



## Development of Interactive Multimedia on Acids and Bases Contextually (IMPAC): Incorporating Multiple Representations

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**Abstract:**

The research for the development of the interactive multimedia IMPAC carries important implications for chemistry education, particularly in the topic of acid-base solutions. The contextual approach applied makes the material more relevant to students' daily lives, thereby enhancing their motivation and engagement in learning. Research method 4D Development. Validation by media and content experts, as well as practicality tests by teachers and readability tests by students, respectively, resulted in ideal scores of 95%, 87%, 92%, and 94%. All scores were categorized as "Very Good," reinforcing IMPAC's feasibility for broader implementation. Therefore, IMPAC has the potential to serve as an innovative and effective learning medium that not only strengthens conceptual understanding but also fosters a more engaging, interactive, and meaningful chemistry learning experience. The implication for research is to provide recommendations for teaching materials on the acid-base solutions topic.

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### Introduction

The information and communication technology revolution has changed the face of the world, including the way we educate and learn in the modern era ([Tavares et al., 2024](#)). Technology opens up great opportunities to create more interactive, engaging, and student-centered learning methods ([Consoli et al., 2023](#); [Davies & West, 2014](#)). The use of technology enables learning to be more individualized and relevant, thus addressing the skills needs of the 21st century ([Backfisch et al., 2021](#); [Chauhan, 2017](#)). Research shows that adaptive and interactive technology-based approaches can significantly improve student engagement and learning outcomes ([Fütterer et al., 2022](#)). However, one of the main obstacles is the limited ability of teachers to use educational technology optimally, so that the potential of the technology has not been fully utilized ([Cattaneo et al., 2024](#); [Fraile et al., 2018](#); [Nagel et al., 2023](#)).

In the context of chemistry learning, technology can help students understand abstract concepts, particularly in the complex topic of acid and base solutions (Jones, 2013). This certain topic involves many basic chemical concepts, including pH, acid and base strength and neutralization reactions, which often challenge students due to required basic mathematical skills and a solid understanding of chemical theory ([Chittleborough & Treagust, 2007](#)). In addition, common misconceptions such as the assumption that all acids are corrosive or all bases are slippery, compound these challenges ([Barke et al., 2009](#); [Lin et al., 2016](#)). When encountering challenging topics, students frequently experience a loss of confidence, which in turn diminishes their motivation to continue learning ([Chiu et al., 2021](#); [Chiu & Hew, 2018](#)).

The topic of acids and bases encompasses three interconnected levels of representation (macroscopic, microscopic, and symbolic) ([Gkitzia et al., 2020](#); [Johnstone, 1991](#); [Reid, 2021](#); [Schmidt, 2021](#)). However, many students struggle to link these levels effectively, which interrupt their overall conceptual understanding ([Opona et al., 2022](#); [Trang et al., 2021](#)). For instance, students often fail to grasp how the observable properties of acidic solutions at the macroscopic level relate to ionic interactions occurring at the microscopic level, which are further abstracted and represented in chemical equations at the symbolic level ([Chittleborough & Treagust, 2007](#); [Kapici, 2023](#); [Murni et al., 2022](#); [Taber, 2013](#)).

The concept of *multiple representations*, which includes macroscopic, microscopic, and symbolic, plays an important role in chemistry learning ([Hammer & Avram, 2024](#); [Wiguna & Zamhari, 2023](#)). These representations provide students with a variety of points of view, which helps them understand the concepts more deeply ([Kozma, 2002](#); [Wu & Shah, 2004](#)). However, traditional teaching media often focus only on symbolic representations without providing adequate visualization for macroscopic and microscopic levels. This imbalance can hinder students' ability to integrate these levels, thus complicating their understanding to comprehend chemical concepts holistically ([Derman & Ebenezer, 2020](#)).

Furthermore, students often rely on rote memorization of concepts without understanding the relationships between representation levels, particularly at the submicroscopic level. This tendency significantly contributes to misconceptions, particularly in acid-base topics. Research by [Yunitasari et al. \(2019\)](#), found that 47.50% of students held misconceptions about acid and base strength, while 67.37% struggled

with acid and base pH. Most of these misconceptions arose from questions involving submicroscopic representations. Consequently, there is a notable demand for a learning approach that helps students developing a thorough understanding into the connections between these levels.

Unfortunately, the learning approach used nowadays is still predominantly teacher-centered. This approach tends to leave students as passive recipients, thus not encouraging their active engagement in the learning process (Lucila & Adolfo, 2021). Conversely, contextual learning approaches have enhanced conceptual understanding and motivation by linking academic content to real-world contexts (Chen et al., 2023; Herrington & Oliver, 2000; Hwang et al., 2012). In chemistry learning, the contextual approach can help students understand the topic of acids and bases by applying concepts in everyday life (Eichler, 2020; Sristy et al., 2023). Unfortunately, the application of this method is often constrained by the lack of interactive learning media and adequate visualization tools. (Broman, 2020).

