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Development of Interactive Website-Based Learning Media with the Assistance of Educandy on the Periodic Table of Elements Material

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ABSTRACT

Learning the periodic table of elements is often perceived as difficult because it involves abstract concepts, symbolic representations, and multiple relationships among elements that students must understand. This study aimed to develop interactive web-based learning media for periodic table material by integrating the Carrd platform with Educandy and to examine its validity and feasibility at the development stage. The study employed a Research and Development approach using the ADDIE model up to the development phase. The product was validated by five expert validators consisting of lecturers and chemistry teachers, and its feasibility was tested with 15 tenth-grade students at SMAN 1 Banjaran. The validation results showed an average score of 0.85, which was categorized as very high. Across aspects, the scores included software engineering (0.864), visual communication (0.872), functionality (0.810), learning achievement (0.883), media quality and relevance (0.790), interactivity (1.000), ease of understanding (0.830), learning guidance (0.830), and concept and theory accuracy (0.776). The feasibility test produced an average percentage of 89.13%, indicating that the media was feasible for limited use. Qualitative feedback from validators suggested improving the interface, adding supporting images, and refining several presentation elements. These findings indicate that the developed Carrd–Educandy-based learning media is valid and feasible as a learning support medium for periodic table material at the development stage.

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Introduction

Chemistry learning at the secondary school level continues to face substantial challenges because many of its concepts are abstract, hierarchical, and symbolically represented, which often makes the subject difficult for students to understand (Huda & Rohaeti, 2023). These difficulties may become more pronounced when learning is still dominated by less varied instructional approaches and by learning media that do not adequately support active student engagement. In such conditions, students may experience reduced interest and lower involvement in the learning process, which can also affect the quality of their understanding of chemistry concepts (Murti et al., 2024). Therefore, the need for more meaningful, engaging, and accessible learning support has become increasingly important, particularly in the context of 21st-century education, where technology is expected to function not only as a delivery tool but also as a medium that supports interaction and active learning (Raudah et al., 2021; Said, 2023; Syifa & Julia, 2023).

One chemistry topic that frequently presents learning difficulties is the periodic table of elements. This topic is fundamental because it provides the basis for understanding the classification of elements and the relationships among their structures and properties (Rahmatsyah & Dwiningsih, 2021). However, many students perceive the periodic table as difficult because it involves multiple interconnected concepts, including element grouping, periods, electron configuration, and periodic trends (Bintiningtiyas & Lutfi, 2016). As a result, learning about the periodic table is often approached through memorization rather than conceptual understanding. This challenge indicates the importance of instructional media that can help students organize, revisit, and interact with the material more effectively.

The use of digital learning media is increasingly relevant in addressing this need. Technology-based media can facilitate access to material, support visual presentation, and make learning activities more flexible and interactive (Sukma et al., 2022; Said, 2023). Visual and interactive media also have the potential to support the achievement of learning objectives

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because they help students engage more actively with the material presented (Kustandi et al., 2021). In this context, the development of web-based learning media becomes particularly relevant because websites can combine text, visuals, and navigation structures in a way that supports gradual learning.

One platform that can be used for this purpose is Carrd. Carrd is a website-building platform that enables users to create concise and responsive single-page websites relatively easily (Aeni et al., 2022). In educational contexts, Carrd has been recognized as a practical medium for delivering content in a structured web-based format (Muthmainnah, 2022). Previous work has also shown that Carrd-based media can receive positive responses from users and can support the delivery of information in an accessible manner (Yuniar et al., 2023). However, despite these advantages, Carrd primarily functions as a content presentation platform and does not inherently provide varied interactive practice or assessment features. For chemistry topics such as the periodic table, this limitation is important because students need not only access to information but also opportunities to test their understanding through repeated and structured interaction.

