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Development of Android CHEMDIC Mobile Learning to Prevent Student Misconceptions on Periodic System of Elements Material

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Abstract: Chemistry is a multidimensional discipline that contains concepts from simple to complex and concrete to abstract. This makes it difficult for students to understand chemistry and causes a lot of misconceptions. Facts in the field show that only some students understand the concept of the periodic system of elements. In preliminary research, mobile learning has been studied and can improve the effectiveness of individual learning for students anywhere and anytime. This study aims to determine the feasibility of CHEMDIC mobile learning in preventing student misconceptions in the context of the periodic system of elements. This feasibility is reviewed based on the validity and practicality of mobile learning in preventing student misconceptions. The methodology in this study is Research and Development (R&D) using the 4D development model proposed by Thiagarajan with the following stages: define, design, develop, and disseminate. However, this research is limited only to the development stage due to several considerations such as time, effort, and facilities. The limited trial was carried out with 15 students of SMAN 1 Krian Sidoarjo who had obtained learning materials in the context of the periodic system of elements and were selected based on the largest number of students who were included in the category of not understanding concepts based on the results of the pretest. CHEMDIC mobile learning is declared valid if it fulfils the minimum mode score of 4, while it is stated as practical if it fulfils the minimum percentage of ≥61%. This research shows the results of the validity of CHEMDIC mobile learning with the acquisition of content validity mode scores of 5 with a very valid category and a construct validity mode score of 4 with a valid category. Then, practicality, with the acquisition of a percentage in the student response questionnaire of 96%, was in the very practical category. This result shows that android CHEMDIC mobile learning is feasible to prevent students' misconceptions about the material of the periodic system of elements.

Keywords: Android M-Learning; Misconceptions; Periodic System of Elements; PracticalityValidity.

Introduction

Chemistry is a branch of science that is multidimensional and central. Chemistry discusses matter, its composition, reactions, energy, and changes, which are divided into five disciplines of science: biochemistry, organic, physical, analytical, and inorganic [1]. This is related to the many concepts in chemistry that are simple to complex and concrete to abstract so that they present problems that seem complicated and complex [2].

Chemistry with complex and abstract concepts is a source of misunderstanding for students in learning. Chemistry involves three levels of representation: macroscopic, which relates to visible phenomena in life; submicroscopic, which refers to phenomena at the molecular or invisible level; and symbolic, which is expressed in formulas or models. Chemistry with abstract concepts is dominantly in biased representation, making it difficult for students to imagine the process that occurs concretely and precisely [3].

Chemistry needs to be presented in structured content to get a complete and correct understanding. If students' difficulties in learning chemical materials are left unchecked, it can lead to new misconceptions or reinforcement of previous misconceptions [4]. Misconception is a process of assimilation and accommodation in cognitive structures that contradict scientific principles accurately and objectively. Misconceptions can hinder the effectiveness of learning and the acceptance of new knowledge. Misconceptions in students can occur due to other factors such as the number of formulas, interest in the material, the way the teacher explains, and the ineffectiveness of the media and learning time [5].

A person's understanding of a concept consists of understanding the concept (U), not understanding the concept (DU), and having a misconception (M). All three levels of interrelated chemical representation can overcome misconceptions [6]. However, it must be admitted that students still need help making that representation. Periodic system material requires more understanding at the submicroscopic and symbolic levels, so many students need help understanding concepts and misconceptions.

In the preliminary research that has been carried out on the periodic system material, the elements are obtained as follows. In the atomic electron configuration, U students were 12%, DU students were 64%, and M students were 24%. In the ion-electron configuration, U students were 16%, DU was 44%, and M students were 40%. In the electron position in the orbital, student U is 12%, student DU is 72%, and student M is 16%. Predicting the location of groups and elements, U students are 4%, DU students are 68%, and M students are 28%. In quantum numbers, U

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students are 12%, DU students are 64%, and M students are 24%. The results of this study show that many students have misconceptions and need help understanding the concepts in the material of the periodic system of elements.