Interactive multimedia offers an innovative solution to address these challenges. This medium fosters student engagement and provides multi-level visualizations to support contextual learning by incorporating animations, audio, videos, and other interactive elements (Chiu & Churchill, 2016; Hu et al., 2021; Mayer, 2009; Zhu et al., 2020). Several studies indicated that interactive multimedia is effective in helping students overcome their difficulties with abstract topics by providing visual representations that can be easily accessed and understood (Ainsworth, 2014; Moreno & Mayer, 2007; Osman & Lee, 2014). Despite the proven benefits, tools specifically designed to teach acids and bases using a contextual and multiple representations approach remain scarce (Lee & Osman, 2012).

To fill this gap, this study aims to develop Interactive Multimedia on Acids and Bases Contextually (IMPAC) with Multiple Representations. Specifically, IMPAC is designed to improve students' conceptual understanding by integrating interlevel visualizations (macroscopic, microscopic, and symbolic) with contextual learning strategies. This innovative tool aspires to make chemistry learning more effective, engaging, and relevant to students' authentic experiences.

## **Research Method**

This research employs the 4D method developed by Thiagarajan (1974), which comprises four stages: Define, Design, Development, and Disseminate. In the define stage, researchers identify learning challenges or needs to be addressed. This phase includes analyzing students to determine the specific requirements for teaching materials that can enhance learning quality. Research objectives are also formulated during this stage to ensure that the proposed solutions align with identified learning needs.

The design stage focuses on planning and developing the intended learning solution. This phase involves creating a teaching approach or methodology and developing research instruments for data collection. Key data elements include teaching material specifications, the structure of interactive multimedia, and the integration of multiple representation concepts into the materials.

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The development stage involves the implementation of the design plan to produce relevant and innovative learning products. The resulting product is a contextual interactive multimedia tool for acid-base solution topics, incorporating multiple representations (macroscopic, microscopic, and symbolic). Named IMPAC (Interactive Multimedia on Acids and Bases Contextually with Multiple Representations), this product aims to enhance students' conceptual understanding while aligning with the interactive and technology-driven context of 21st-century education.

The product was developed using Figma software and is equipped with materials, videos, and interactive quizzes to support contextual-based learning. The development process included validation by media and subject matter experts, followed by revisions based on their feedback. The product was then evaluated for practicality by teachers and for readability by students, assessing its effectiveness and usability in terms of design, content presentation, and applicability in the classroom.

Research instruments used in this study included product validation sheets, practicality sheets, and readability sheets. Validation and practicality tests were conducted using Likert-scale questionnaires, while readability assessments employed Guttman-scale questionnaires.

Data analysis involved converting qualitative assessments into quantitative measures using predefined scales. Validation data from media and subject matter experts, along with product quality evaluations by chemistry teachers, were analyzed using the Likert scale, which provides five response options: Very Good, Good, Fair, Poor, and Very Poor, as detailed in Table 1. Readability data were gathered using Guttman-scale questionnaires with binary Yes or No responses, as shown in Table 2.

**Table 1. Likert Scale Category Conversion Rules to Scores**

| Category  | Positive Statement Score | Negative Statement Score |
|-----------|--------------------------|--------------------------|
| Very Good | 5                        | 1                        |
| Good      | 4                        | 2                        |
| Fair      | 3                        | 3                        |
| Poor      | 2                        | 4                        |
| Very Poor | 1                        | 5                        |

**Table 2. Guttman Scale Category Conversion Rules to Scores**

| Description | Positive Statement Score | Negative Statement Score |
|-------------|--------------------------|--------------------------|
| Yes         | 1                        | 0                        |
| No          | 0                        | 1                        |

Next, the average score for each aspect and the overall assessment is calculated from the obtained scores. The average score can be determined using Equation 1. The scores are then converted into qualitative values based on the guidelines for converting scores into a five-point scale, as shown in Table 3. Finally, the ideal percentage (%) is calculated using Equation 2.

$$\bar{X} = \frac{\sum x}{n} \quad (1)$$

$$\% = \frac{\text{Score achieved}}{\text{Ideal maximum score}} \times 100\% \quad (2)$$

Table 3. Ideal Assessment Criteria

| Score Range   | Category  |
|---|-----------|
| $X_i + 1,80 S_{Bi} < X$                               | Very Good |
| $X_i + 0,60 S_{Bi} < X \leq X_i + 1,80 S_{Bi}$        | Good      |
| $X_i - 0,60 S_{Bi} < X \leq X_i + 0,60 S_{Bi}$        | Average   |
| $X_i - 1,80 S_{Bi} < X \leq X_i - 0,60 S_{Bi}$        | Poor      |
| $X \leq X_i - 1,80 S_{Bi}$                            | Very Poor |
| Ideal average score ( $\bar{X}_i$ )                   |           |
| $\bar{X}_i = 1/2$ (ideal max score + ideal min score) |           |
| Ideal standard deviation ( $S_{Bi}$ )                 |           |
| $S_{Bi} = 1/6$ (ideal max score - ideal min score)    |           |

## Results and Discussion

This study aims to develop a product in the form of contextual interactive multimedia for acid-base solution material containing multiple representations (IMPAC). The results of the study are described in each stage according to the 4D method as follows.