To address this limitation, the present study integrates Carrd with Educandy as an interactive learning feature. Educandy is a digital platform that enables the creation of game-based learning activities such as matching tasks, quizzes, and recall exercises. Previous studies have shown that the use of Educandy can support student participation and improve learning engagement in classroom activities (Cholidatul et al., 2024). Although such findings were reported in contexts outside chemistry, they indicate that Educandy has potential as a formative learning support tool, especially when students need repeated practice and immediate response opportunities. In this respect, integrating Carrd as a web-based content delivery platform with Educandy as an interactive exercise feature is pedagogically relevant for periodic table material, which requires repeated recognition, categorization, and understanding of relationships among elements.

Despite the growing use of digital learning media, studies specifically integrating Carrd and Educandy into a single interactive learning medium for periodic table material remain limited. Existing studies in the available references tend to discuss Carrd or digital interactive media more generally, rather than examining the practical value of combining Carrd and Educandy into one structured chemistry learning medium (Aeni et al., 2022; Muthmainnah, 2022; Raudah et al., 2021). This indicates a research gap, particularly in relation to the development of media that combines structured web-based content delivery with interactive formative activities for learning the periodic table of elements.

Accordingly, this study aimed to develop interactive web-based learning media by integrating Carrd and Educandy for periodic table material and to examine its validity and feasibility at the development stage. The contribution of this study lies in presenting a structured design of a Carrd–Educandy-based learning medium for periodic table instruction, documenting expert validation results, and reporting limited student feasibility responses in the context of Grade X chemistry learning.

The study was guided by the following research questions. First, how can Carrd and Educandy be integrated into an interactive web-based learning medium for periodic table material? Second, how valid is the developed learning medium based on expert validation? Third, how feasible is the developed learning medium based on limited responses from Grade X students?

Methods

This study employed a Research and Development (R&D) approach to develop interactive web-based learning media on the periodic table of elements by integrating the Carrd platform with Educandy. The development procedure referred to the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation (Sugiyono, 2013; Purnamasari, 2019). However, the present study was limited to the development stage. Therefore, the study focused on product design, expert validation, revision, and limited feasibility testing, and did not include full classroom implementation or effectiveness testing.

Research Design and Development Procedure

The study was conducted through three main stages. The first stage was analysis, which involved identifying learning needs related to the periodic table of elements, examining curriculum demands, analyzing the content to be included in the media, and determining the software requirements needed for the development of interactive web-based learning media. At this stage, the researcher also formulated learning objectives based on the Merdeka Curriculum Phase E learning outcomes, prepared a concept map, and developed question indicators aligned with the intended competencies (Kemendikbudristek, 2022).

The second stage was design, during which the structure and navigation of the media were planned through the preparation of flowcharts and storyboards. The flowchart was used to describe the sequence and logic of the media, while the storyboard provided a more detailed representation of content arrangement, page layout, navigation system, and the placement of interactive elements. These design tools were important because they functioned as the blueprint for the development of the final product (Indrajani, 2015; Erviani et al., 2023).

The third stage was development, in which the learning media was produced based on the results of the analysis and design stages. Carrd was used as the main platform to organize the website structure and present the learning material, whereas Educandy was integrated as an interactive exercise and formative evaluation feature. After the initial product had been completed, it underwent expert validation, revision based on the validators' suggestions, and limited feasibility testing with students. This sequence is consistent with the purpose of development research, namely to produce and refine an educational product before broader application (Sugiyono, 2013; Widodo et al., 2023).

Participants and Validators

The expert validation process involved five validators, selected purposively according to their relevance to the developed product. These validators consisted of two media expert lecturers, one chemistry content expert lecturer from UIN Sunan Gunung Djati Bandung, and two chemistry teachers from SMAN 1 Banjaran. The involvement of these validators was intended to ensure that the developed media was assessed from technical, visual, pedagogical, and content-related perspectives.

The feasibility test was conducted with 15 tenth-grade students of SMAN 1 Banjaran who had studied the periodic table of elements. These students participated in a limited trial to provide responses regarding the practicality and feasibility of the developed learning media. Prior to the feasibility test, students were given a short simulation session to familiarize them with the media features and navigation.