Misconceptions need to be prevented so that they do not continue and interfere with learning outcomes. Effective learning media that does not cause misconceptions is necessary for students to acquire the right concepts [7] collectively. One of the learning media that is able to accommodate and combine text, audio, images, animation, and video is multimedia [8]. Multimedia is able to personalise students' learning styles and needs. In the context of chemistry, multimedia is able to visualise, analogise, and present abstract concepts in concrete, so it is expected to be able to prevent misconceptions [9]. Based on similar preliminary research, mobile learning is effective in learning and able to prevent students' misconceptions about atomic structure material by obtaining an effectiveness of 95.91%. This is influenced by media components such as animation and video, which can visualise complex material in microscopic representation [10], [11].

Multimedia, as a learning tool in the context of chemistry, can utilise mobile learning or m-learning [12]. M-learning is a form of learning that utilises smartphone or tablet devices and networks. This allows students to personalise their devices and content with flexible access anytime and anywhere. The use of mobile learning is considered practical based on the results of pre-research by students, especially since multimedia is rarely used in schools.

Using multimedia in mobile learning on smartphones globally dominantly uses the Android operating system [13]. Android is an interactive, user-friendly, and attractive touchscreen-based open-source software operating system. In mobile learning with the Android smartphone operating system, graphics, audio, images, animations, videos, and texts are displayed elegantly and attract users to be made comfortable and enjoyable in learning. Smartphones can be easily carried and used. This technology is recognised as the most suitable technological tool for chemistry learning. In addition, this technology is effectively applied in learning and can relate to cognitive, sociocultural, and motivational aspects of learning by incorporating instructional strategies into its content [14].

The development of mobile learning in the context of chemistry on the periodic system of elements in this research aims to prevent students' misconceptions with animation-mediated media and students gain a complete conceptual understanding. Thus, it is necessary to have indicators that must be achieved by knowing their feasibility. The feasible aspects in this study are known based on the validity and practicality of mobile learning. Validity includes the validity of the content and the validity of the construct. Content validity is related to content based on theoretical rationality, while construct validity is related to internal components consistent with other components [15]. Practicality refers to the user considering the usefulness of a trial to influence aspects and conditions [16].

Research Methods

According to Thiagarajan, this development research uses research and development (R&D) methods. This develops a research product in the form of Android mobile learning on the material of the periodic system of elements. Thiagarajan's 4D research and development method consists of four stages, namely, (1) define, (2) design, (3) develop, and (4) disseminate. However, this research was carried out until the development stage with limited trials because it was to determine the feasibility of the product and several considerations such as labour, time, and facilities. The three stages used in research and development, according to Thiagarajan, are illustrated in Figure 1.

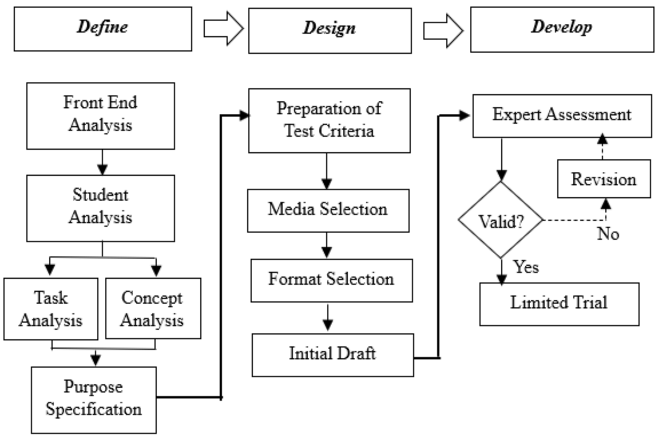


Figure 1. Steps for the Use of Research and Development Methods [17]

Based on Figure 1, the definition stage includes front-end analysis, student analysis, task analysis, concept analysis, and purpose specification. The design stage involves preparing test criteria, media selection, format selection, and initial draft. The development stage includes expert assessment in the form of media review and validation, media revision, and limited trials. This research was conducted at SMAN 1 Krian Sidoarjo to research as many as 15 grade XII students in the odd semester of the 2024/2025 school year.