### Define

The define stage begins with a front-end analysis conducted through interviews with chemistry teachers and students. The interviews revealed that the teaching of acid-base solution concepts relies heavily on conventional methods, such as lectures, without the support of interactive learning media. Students noted that these lessons are often centered on teacher explanations drawn from textbooks and problem-solving exercises, leading to boredom and difficulty in grasping the concepts of acids and bases. Furthermore, students expressed greater enthusiasm for learning when the material is presented through engaging media that relates to real-world contexts. These findings highlight the need for interactive learning media that can enhance students' interest and engagement. Subsequently, a curriculum and material analysis was conducted to streamline the integration of content into the learning media. Researchers compiled material concepts aligned with the current curriculum, including clear learning outcomes and objectives.

### Design and Development

The design phase focused on determining the type of media to be developed based on the interview findings. Following the analysis, it was decided to create Interactive Multimedia on Acids and Bases Contextually with Multiple Representations (IMPAC), an interactive and contextually designed multimedia tool for teaching acids and bases through multiple representations. The next step involved designing the multimedia format, which included the layout of the homepage, main

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menu, and content structure. The homepage features a "Start" button that allows users to begin the learning experience through IMPAC. The main menu offers various features, including Home, Instructions, Competencies, About Us, and Evaluation, as illustrated in Figure 1. This structure ensures that the multimedia is intuitive, engaging, and aligned with modern educational needs.



Figure 1. IMPAC Product

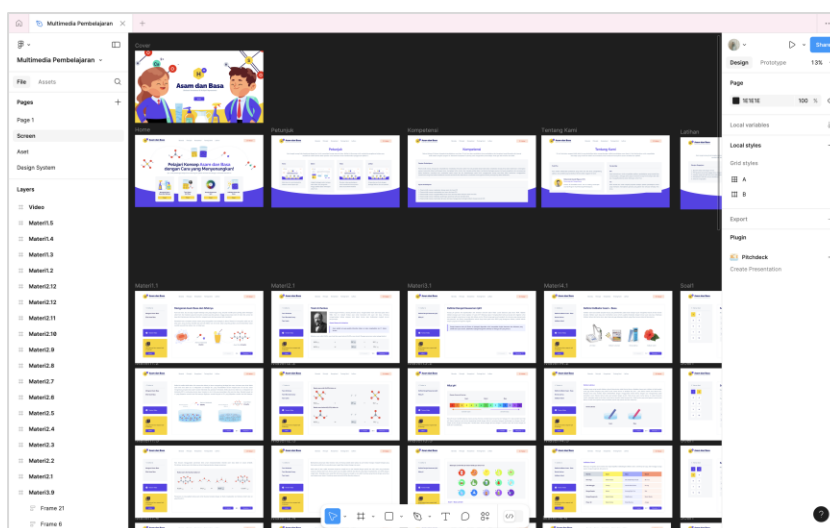


Figure 2. Multimedia Prototype Design Using Figma

The content on acid-base solutions is delivered through real-life contexts, aligning with the principles of contextual learning by connecting the subject matter to students' everyday experiences. The material is organized into several subtopics: Introduction to Acids and Bases and Their Properties, Acid and Base Theories, Acidity (pH), and Acid-Base Indicators. To enhance understanding, the material is supported by visualizations based on multiple representations designed using the Figma application, as shown in Figure 2.

This multimedia tool incorporates key components of contextual learning, including constructivism, discovery, inquiry, learning communities, modeling, reflection, and authentic assessment. The constructivism component focuses on students building knowledge through personal experiences and social interactions, following the principles of Vygotsky (1978), to make learning meaningful and relevant. Within IMPAC, multiple representations assist students in constructing their understanding visually and conceptually, as depicted in Figure 3.



Students are encouraged to engage in exploration activities, such as determining the pH of various solutions using natural indicators. These activities allow students to identify and categorize everyday substances as acidic or basic, fostering understanding through hands-on discovery (Bruce & Bruce, 1992). The interface for the exploration activity is illustrated in Figure 4.