Research Instruments

Two main instruments were used in this study, namely a validation questionnaire for expert validators and a feasibility questionnaire for students. The validation questionnaire consisted of 25 items distributed across nine aspects, namely software engineering (4 items), visual communication (3 items), functionality (3 items), learning achievement (3 items), media quality and relevance (3 items), interactivity (2 items), ease of understanding (2 items), learning guidance (2 items), and concept and theory accuracy (3 items). These aspects were used to evaluate the quality of the developed learning media from both media and subject-matter perspectives.

The feasibility questionnaire also consisted of 25 items, covering five main aspects: ease of use, display quality, material quality, interactivity, and usefulness. Both instruments employed a four-point Likert scale, with higher scores indicating more positive judgments toward the developed media. In addition to quantitative data, qualitative data in the form of comments, suggestions, and revision notes from validators and respondents were also collected to support product refinement. The use of both quantitative and qualitative data is consistent with the need to evaluate not only score-based outcomes but also descriptive input for revision (Jailani & Saksitha, 2024).

Data Collection Procedure

Data collection was carried out in a sequential manner. First, the researcher conducted a needs analysis and material analysis related to the periodic table of elements, followed by the preparation of learning objectives, concept maps, and question indicators. Second, the media structure was designed through flowcharts and storyboards. Third, the interactive learning media was developed using Carrd and integrated with Educandy-based activities. Fourth, the initial product was submitted to the five expert validators for assessment using the validation questionnaire. The comments and suggestions provided at this stage were used to revise the media. Finally, the revised product was tested on 15 students in a limited feasibility trial. After using the media, students completed the feasibility questionnaire to provide their responses to the developed product.

Data Analysis

The data obtained in this study consisted of qualitative and quantitative data. Qualitative data were analyzed descriptively by summarizing the comments, suggestions, and revision notes provided by expert validators and student respondents. These data were used as the basis for improving the design, appearance, clarity, and usability of the developed media (Jailani & Saksitha, 2024).

Quantitative data from expert validation were analyzed by calculating the mean validity score for each aspect and the overall validity score of the product using the following formula:

$$r = \frac{\sum x}{N \times n}$$

r = Feasibility value

x = Respondent's answer weight

n = Number of respondents N = Number of items

where r is the validity score, $\sum x$ is the total score obtained, N is the number of items, and n is the number of validators. The resulting score was then interpreted according to the validity criteria shown in Table 1.

Table 1. Interpretation of Feasibility (r) (Sugiyono, 2015)

No	Eligibility value (r)	Interpretation
1	$0.80 \geq r \leq 1.00$	Very High
2	$0.60 \geq r \leq 0.80$	High
3	$0.40 \geq r \leq 0.60$	Medium
4	$0.20 \geq r \leq 0.40$	Low
5	$0.00 \geq r \leq 0.20$	Very low

The feasibility test data were analyzed by calculating the percentage of the total score obtained from student responses relative to the maximum possible score using the following formula:

$$\text{Feasibility Percentage} = \frac{\text{Total Score Obtained}}{\text{Maximum Possible Score}} \times 100\%$$

The percentage scores were interpreted according to the criteria shown in Table 2 (Arikunto, 2009).

To determine the feasibility of the game that has been created, the calculation results are compared with the following feasibility criteria:

Table 2. Interpretation of Feasibility Percentage Values (Arikunto, 2009)

Percentage (%)	Qualification
90 – 100	Very Worth It
80 – 89	Worthy
70 – 79	Quite Decent
60 – 69	Less Worthy
< 60	Totally Unworthy

Through these analyses, the study determined the level of validity of the developed media based on expert judgment and its feasibility based on limited student responses. Because the study was limited to the development stage, the findings should be interpreted as evidence of product validity and feasibility rather than proof of instructional effectiveness

Results and Discussion

This study produced an interactive web-based learning medium for the periodic table of elements by integrating Carrd as the main content-delivery platform and Educandy as the interactive exercise feature. Because the study was limited to the development stage of the ADDIE model, the results reported in this section focus on four main outputs: (1) the analysis of learning objectives and content structure, (2) the design and development of the learning media, (3) expert validation results, and (4) limited feasibility responses from students. In line with the reviewer's concern, these findings should be interpreted as evidence of product development quality and limited feasibility, rather than as proof of effectiveness in improving learning outcomes.