In this research, an instrument in the form of a validation sheet for mobile learning was used and developed to be assessed by validators. The validators include two chemistry lecturers and one chemistry teacher. Assessment aspects include the content's validity and the construct's validity to prevent student misconceptions. The validation sheet contains a table with multiple statements with a given score range. Each statement is scored on a Likert scale of 1 to 5.

Table 1. Validity of Likert Scale Scores [18]

Nomination	Value/Score
Invalid	1
Less Valid	2
Valid Sufficient	3
Valid	4
Very Valid	5

The validity data obtained is ordinal, meaning it cannot be calculated based on addition, subtraction, division, or multiplication operations. Thus, the score calculation uses a mode: making decisions on the number that appears the most in a series of values [19]. The obtained model scores are interpreted using the Likert scale, as shown in Table 1.

Mobile learning is declared valid if it fulfils the minimum mode score of 4.

After passing the validity test, the next stage is a limited trial of the model to students. This stage will obtain practical data through student response questionnaires. Student activity observation instruments also support this data during the trial. The student response questionnaire consists of positive and negative statements based on the Guttman scale. The assessment is in Table 2.

Table 2. Guttman Scale [18]

Response	Answer	Value/Score
Negative	Yes	0
	No	1
Positive	Yes	1
	No	0

The data obtained was analysed using the following formula to determine the percentage of practicality.

$$\% \text{ practicality} = \frac{\Sigma \text{ score for each question}}{\text{number of respondents}} \times 100\%$$

The results obtained will be interpreted based on Table 3. Android CHEMDIC mobile learning is declared practical if the percentage of practicality obtained is ≥61%.

Table 3. Percentage of Practicality Category [18]

Percentage (%)	Category
0 - 20	Impractical
21 - 40	Less Practical
41 - 60	Quite Practical
61 - 80	Practical
81 - 100	Very Practical

The student activity observation sheet results also supported the student response questionnaire in this research. The observer did this during the trial. There were four observers, three observing four students and one observing three students. The results of student activity observations are stated to be supportive if the percentage of supporting activities is ≥61%.

Results and Discussion

Research and development of mobile learning on elemental periodic system materials to prevent student misconceptions are reviewed based on the feasibility of the validity tested, namely the validity of the content and the validity of the construct. The development of mobile learning refers to the research and development (R&D) design of a 4D model according to Thiagarajan which consists of define, design, develop, and disseminate. However, this research was carried out only up to the development stage with limited trials.

Define

Front End Analysis

The researcher surveyed the state of learning at SMAN 1 Krian Sidoarjo, where the researcher conducted the research. Data were obtained on the system and implementation of learning in schools. Among others, the curriculum used is independent; dominant learning is carried out by teachers using conventional lecture methods, and the learning resources used are package books and student worksheets. Less creative teaching methods and materials show that students' interest in learning could be more enthusiastic.

Student Analysis

The researcher conducted student analysis by collecting data based on the results of the pre-research. It was found that students found it difficult to learn chemistry material and felt bored; this was influenced by abstract material, many difficult-to-understand terms, and less creative teaching methods of teachers. In the substance of the periodic system material, it was found that DU students comprised 51% of the total M students comprised 23%, and the rest understood the concept. This shows that many students need help understanding the idea well in the material of the periodic system of elements.

Task Analysis & Concept Analysis

At the stage that can be carried out jointly related to task analysis and concept analysis, the researcher refers to the results of the pre-research that has been carried out. The researcher identified the competencies that were studied and needed to be mastered by students on the material of the periodic system of elements. The concepts listed include the electron configuration of an atom, the electron configuration of an ion, the electron in the orbital in principle, the relationship between the electron configuration and the location of an element, and the quantum number.

Purpose Specification

Based on the results of pre-research, learning surveys in schools, and conducting theoretical studies, researchers chose to develop multimedia in the form of mobile learning. Mobile learning in the context of information processing can visualise and interestingly listen to content information in detail and structured with the presence of text, images, videos, and animation components that can be abstractly made concrete and clear [20]. The advantages of using mobile learning in the Android operating system are access to economical portability, deployment, speed, standardisation, independence of space and time, flexibility, and the creation of many learning spaces [21].

