, and feedback from exercises each obtained a mean score of 3.2. Support for active participation obtained a score of 3.1, while continuous accessibility received the lowest score of 3.0. Nevertheless, all evaluated aspects contributed to an overall practicality rating in the good category.

Overall, the findings showed that the developed SSI-based interactive e-book met the established quality criteria. The product obtained a Good rating for content validity, a Very Good rating for media validity, and a Good rating for practicality. These results indicate that the product was sufficiently valid and practical for further implementation and evaluation in acid-base chemistry learning.

DISCUSSION

Characteristics of the SSI-Based Interactive E-Book

The developed e-book integrates structured acid-base content, multimedia representations, interactive activities, assessment features, and SSI within a single digital resource. As shown in Figure 1(a–e), students can navigate the material, access audiovisual explanations, complete exercises, receive feedback, and encounter acid-base concepts through contexts related to everyday life, technology, the environment, and society. This design is relevant because students frequently experience difficulties connecting the different representations required for understanding acid-base chemistry (Baldwin & Orgill, 2019; Czysz et al., 2020; Schmidt-McCormack et al., 2019; Shah et al., 2018) . Research has also shown that explicit support for connecting macroscopic, submicroscopic, and symbolic representations can facilitate chemistry learning (Schwedler & Kaldewey, 2020; Ye et al., 2019) .

The multimedia characteristics of the product are consistent with previous digital chemistry research. Day & Pienta (2019) showed that visualization-supporting e-book features were valued by chemistry students, while Franco & Provencher (2019) reported positive responses to a digital chemistry book integrating videos, images, and self-quizzing. Seibert et al. (2020) similarly demonstrated that learning content and interactive activities can be organized within a single digital environment. Studies involving computer simulations, digital titration environments, and video instruction further indicate that digital tools can support interaction with chemical phenomena when the technology is aligned with clear instructional purposes (Groos et al., 2021; Pekdağ, 2020) .

Another distinguishing characteristic is the integration of SSI into acid-base chemistry. The e-book connects chemical concepts with environmental, technological, and societal situations. This approach aligns with evidence that SSI can situate scientific content within issues that require consideration of evidence and multiple perspectives. Chemistry-specific studies have similarly demonstrated the value of contextualizing chemical knowledge through plastics, biodiesel, and other socially relevant issues (López-Fernández et al., 2021, 2022; Nida et al., 2021). Wiyarsi et al. (2021) provides particularly relevant evidence because SSI was applied directly to acid-base learning.

These characteristics do not yet demonstrate that the e-book improves chemical literacy, critical thinking, or argumentation. Rather, they establish a theoretically supported digital and contextual learning environment that can be examined for these outcomes in subsequent implementation studies.

Validity of the SSI-Based Interactive E-Book

The content validation resulted in an overall score of 8.31 in the Good category, whereas media validation obtained 3.56 in the Very Good category. These findings indicate that the e-book met the quality criteria used for both chemistry content and digital presentation. Expert recommendations addressed sentence structure, equation numbering, examples, table presentation, sources, and conceptual accuracy. Such revisions are important because chemistry learning requires accurate coordination of concepts, symbols, equations, and

representations. Studies of acid-base chemistry and representational competence consistently demonstrate that unclear or disconnected representations can become an additional source of learning difficulty (Baldwin & Orgill, 2019; Czysz et al., 2020; Wang & Lewis, 2020).

The Very Good media validation indicates that the design, navigation, and operational features were considered appropriate. This supports the principle that interactive digital resources should organize multimedia and activities coherently rather than simply maximize the number of digital features. Groos et al. (2021) emphasized interactivity and usability in designing student-centered digital chemistry environments, while Seibert et al. (2020) demonstrated the feasibility of integrating several learning functions into a single digital resource. Turner and Chung (2020) also cautioned that the existence of an e-book does not itself ensure student adoption, reinforcing the importance of usability and purposeful instructional integration.