Analysis Stage

The development of the interactive web-based learning media began with an analysis of instructional needs related to the periodic table of elements. At this stage, it was identified that the topic requires not only factual recall but also conceptual understanding of element classification, electron configuration, and periodic properties. This is in line with the position of the periodic table as a fundamental topic in chemistry learning, because it helps students understand the relationships among elements and their properties (Rahmatsyah & Dwiningsih, 2021). However, this topic is often perceived as difficult because students are required to connect multiple concepts, including groups, periods, and electron configurations, which are frequently approached through memorization rather than conceptual understanding (Bintiningtiyas & Lutfi, 2016).

Based on the Merdeka Curriculum Phase E learning outcomes, specific learning objectives were formulated to guide the development process. These objectives are presented in Table 3. As shown in Table 3, the developed media was intended to support students in analyzing elements in each group and period, identifying elements based on electron configuration and atomic number, and analyzing periodic properties such as atomic radius, electron affinity, ionization energy, and electronegativity (Kemendikbudristek, 2022). The formulation of these objectives was important because it ensured that the development process was instructionally grounded rather than merely focused on technical media production.

Table 3. The Learning Objectives

Learning Outcomes	Learning Objectives
Students are able to observe, investigate, and explain phenomena according to scientific principles in explaining chemical concepts in everyday life; apply chemical concepts in environmental management, including explaining the phenomenon of global warming; write chemical reactions and apply basic laws of chemistry; understand atomic structure and its application in nanotechnology. Students are able to observe, investigate, and explain phenomena according to scientific principles in explaining chemical concepts in everyday life; apply chemical concepts in environmental management, including explaining the phenomenon of global warming; write chemical reactions and apply basic chemical laws; understand atomic structure and its application in nanotechnology. (Ministry of Education, Culture, Research, and Technology, 2022)	Students can analyze elements in each group and period of the periodic table. Students can analyze an element in the periodic table based on its electron configuration and atomic number. Students can analyze the periodic properties of elements (atomic radius, electron affinity, ionization energy, electronegativity).

Based on the learning objectives in Table 3, question indicators were then prepared and aligned with the intended cognitive processes, as presented in Table 4. In the revised manuscript, Table 4 is more appropriate than the original figure because it presents the indicators in a clearer and more systematic way. As shown in Table 4, the developed exercises addressed not only remembering-level tasks, but also understanding, application, and analysis. This arrangement is important because it demonstrates that the interactive activities embedded in the media were aligned with the targeted learning objectives and with the structure of the material being taught.

Table 4. Question Indicators and Cognitive Levels

Learning Objective	**Indicator**	**Cognitive Level**
Analyze elements in groups and periods	Identify the position of an element based on its group and period	C1–C2
Analyze elements based on electron configuration and atomic number	Determine an element from its electron configuration or atomic number	C2–C3
Analyze periodic properties	Compare and explain periodic trends among elements	C2–C4

The conceptual structure of the material was then organized through a concept map, which is presented in Figure 1. Figure 1 shows how the main concepts and sub-concepts of periodic table material were connected to one another. This figure is important because it demonstrates that the content presented in the media was arranged systematically rather than as isolated pieces of information. A concept map supports the organization of material and helps clarify conceptual relationships that students are expected to understand during the learning process.