Design

Researchers, after completing and identifying needs and expectations based on the defined stage. So, the design of mobile learning and research instruments is carried out. At this stage, it begins with the creation of storyboards related to mobile learning. The mobile learning developed was assisted by additional platforms such as animation creation with PowerPoint, Canva, CapCut, and Handbrake. The mobile learning in this research is called CHEMDIC. The initial draft produces media, as shown in Figure 2 below.

Mobile learning contains a menu of user guides, learning objectives, periodic tables of elements, materials, and quiz questions. The components in the material are equipped with text, images, videos, and animations. Mobile learning is used to prevent misconceptions so that each sub-material will be continued with practice questions and equipped with discussions so that students are still focused and understand the material. The quiz section contains practice questions for all submaterials and, at the end, is equipped with a solution or discussion. The quiz can be repeated until students understand the problem and its solution. This is one component of preventing misconceptions. The completeness of the material with animated visualisations of atoms, electron configurations, and other concepts makes students gain a concrete understanding. This is in the material section, where visually appealing videos and animations are displayed.

Figure 2. Early design of mobile learning

Develop

After the initial media stage has been completed, experts will assess it, or a validator will carry out a validation stage. The validators include media and material experts, namely two chemistry lecturers and one chemistry subject teacher, who will assess and review the feasibility of mobile learning on elemental periodic system materials to prevent student misconceptions. The instruments used in the validation process use validation sheets.

Table 4. Content Validity Results

Objective	Aspects	Mode/ Nominations
The truth of the concept of materials	Suitability of material at school level	5/very valid
	Systematic material concepts	5/very valid
	There are no errors in writing	5/very valid
Qualify as mobile learning to prevent misconceptions	Quizzes according to learning objectives	4/valid
	Components to prevent misconceptions	5/very valid
	Components to correct wrong concepts	5/very valid

The validity assessed and reviewed was content and construct validity. Content validity is defined as measuring how mobile learning is developed to prevent misconceptions based on the current context [22]. The results of the validity mode of the content of each aspect are shown in Table 4.

In the first objective, three aspects related to the correctness of the material concept are assessed. The scores show that the mobile learning developed is in accordance with the learning curriculum in schools, which has structured and up-to-date material presentations. Media developed to meet the validity of content can provide relevance to the purpose, up-to-date content, and accuracy of the concept. The content of the materials is brief, structured, and comprehensive, effectively obtaining information conceptually; this is related to preventing student misconceptions. [23].

In the second objective, three aspects are assessed based on the requirements for mobile learning to be met to prevent misconceptions. The scores obtained show that the quizzes accommodate questions to ensure the abilities that students must master. In each question that has been answered, students will display the results with a justification of the concept to avoid misconceptions and strengthen their knowledge. Mobile learning components provide an animation that connects chemical processes in the abstract realm, namely submicroscopic and symbolic, with accurate visualisation [24], [25].

Content validity has two specific purposes. Based on the above explanation, the first objective obtained a score of 5 with a very valid nomination, and the second obtained a 5 with a very valid nomination. Based on the Likert scale of Riduwan's adaptation, validity is declared valid if it meets the minimum requirement of a mode score of 4. The validation results obtained a content validity mode score 5, so it was declared very valid.

Construct validity measures the consistency and completeness of components in mobile learning [26]. Some things listed in media development research include visualisation, style, format, language, and utilisation [22]. The results of the construct validity mode of each aspect are shown in Table 5 below.

Table 5. Construct Validity Results

Objective	Aspects	Mode/ Nominations
Quality of mobile learning display	Background selection	4/valid
	Font size and type	4/valid
	Font colour	4/valid
	Graphics and layout settings	5/very valid
	Presentation of text, audio, images, and animations	5/very valid
Quality of using mobile learning	Ease of use of mobile learning	4/valid
	Loading of mobile learning runs	4/valid
	Ease of page transition	5/very valid
	Instruction for use	5/very valid
	Suitability of control buttons	4/valid
Feasibility of using language	Use of language spelling	5/very valid
	No ambiguous words	5/very valid

The validity of the construct of this research has three objectives. In the first objective, five aspects are considered related to the quality of the mobile learning display. Based on the results obtained show that mobile learning has a dynamic balance proportion in its appearance. Text, colour, and images are continuous with their placement and increase contrast so that visibility can attract attention [27]. An important component is the animation on the material menu. The alignment of instructions, audio, images, and text in animations makes it easier to accept information in memory. The combination of these components can further stimulate cognitive channels to improve information processing [28].