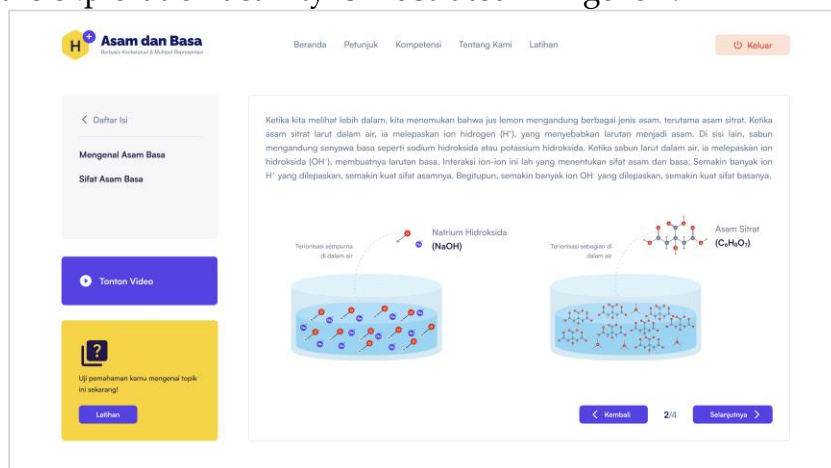


Figure 3. Constructivism Components in Products

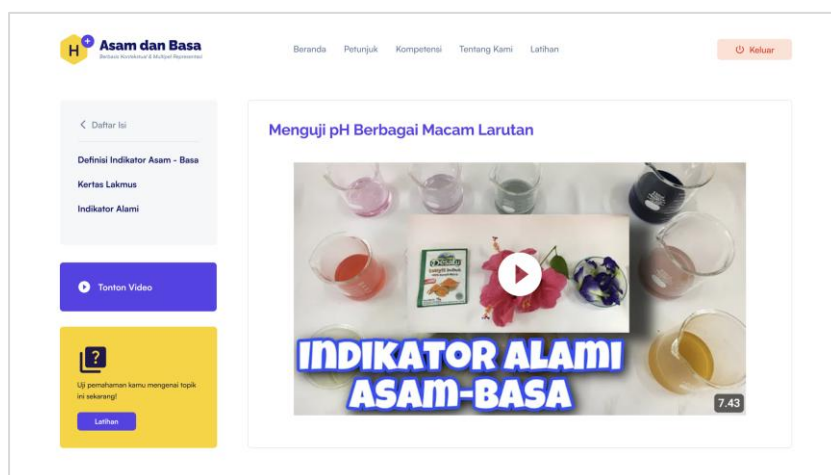


Figure 4. Discovery Component in the Product

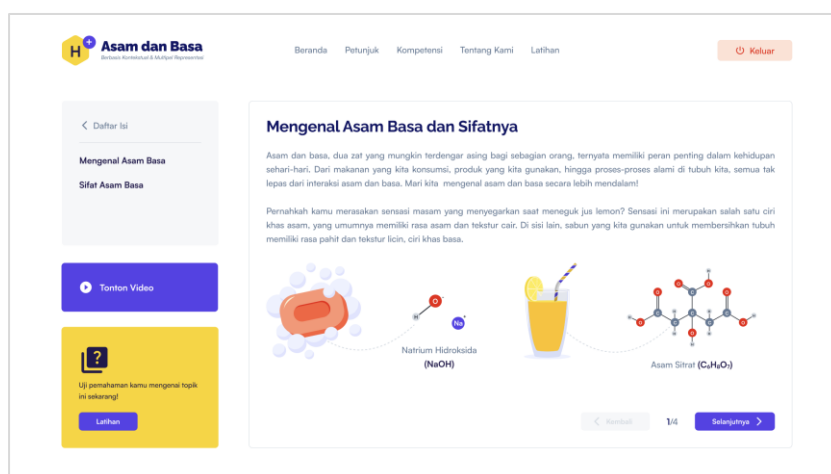


Figure 5. Inquiry Component in the Product

The inquiry component integrates thought-provoking questions into IMPAC to capture students' attention and encourage them to delve deeper into the material (Lotulung et al., 2018). The inquiry interface is shown in Figure 5. The learning community component emphasizes the importance of collaborative learning, where outcomes are more meaningful when achieved in groups rather than individually (Glynn & Winter, 2004). IMPAC facilitates group activities, such as discussions, idea-sharing, and collaborative task completion, enriching the learning experience and fostering teamwork. The learning community interface is illustrated in Figure 6. The modeling component provides real-life examples to guide students in developing their thinking, learning, and task performance skills (Sears, 2003). In IMPAC, materials are supported by relevant examples and accompanying visuals to clarify concepts, helping students avoid misconceptions. The modeling interface is depicted in Figure 7.