The availability of a validated SSI-based resource may also support practical classroom implementation. Chen and Xiao (2021) identified instructional support and teacher preparation as important challenges in SSI teaching. Lee et al. (2020) further showed that SSI can introduce epistemic and classroom tensions because students must move beyond the certainty commonly associated with traditional school science. Embedding contextual content within a structured resource may therefore reduce some of the preparation burden while providing a more explicit framework for engaging with SSI.

Nevertheless, the validity findings demonstrate product appropriateness rather than instructional effectiveness. Further implementation is required before conclusions can be made regarding learning outcomes.

Practicality of the SSI-Based Interactive E-Book

The practicality assessment produced an overall mean score of 3.3 in the Good category. The highest score was obtained for the combination of concepts with animations, images, and videos at 3.6, followed by the contribution to information and communication technology knowledge at 3.5. Ease of use and contextual multimedia presentation each obtained 3.4.

The strong response to multimedia presentation is consistent with Day & Pienta (2019, Franco & Provencher (2019), Pekdağ (2020) whose studies support the educational value of visual and audiovisual resources when they are linked to instructional content. Watson et al. (2020) likewise found that a collaborative computer simulation improved students' knowledge, confidence, and conceptual understanding of pH, while Groos et al. (2021) demonstrated that a digital titration environment can be designed around student interaction and usability. These findings support the present result that students responded positively to the combination of multimedia and interactive features in an acid-base resource.

The positive ease-of-use score is also consistent with the Very Good media validation result, showing agreement between expert evaluation and user perceptions. However, continuous accessibility received the lowest score, 3.0. This result should not be attributed to internet connectivity or devices without supporting evidence. Turner and Chung (2020) nevertheless demonstrate more broadly that access to digital texts does not necessarily translate into effortless or

sustained use, suggesting that accessibility and user adoption should remain important considerations in future development.

Overall, the findings demonstrate the feasibility of integrating interactive digital features and SSI contexts within one acid-base chemistry resource. The product achieved good content validity, Very Good media validity, and Good practicality. The contribution of the study therefore lies in providing an initial validated and usable model for combining digital interactivity with socioscientific contextualization. Claims regarding conceptual understanding, chemical literacy, critical thinking, argumentation, or academic achievement require subsequent experimental investigation.

CONCLUSIONS AND RECOMMENDATIONS

This study successfully developed a Socio-Scientific Issues (SSI)-based interactive e-book for acid-base chemistry that integrates structured chemistry content, multimedia representations, interactive exercises, competency tests, feedback, and contextual SSI elements. The product was designed for access through laptops and smartphones and provides students with opportunities to interact with acid-base concepts through both digital features and real-life contexts.

The evaluation results showed that the e-book achieved a Good category for content validity and a Very Good category for media validity. The practicality test also resulted in a good category, indicating that the e-book was generally easy to use, visually engaging, and suitable for supporting independent learning. Students responded most positively to the integration of concepts with animations, images, and videos.

Based on these findings, the developed e-book can be considered a valid and practical digital learning resource for acid-base chemistry. Its main contribution lies in integrating interactive digital features with SSI-based contextualization within a single learning resource. However, the present study focused on product development, validation, and practicality. Therefore, further implementation is recommended to examine the effectiveness of the e-book in improving students' conceptual understanding, chemical literacy, critical thinking, argumentation, and other relevant learning outcomes.

Future development should also pay particular attention to accessibility, as continuous access received the lowest score among the practicality indicators. Further refinement of the platform, navigation, and access options may improve the usability of the e-book in different learning conditions. The product may also be adapted to other chemistry topics that have strong connections with environmental, technological, and societal issues.

FURTHER STUDY

Future studies should evaluate the effectiveness of the SSI-based interactive e-book through broader classroom implementation and appropriate experimental designs. Further research may examine its effects on students' conceptual understanding, chemical literacy, critical thinking, and argumentation skills. The e-book may also be further developed for other

chemistry topics and optimized to improve accessibility across different devices and learning conditions.

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