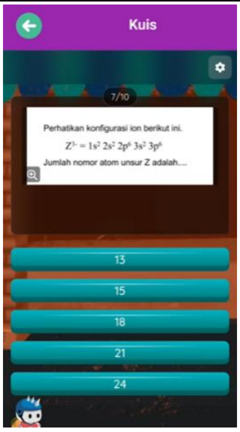
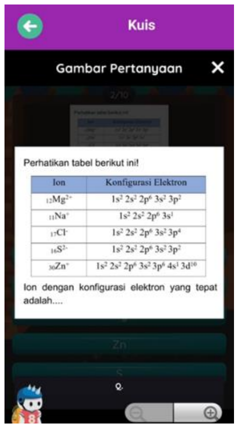
In the second objective, five aspects are considered related to the quality of mobile learning use. Based on the scores obtained show that accommodations and regulations in mobile learning make it easier for students to use them successfully. The ease of access and concrete features provided help students achieve maximum learning outcomes, and an attractive menu encourages the active participation of students in the learning process [29].

In the third objective, two aspects related to the use of language in mobile learning are assessed. The results show that the language used follows the correct rules and spelling. This will affect acceptance, engagement, and learning experiences. Mobile learning with clear and concrete language content accommodates the accessibility of the material efficiently and actively attracts students' attention in the learning process [30]. This aligns with Kusuma and Sukarmin's research, which states that student misconceptions are effectively prevented by media displaying good, correct, concrete, and unambiguous language quality, which is relevant to the good validity obtained.

The validity of the construct for the three objectives shows that mobile learning is valid. Based on the Likert scale adapted from Riduwan, validity is declared valid if it meets the minimum requirement of a mode score of 4. Thus, mobile learning is declared valid for the validity of the construct.

After the validation process, several suggestions and inputs are provided by validators. Suggestions or inputs are used to improve and perfect the mobile learning developed. In context, this is related to adjusting learning objectives at a more appropriate level, the source of animation development for the researcher's claims that still need to be added, and the adjustment of questions in mobile learning to the enhanced learning objectives. The validity results are in accordance with what has been presented. The visualisation of the results of improvements in mobile learning can be seen in the following table 6.

Table 6. Mobile Learning Design Revision

No	Initial Design	After Revision
1.	 Learning objectives at a low cognitive level	 Learning objectives have been adapted to higher cognitive levels
2.	 There is no description of the source of the animation video yet	 There is a caption from the source of the animated video
3.	 Quiz questions are in low cognitive levels	 Quiz questions have been adapted to a higher cognitive level

Android CHEMDIC mobile learning, declared valid in content and construct, enters the next phase, a limited trial. In this context, the practicality of mobile learning is the second objective of obtaining the feasibility of the developed product.

Practicality is a measurement of the ease and efficiency of using media developed by considering the interventions and indicators of a trial [16]. Practicality data analysis was obtained through student response questionnaire sheets at the end of the product trial. In addition, observations were made by observers by filling out student activity observation sheets during the trial. This is to support and compare the results of the response questionnaire. Android CHEMDIC mobile learning is declared practical if it meets the percentage ≥61% [18]. The results of the student response questionnaire are shown in Table 7.

The student response questionnaire in this research contains four objectives. All aspects of each objective are categorized as very practical. Practical media in preventing student misconceptions means that it is practical to correct wrong concepts in students and motivate them to improve their learning. In addition to being easy to use, the utilisation of all component functions in the media runs quickly, clearly, interestingly, and efficiently, supporting an interactive and in-depth learning process.