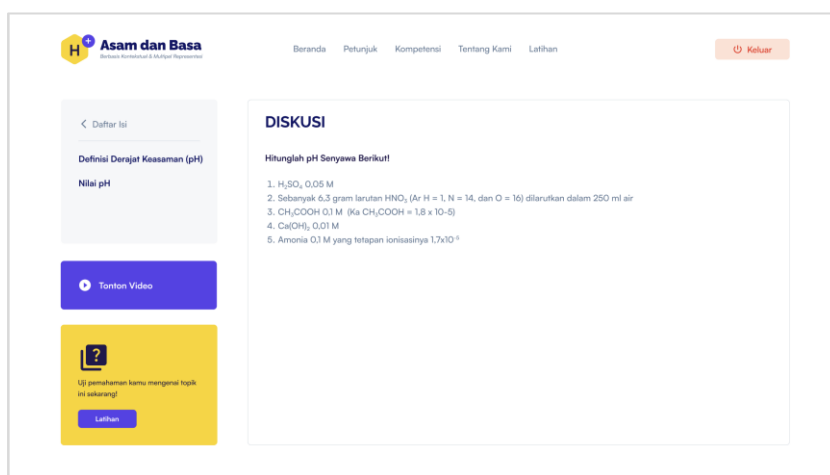


Figure 6. Learning Community Component in the Product

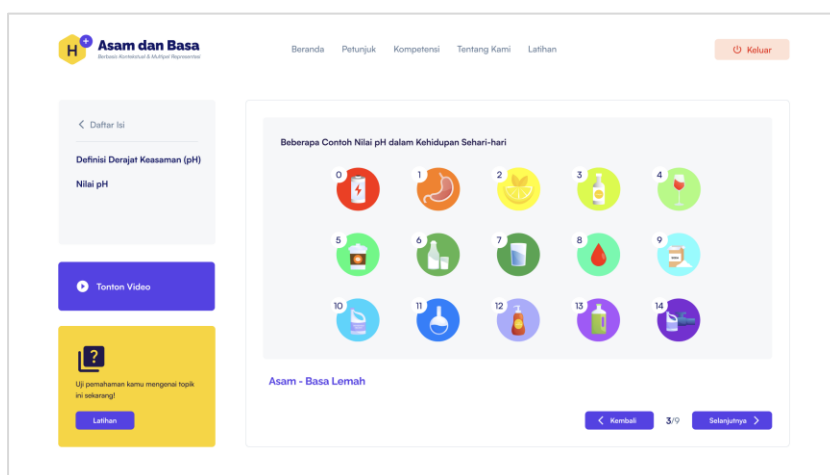


Figure 7. Modeling Component in the Product

Reflection serves as a tool for consolidating students' understanding by summarizing all the material covered on acid-base solutions. This feature helps reinforce students' knowledge and is illustrated in Figure 8 (Pangemanan, 2020). The authentic assessment component of IMPAC includes practice questions designed to



evaluate students' comprehension of the material. Each question is accompanied by detailed explanations, enabling students to review their learning progress and solidify their understanding (Johnson, 2002). Examples of these practice questions are shown in Figure 9.

IMPAC integrates the three levels of chemical representation, covering macroscopic, microscopic, and symbolic, to provide a comprehensive learning experience. This approach enables students to view chemistry concepts from diverse perspectives, linking observable phenomena to abstract ideas for a deeper understanding (Opfermann et al., 2017). In IMPAC, the macroscopic level is conveyed through visuals and descriptions of the observable properties of acids and bases. For instance, color changes when using acid-base indicators. The microscopic level, on the other hand, focuses on particle-level phenomena, including atoms, molecules, ions, and their interactions. These are illustrated through visualizations or theoretical models to explain macroscopic observations, such as acid-base reactions. Lastly, the symbolic level employs symbols, chemical equations, graphs, and other notations to represent chemical processes abstractly and mathematically. This approach allows scientific concepts to be communicated in more concise and efficient ways. Also, these symbolic representations, such as reaction equations and chemical formulas, are integrated into IMPAC to support students in mastering abstract ideas.

By combining these three levels of representation, IMPAC provides a holistic and engaging learning experience, ensuring students gain a thorough and integrated understanding of acid-base concepts, as illustrated in Figure 10.