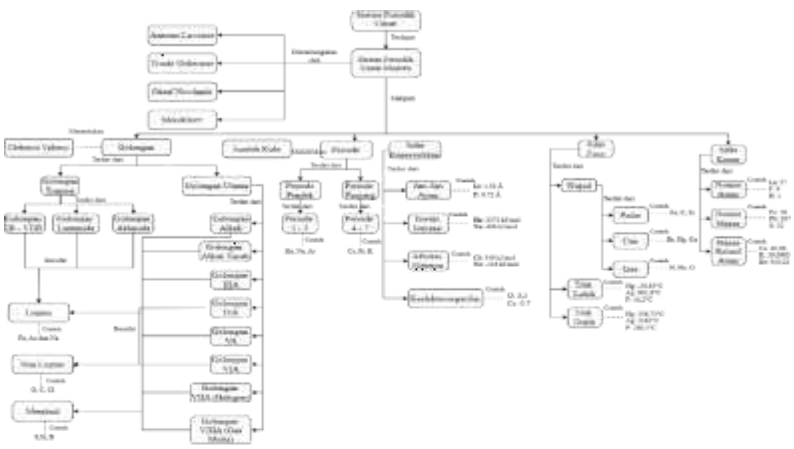

Figure 1. Concept maps

Design Stage

The results of the analysis stage were then translated into the design of the learning media. This stage involved the preparation of a flowchart and storyboard that functioned as the structural blueprint of the product. The flowchart is shown in Figure 2, while the storyboard is shown in Figure 3. As seen in Figure 2, the flowchart describes the logic of user navigation through the media, from entry into the website to access to content pages and interactive activities. This is consistent with the function of a flowchart as a visual representation of process logic and navigation sequence (Indrajani, 2015).

Figure 2. Min map

Figure 3. Storyboard

Meanwhile, Figure 3 presents the storyboard used to plan the arrangement of each page before development. The storyboard included the structure of page elements, content placement, and intended user interaction. In media development, storyboards are useful because they provide a detailed representation of each stage of the user experience and make the development process easier to organize systematically (Erviani et al., 2023). Therefore, the use of Figure 2 and Figure 3 in this study shows that the product was developed through a planned instructional design process.

Development Stage and Product Display

The development stage resulted in an interactive web-based learning medium that integrated Carrd as the main platform for content delivery and Educandy as the interactive exercise feature. This stage was carried out based on the design prepared in the previous stage. Carrd was used to organize the website structure and present the material in a concise and accessible format. The use of Carrd is relevant because the platform allows content to be presented in a practical and manageable web format (Aeni et al., 2022; Muthmainnah, 2022). In addition, interactive media are considered increasingly important in 21st-century learning because they can support more engaging and student-centered learning experiences (Raudah et al., 2021; Said, 2023).

The initial page of the developed website is presented in Figure 4. This page serves as the entry point for users and establishes the visual identity of the learning media. The problem identification page is shown in Figure 5, which was designed to introduce students to the context of the topic and orient them toward the logic of periodic relationships among elements. The main menu page is presented in Figure 6, which functions as the central navigation point for accessing learning objectives, personal data, and assignments. The compiler profile page is shown in Figure 7, documenting the identity of the developer and supervisors as part of the educational product documentation.

The work progress page is shown in Figure 8, while the material display page is shown in Figure 9. These figures illustrate how the periodic table material was segmented into manageable learning units. This segmentation is pedagogically relevant because the periodic table contains conceptually dense material that may be easier to understand when arranged in a gradual sequence. Finally, the Educandy activity page is shown in Figure 10. This figure is especially important because it demonstrates how the product moved beyond static content delivery and incorporated interactive formative activities. In relation to Table 4, Figure 10 shows how the question indicators were translated into interactive tasks such as matching, recall, and quiz-based activities. Thus, the product structure shown in Figure 4 through Figure 10 reflects the integration of content presentation and interactive learning support.