Table 7. Student Response Questionnaire Results

Objective	Aspects	Percentage/ Category
Quality of display presentation in mobile learning	Android CHEMDIC has an attractive appearance	100.00%/very practical
	Illustrations in animated video are clear	100.00%/very practical
	Display and features are not confusing	100.00%/very practical
Clarity on how to use mobile learning	Ease of steps to use mobile learning	100.00%/very practical
Clarity of content and language in mobile learning	Writing and language are clear and easy to understand	100.00%/very practical
	Material presented is easy to understand	93.33%/very practical
	Questions presented are easy to understand	93.33%/very practical
The helpfulness of mobile learning on understanding and interest in chemistry	Interest in learning chemistry	86.67%/very practical
	Makes it easy to correct misconceptions	86.67%/very practical
	Help improve chemical knowledge	100.00%/very practical

Relevant student activities during the trial supported the results for each objective in the response questionnaire. Table 8 shows the observations made on each objective to obtain accurate and relevant results in the supporting activity criteria.

Table 8. Student Activity Observation Results

Objective	Percentage/ Category
Quality of display presentation in mobile learning	93.33%/very supportive
Clarity on how to use mobile learning	100.00%/very supportive
Clarity of content and language in mobile learning	93.33%/very supportive
The helpfulness of mobile learning on understanding and interest in chemistry	93.33%/very supportive

Based on the student activity observation data results, each activity in each objective strongly supports the results of the student response questionnaire. Thus, the android CHEMDIC mobile learning is considered very practical based on four aspects of the goal to prevent student misconceptions, with a percentage of the practicality category of 96%. This statement is supported by the activity sheet data for each objective, which strongly supports the results of the student response questionnaire.

Conclusion

Based on the results, it was obtained that CHEMDIC mobile learning fulfils the feasibility of preventing student misconceptions about the periodic system of elements material based on the validity and practicality scores, among other things; mobile learning was declared valid by obtaining a content validity mode score of 5 with a very valid category and a construct validity score of 4 with a valid category. Then, practicality was obtained by obtaining a percentage in the student response questionnaire of 96% with the very practical category.

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References

[1] Overby, J., & Chang, R. (2022). *Chemistry Fourteenth Edition*. New York: McGraw Hill.
[2] Murni, H., Azhar, M., Ellizar, E., Nizar, U., & Guspatni, G. (2022). Three Levels of Chemical Representation-Integrated and Structured Inquiry-Based Reaction Rate Module: Its Effect on Students' Mental Models. Journal of Turkish Science Education, 19(3), 758-772 .
[3] Stojanovska, M., M. Petruševski, V., & Šoptrajanov, B. (2017). Study of the Use of the Three Levels of Thinking and Representation. *Contributions, Section of Natural, Mathematical and Biotechnical Sciences*, *35*(1), 37–46.
[4] Suparwati, N. M. (2022). Analisis Reduksi Miskonsepsi Kimia dengan Pendekatan Multi Level Representasi: Systematic literatur Review. *Jurnal Pendidikan MIPA*, *12*(2), 341-348.
[5] Irsanti, R., Khaldun, I., & Hanum, L. (2017). Identifikasi Miskonsepsi Siswa Menggunakan Four - Tier Diagnostic Test pada Materi Larutan Elektrolit dan Larutan Non Elektrolit di Kelas X SMA Islam Al-falah Kabupaten Aceh Besar. *Jurnal Ilmiah Mahasiswa Pendidikan Kimia (JIMPK)*, *2*(3), 230–237.
[6] Fahmi, T., & Fikroh, R. (2022). Pengembangan Modul Bermuatan Multirepresentasi pada Materi Hidrokarbon untuk SMA/MA. *Jurnal Inovasi Pendidikan Kimia*, *16*(1), 53-58.
[7] Pfefferová, S. M. (2015). Computer simulations and their influence on students' understanding of oscillatory motion. *Informatics in Education*, *14*(2), 279–289.
[8] Wang, C., & Hung, S. (2022). Gender, regions and multimedia applications: A medium-scale study of online learners towards media environments. *Cogent Education*, *9*(1), 2043994.
[9] Fitriyah, N., & Sukarmin. (2013). Penerapan Media Animasi Untuk Mencegah Miskonsepsi Pada Materi Pokok Asam-Basa di Kelas XI SMAN 1 Menganti Gresik. *Unesa Journal of Chemical Education, 2*(3), 78–84.
[10] Winarso, W., Toheri, & Udin, T. (2023). Addressing the Challenge of Mathematical Misconceptions :