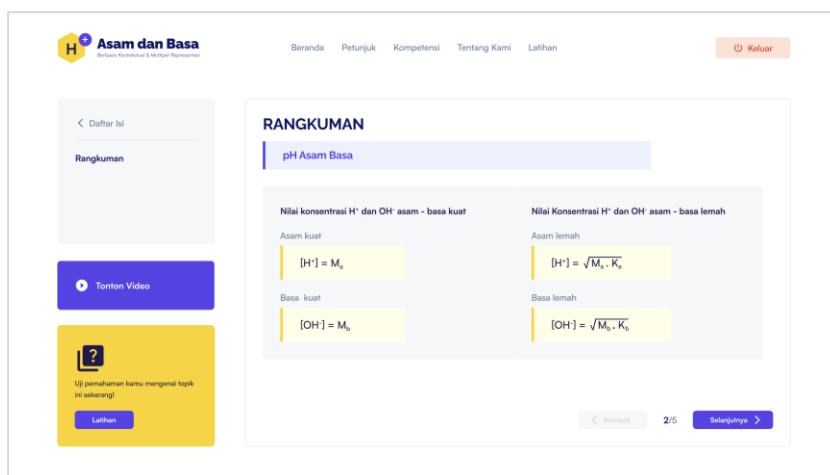


Figure 8. Reflection Component in the Product

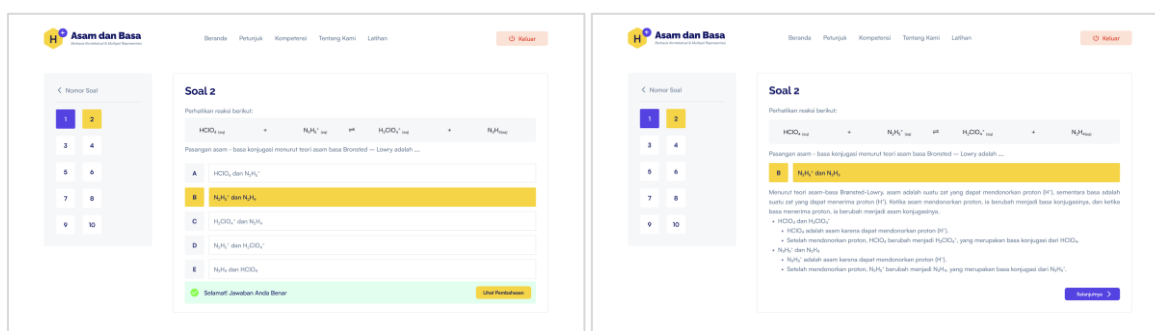


Figure 9. Authentic Assessment Component in the Product

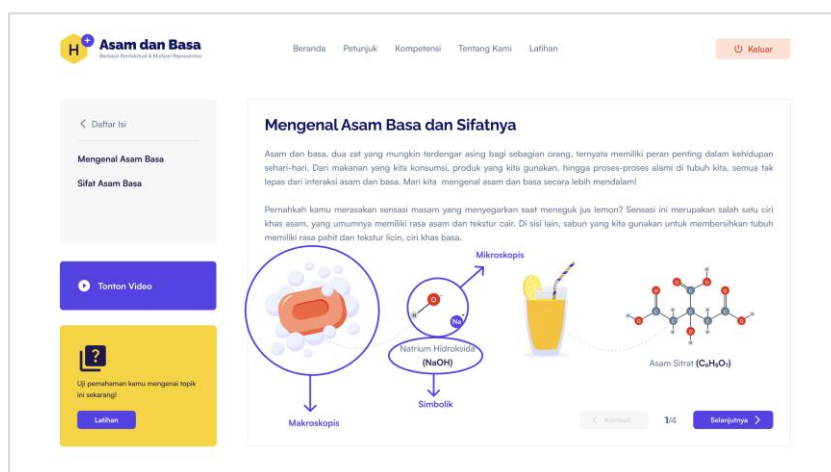


Figure 10. Multiple Representation Levels Interface in the Product

### Expert Validation and Product Assessment

The interactive multimedia product developed, IMPAC, underwent a validation process involving instructional media experts, subject matter experts, as well as practicality testing by chemistry teachers and readability testing by students. The validation covered several aspects, including multimedia feasibility, interactivity, content accuracy, representation, and contextual learning. Media experts focused on assessing the multimedia and interactivity aspects, while subject matter experts evaluated content, multiple representations, and contextualization. The validation results are presented in Tables 4 and 5.

Table 4. Product Validation by Instructional Instructional media experts

| No    | Assessment Aspect | Percentage of Ideal Score | Category  |
|-------|-------------------|---------------------------|-----------|
| 1     | Multimedia        | 95%                       | Very Good |
| 2     | Interactivity     | 90%                       | Very Good |
| Total |                   | 95%                       | Very Good |

Table 5. Product Validation by Subject Matter Experts

| No    | Assessment Aspect          | Percentage of Ideal Score | Category  |
|-------|----------------------------|---------------------------|-----------|
| 1     | Content                    | 90%                       | Very Good |
| 2     | Multiple Representatitions | 80%                       | Very Good |
| 3     | Contextualization          | 90%                       | Very Good |
| Total |                            | 87%                       | Very Good |

The validation results from instructional media experts indicate that the multimedia (95%) and interactivity (90%) aspects were rated in the "Very Good" category. These results suggest that the visual design, navigation flow, page transitions, and audiovisual integration in the IMPAC product are in line with the

principles of multimedia learning proposed by Mayer (2002). According to this theory, the synergistic use of images, animations, and audio can significantly enhance students' cognitive absorption and understanding of complex material. Furthermore, high interactivity in instructional media plays a critical role in improving student attention and cognitive engagement. That is, Domagk et al. (2010) highlighted that interactive media do not merely deliver information but also support active learning, encouraging students to explore content independently and engage in critical thinking processes.