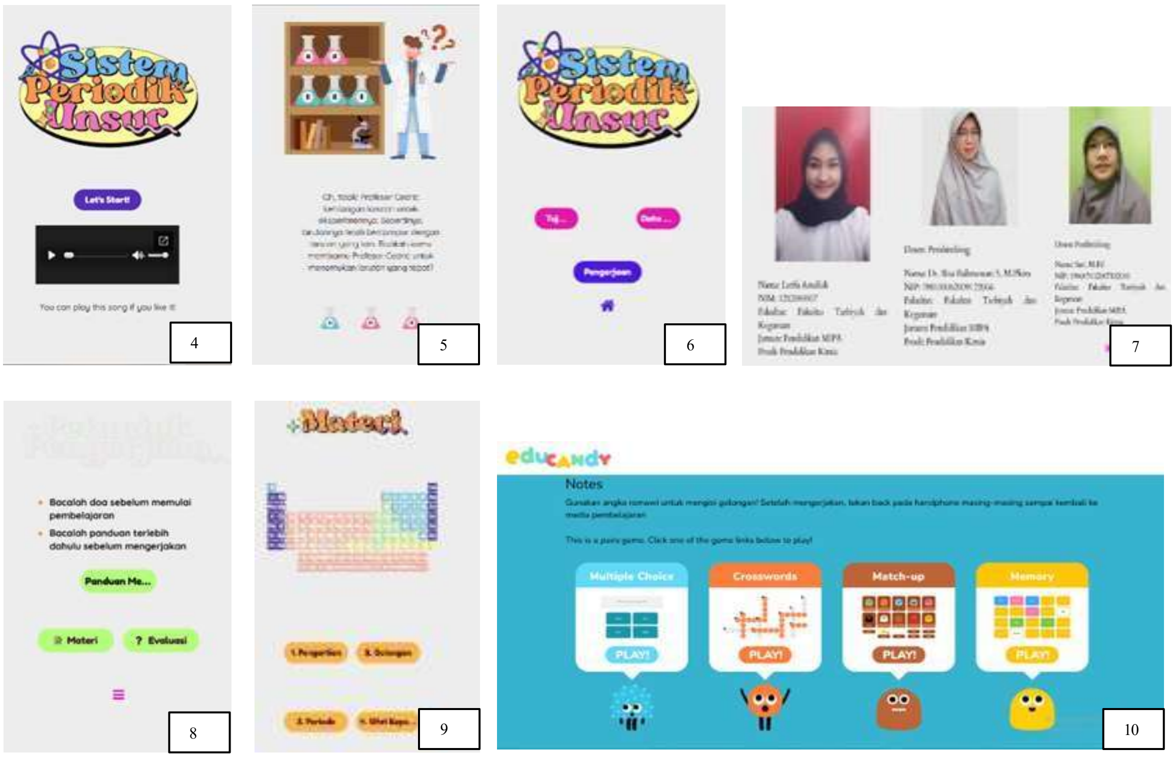

Figure 4. Initial view of the website, 5. Display of problem identification, 6. Main menu view of the website, 7. Compiler profile view, 8. work progress page display, 9. start game display, 10. educandy display

Expert Validation Results

After the product had been developed, it was evaluated by five expert validators. The validation results are presented in Table 5. As shown in Table 5, the overall average validation score was 0.85, which falls into the very high category according to the criteria in Table 1. All assessed aspects obtained scores above the criterion used in the study, indicating that the developed media was considered valid from the perspective of expert judgment (Sugiyono, 2013).

Table 5. Validation Test Results Website

Aspects that Observed	rcount	rcritical	Results
Engineering and software aspects	0.864	0,30	Valid
Visual communication aspects	0.872	0,30	Valid
Functionality aspects	0.81	0,30	Valid
Learning achievement aspects	0.883	0,30	Valid
Media quality and relevance aspects	0.79	0,30	Valid
Interactive aspects	1	0,30	Valid
Ease of understanding aspects	0.83	0,30	Valid
Learning guidance aspects	0.83	0,30	Valid
Concept and theory accuracy aspects	0.776	0,30	Valid
Average	0.85	0,30	**Valid**

A closer reading of Table 5 shows that the highest score was obtained in the interactivity aspect (r = 1.000). This finding indicates that the integration of interactive activities into the learning structure was considered one of the strongest elements of the product. High scores were also obtained for learning achievement (r = 0.883), visual communication (r = 0.872), and software engineering (r = 0.864), suggesting that the product was positively judged in terms of instructional relevance, visual structure, and technical organization. Meanwhile, the relatively lower scores for media quality and relevance (r = 0.790) and concept and theory accuracy (r = 0.776) indicate that these aspects still required refinement, even though they remained in the valid category.