Development of Interactive Multimedia Based on Cognitive Conflict Strategy. *Journal of Education Technology*, *7*(3), 513–522.
[11] Nuri, L., Wahyuni, S., & Ridlo, Z. (2023). Development of an Android-Based Mobile Learning Module to Improve the Students Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 4991–4998
[12] Lok, W. F., & Hamzah, M. (2021). Student experience of using mobile devices for learning chemistry. *International Journal of Evaluation and Research in Education*, *10*(3), 893–900.
[13] Saputra, D., Gürbüz, B., & Haryani, H. (2021). Android-based Animation for Chemical Elements and Experiments as an Interactive Learning Media. *Journal of Science Learning*, *4*(2), 185–191.
[14] Ah-Nam, L., & Kamisah, O. (2018). Developing 21st Century Chemistry Learning through Designing Digital Games. *Journal of Education in Science, Environment and Health*, *4*(1), 81–92.
[15] Rochmad. (2012). Desain Model Pengembangan Perangkat Pembelajaran Matematika. *Jurnal Kreano, 3*(1), 59–72.
[16] Daryono, D., Rayanto, Y. H., & Damayanti, A. M. (2023). Assessing Aspects and Items Validity, Practicality and Effectiveness on Students' Final Project. *EDUTEC : Journal of Education And Technology*, 6(4), 684–703.
[17] Thiagarajan, S., & Semmel, M. (1974). *Instructional development for training teachers of exceptional children: A sourcebook*. Indiana University.
[18] Riduwan. (2018). *Dasar-Dasar Statistika*. Bandung: Alfabeta.
[19] Cao, W. (2021). Discussion about the Mean, Median, Mode and their Validity, and the Representative Number. *Journal of Contemporary Educational Research*, *5*(3),71-74.
[20] Casfian, F., Fadhillah, F., Septiaranny, J. W., Nugraha, M. A., & Fuadin, A. (2024). Efektifitas Pembelajaran Berbasis Teori Konstruktivisme Melalui Media E-Learning. *Jurnal Pendidikan Sosial dan Humaniora*, *3*(2), 636-648.
[21] Chavoshi, A., & Hamidi, H. (2019). Social, individual, technological and pedagogical factors influencing mobile learning acceptance in higher education: A case from Iran. *Telematics and Informatics*, *38*(5), 133–165.
[22] Kusuma, R.R., & Sukarmin. (2023). Development of Interactive Learning Multimedia on Atomic Model Topic to Minimize Students Misconceptions at SMAN 1 Driyorejo. *Hydrogen: Journal of Chemical Education*, *11*(4), 412-425.
[23] Lutfi, A. (2021). *Research and Development (R&D): Implikasi dalam pendidikan kimia (Issue 1).* Surabaya: State University of Surabaya.
[24] Unsworth, L. (2020). *Learning from Animations in Science Education*. Springer International Publishing.
[25] Tasker, R., & Dalton, R. (2008). Visualizing the Molecular World-Design, Evaluation, and Use of Animations. *Visualization: Theory and Practice in Science Education*. Springer.
[26] Akker, J. van den, Nieveen, N., Bannan, B., Plomp, T., & E. Kelly, A. (2013). *Educational Design Research*. Netherlands Institute for Curriculum Development (SLO).
[27] Kim, J., & Lee, J. K. (2020). Stochastic detection of interior design styles using a deep-learning model for reference images. *Applied Sciences (Switzerland), 10*(20), 1–20.
[28] Mayer, R. E. (2002). *Multimedia Learning*. Cambridge University Press.
[29] Wang, Y., Gong, S., Gao, Y., Lang, Y., & Xu, X. (2023). The effects of affective pedagogical agent in multimedia learning environments: A meta-analysis. *Educational Research Review*, *38*, 100506.
[30] Abdulrahaman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V., Imam-Fulani, Y. O., Fahm, A. O., & Azeez, A. L. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon*, *6*(11), e05312.