The validation by subject matter experts also resulted in high scores in terms of content (90%), contextualization (90%), and multiple representations (80%). The content is structured based on a hierarchy of concepts, progressing from simple to complex, which is consistent with the revised Bloom's taxonomy (Anderson & Krathwohl, 2001). The material is also aligned with core competencies outlined in the national curriculum. The multiple representations are crucial in chemistry education, as students frequently struggle to integrate these three levels simultaneously. A score of 80% suggests that while representational integration is present, further refinement may be needed in the visualization or the explicit linkage between the representational levels. Meanwhile, the contextualization feature in IMPAC assists students in relating acid-base concepts to real-life phenomena, which is consistent with the contextual teaching and learning (CTL) approach. According to Sarwari & Kakar (2023), this approach contributes to creating a comfortable classroom environment, builds students' confidence, and helps reduce stress and anxiety during the learning process.

The practicality test was conducted by chemistry teachers to evaluate the quality of the product from the educators' perspective. The results are presented in Table 6, which reveal that chemistry teachers rated nearly all aspects of the product as "Very Good". In particular, multimedia and interactivity received the highest score of 95%. This outcome indicates that the IMPAC media is profoundly supportive of classroom instruction. Likewise, teachers viewed it as an effective tool that simplifies the explanation of abstract concepts. Teachers' ratings for multiple representations (90%) and contextualization (87%) were high, indicating that the media supports teachers in demonstrating conceptual connections in chemistry and linking their relevance to real-life situations. This finding is in line with Wu et al. (2001), who pointed out that well-designed visual representations in chemistry teaching can significantly improve both pedagogical delivery and students' understanding of concepts.

Table 6. Practicality Testing Results

| No | Assessment Aspect        | Percentage of Ideal Score | Category  |
|----|--------------------------|---------------------------|-----------|
| 1  | Content                  | 92%                       | Very Good |
| 2  | Multiple Representations | 90%                       | Very Good |
| 3  | Contextualization        | 87%                       | Very Good |
| 4  | Multimedia               | 95%                       | Very Good |

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|   |               |     |           |
|---|---------------|-----|-----------|
| 5 | Interactivity | 95% | Very Good |
|   | Total         | 92% | Very Good |

Table 7. Readability Testing Results

| No | Assessment Aspect          | $\sum$<br>indicator | $\sum$<br>Score | $\sum$ Max. Ideal<br>Score | Percentage of Ideal<br>Score |
|----|----------------------------|---------------------|-----------------|----------------------------|------------------------------|
| 1  | Content                    | 2                   | 19              | 20                         | 95%                          |
| 2  | Presentation               | 2                   | 20              | 20                         | 100%                         |
| 3  | Contextualization          | 2                   | 18              | 20                         | 90%                          |
| 4  | Multiple<br>representation | 2                   | 18              | 20                         | 90%                          |
| 5  | Interactivity              | 2                   | 19              | 20                         | 95%                          |
|    | Total                      | 10                  | 94              | 100                        | 94%                          |

Readability testing was performed using a Guttman-scale questionnaire filled out by students. The evaluation covered aspects such as content, presentation, contextualization, multiple representations, and interactivity. The results are shown in Table 7. The readability test conducted with students revealed an average score of 94%, with a perfect score (100%) for presentation. This suggests that the interface was intuitively designed, user-friendly, and appropriate for the cognitive development level of senior high school students. This finding supports user-centered design principles in educational media development (Norman, 2013).

In addition, high scores in interactivity (95%) and content (95%) further confirm that students felt actively engaged and gained a better understanding of the learning material. These results resonate with the findings of Moreno and Mayer (2007), who demonstrated that interactive multimedia significantly enhances student engagement and learning outcomes in science subjects. Students also appreciated the contextualization (90%) and multiple representations (90%) features of the product. As noted by Chandrasegaran et al. (2008), students learn chemistry more effectively when it is presented in a contextual format and when transitions between representational levels are clearly established.

Based on validation by instructional media experts, subject matter experts, practicality testing by teachers, and readability testing by students, the interactive contextual multimedia with multiple representations for acid-base solutions is deemed highly suitable for use as a instructional media. The product not only supports teachers in delivering material but also promotes more interactive and contextual learning.

### Comparison to Previous Research

IMPAC introduces a revolutionary approach to chemistry education by effectively integrating the three levels of chemical representation, including

macroscopic, microscopic, and symbolic into a single interactive learning platform. This innovative approach distinguishes IMPAC from previously developed educational media. For instance, while animation-based media by Rodiah et al (2012) have been shown to improve student comprehension, they lack interactive features that facilitate active engagement. Similarly, the virtual laboratories designed by Muslim & Ardhana (2023), and the e-teaching materials by Nurani & Suyanta (2024), fail to effectively connect chemical concepts with students' real-world experiences, thereby limiting their contextual relevance.

Android-based learning tools, such as those created by Prasetyo et al (2014), and Fauzia et al (2017), offer strong accessibility and flexibility but are hindered by technical issues, such as dependence on external memory and compatibility issues with various devices, which diminish their practicality. Likewise, formats like e-magazines (Tarawi et al., 2020), and e-comics (Halawa et al., 2022), enhance student engagement, however they do not adequately support the three critical levels of chemical representation, which are essential for understanding complex and abstract concepts. A detailed comparison of previous learning media is provided in Table 8.