These quantitative findings are supported by the qualitative comments from validators. Based on the annotated manuscript, validators suggested improving the interface appearance, adding supporting images, and refining several presentation elements. This means that the validation results in Table 5 did not merely confirm that the media was acceptable, but also provided direction for revision. Such use of expert feedback is consistent with the purpose of the development stage in R&D research, where revision is carried out to improve the quality of the product before broader use (Widodo et al., 2023).

Feasibility Test Results

Following revision, the product was tested in a limited feasibility trial involving 15 Grade X students. The results are presented in Table 6. As shown in Table 6, the overall feasibility percentage reached 89.13%, which places the developed media in the feasible category according to the criteria in Table 2. This value is used consistently in the revised manuscript to correct the inconsistency found in the earlier version.

Table 4. Feasibility Test Results Website

Aspects that Observed	Percentage	Information
Ease of use	90.00	Very Feasible
Display quality	90.00	Very Feasible
Material quality	88.00	Feasible
Interactivity	90.33	Very Feasible
Usefulness	87.33	Feasible
Avarage	89,13	**Feasible**

The result shown in Table 6 complements the expert validation results shown in Table 5. While Table 5 indicates that the product was valid according to expert assessment, Table 6 shows that the same product was also positively received by students in a limited trial. This convergence is important because it suggests that the media was acceptable both in design quality and in practical usability. The positive feasibility result also indicates that students were able to access, understand, and use the media without major difficulty.

Overall Interpretation and Study Limitations

Taken together, the findings presented in Table 3, Table 4, Table 5, and Table 6, as well as in Figure 1 through Figure 10, show that the developed Carrd–Educandy-based learning medium was produced through an internally coherent development process. The learning objectives in Table 3 informed the indicators in Table 4, which were then translated into the conceptual organization shown in Figure 1, the design sequence shown in Figure 2 and Figure 3, and the implemented interface shown in Figure 4 through Figure 10. This coherence is one of the strengths of the product because it shows that the media was built through a clear instructional design process.

At the same time, the findings should be interpreted within the limits of the study. First, the study was limited to the development stage of the ADDIE model and did not include broader implementation and evaluation. Second, the feasibility trial involved only a small number of students, which limits the generalizability of the findings. Third, the study relied on expert validation and student feasibility responses rather than direct measures of learning outcomes, motivation, or conceptual gain. Therefore, the most appropriate interpretation of the findings is that the developed media is valid and feasible as a learning support tool for periodic table material at the development stage. It is not yet evidence of broad instructional effectiveness.

Conclusions

This study developed interactive web-based learning media for the periodic table of elements by integrating Carrd as the main content-delivery platform and Educandy as the interactive exercise feature. The development process, which followed the ADDIE model up to the development stage, produced a learning medium that was systematically designed based on curriculum-aligned learning objectives, structured content organization, and interactive activities adapted to the intended indicators.

The expert validation results showed an average score of 0.85, which indicates that the developed media had a very high level of validity. In addition, the limited feasibility test involving 15 Grade X students produced an average percentage of 89.13%, which categorized the media as feasible for limited use. These findings indicate that the developed Carrd–Educandy-based learning media is valid and feasible as a learning support medium for periodic table material at the development stage.

However, this study was limited to the development stage and did not include broader implementation or effectiveness testing. Therefore, future studies are recommended to continue to the implementation and evaluation stages in order to examine the effect of the media on learning outcomes, conceptual understanding, and student engagement in chemistry learning.

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