Table 8. Comparison of Learning Media from Previous Studies

| Learning Media Type    | Three Chemical Representation Levels | Category  |           | Reference               |
|------------------------|--------------------------------------|-----------|-----------|-------------------------|
|                        |                                      | Teacher   | Student   |                         |
| Interactive Multimedia | Available                            | Very Good | Very Good | This Work               |
| Animation              | Available                            | Very Good | Very Good | Rodiah et al. (2012)    |
| Virtual Laboratory     | Available                            | -         | Very Good | Muslim & Ardhana (2023) |
| Android                | Available                            | Very Good | Good      | Prasetyo et al (2014)   |
| Android Game           | Available                            | -         | Very Good | Fauzia et al (2017)     |
| E-magazine             | Not Available                        | Very Good | Very Good | Tarawi et al (2020)     |
| E-Comic                | Not Available                        | Very Good | Very Good | Halawa et al (2022)     |
| Teaching Material      | Available                            | Very Good | Very Good | Nurani & Suyanta (2024) |

IMPAC overcomes these limitations by providing a fully integrated solution that combines multiple representations, interactivity, and a contextual approach. Its interactive features enable students to independently explore and engage with the material, while its real-life contextual connections make the learning experience more meaningful and relatable. These strengths position IMPAC as a cutting-edge tool for

teaching challenging topics, such as acid-base solutions, by bridging theoretical concepts and practical applications.

By addressing the shortcomings of previous educational media and leveraging the power of integrated multiple representations, contextual learning, and interactivity, IMPAC establishes itself as a transformative tool for chemistry education. It not only surpasses the capabilities of earlier media but also fosters a more engaging, effective, and relevant learning experience.

Beyond its technical features and intuitive interface, IMPAC reflects a meaningful pedagogical shift toward more student-centered and cognitively engaging chemistry instruction. By integrating macroscopic, microscopic, and symbolic representations, IMPAC addresses one of the most persistent challenges in chemistry education: students' difficulty in linking abstract chemical symbols with observable phenomena and submicroscopic processes (Chittleborough & Treagust, 2007; Gkitzia et al., 2020; Johnstone, 1991). This integration enhances representational fluency, which is essential for fostering deep conceptual understanding and scientific reasoning (Kozma, 2002; Wu & Shah, 2004).

Equally important is the product's contextual approach, which connects acid-base concepts to real-life situations, making learning more relevant and memorable for students. When students encounter chemistry in the context of their daily lives, they are not only more motivated but also better equipped to transfer knowledge to new and authentic scenarios (Herrington & Oliver, 2000; Johnson, 2002). This approach aligns with constructivist learning theory and the cognitive theory of multimedia learning, which emphasize that students learn best when they actively build knowledge through meaningful interaction with content (Mayer, 2009; Moreno & Mayer, 2007).

Despite its promising results, several areas remain in need of further development. For instance, the slightly lower score in the multiple representations component (80%) suggests that improvements could be made to illustrate the connections among the three levels better. Future iterations of IMPAC might consider incorporating dynamic animations or real-time simulations that explicitly bridge macroscopic observations, particle-level behavior, and symbolic notation (Opfermann et al., 2017). Moreover, the scope of this study was limited to the topic of acid-base solutions and a specific student demographic. Broader implementation across various chemistry topics and more diverse student groups would provide deeper insights into the scalability and adaptability of IMPAC. Longitudinal studies could also offer valuable perspectives on its long-term effects on students' conceptual retention, problem-solving abilities, and attitudes toward chemistry (Chandrasegaran et al., 2008).

## Conclusion

This study developed an innovative product called IMPAC (Interactive Multimedia on Acids and Bases Contextually with Multiple Representations), an interactive learning medium tailored to facilitate contextual learning of acid-base



solutions through a multiple representation approach. The multimedia was rigorously evaluated for its quality through validation by subject matter and instructional media experts, practicality testing by high school chemistry teachers, and readability testing by students.

The validation process yielded excellent results, with media and subject matter experts awarding ideal score percentages of 95% and 87%, respectively. Teachers' practicality testing resulted in a 92% score, while students' readability testing achieved a remarkable 94%. These outcomes fall within the "Very Good" (VG) category, confirming IMPAC's high suitability as a learning tool.

The findings demonstrate that IMPAC is not only effective in supporting the teaching-learning process but also significantly enhances students' motivation and understanding of acid-base concepts, especially in relation to real-life applications. By combining content, interactivity, and a multiple representation approach, IMPAC delivers an engaging and meaningful learning experience. It offers students a more active and contextualized approach to learning, making it a valuable tool for modern chemistry education. The implication for research is to provide recommendations for teaching materials on the acid-base solutions topic.

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