Developing IT-based learning media of the Aufbau electron configuration principle in constructivism-oriented chemistry learning to improve mastery of concepts and problem solving skills

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Developing IT-Based Learning Media of the Aufbau Electron Configuration Principle in Constructivism-Oriented Chemistry Learning to Improve Mastery of Concepts and Problem Solving Skills

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Abstract. The development of IT-based Aufbau electron configuration principle media has been conducted. This study aims to identify the validity, practicality and effectiveness of the use of the media to improve students' mastery of concepts and problem-solving skills. This study utilized R&D design which consists of problem analysis, data and information collection, product design, product validation, product revision, field trials (small scale), revision from trial results, field trials (large scale), data analysis and reporting. The validity from the validator evaluations obtained a percentage of 88.46% with the very good category. The practicality from student responses acquired a percentage on a small scale of 83.65% and on a large scale of 88.01% with the very good category. The subjects of the study were 30 students. The result of the study revealed that the media effectively increased the mastery of concepts and problem-solving skills. It could be proven from the average N-Gain scores on a small scale of 0.72 and on a large scale of 0.78 with the very effective category. Based on the evaluation results, the product was suitable for use in the learning process on electron configuration material.

INTRODUCTION

Chemistry is a branch of Natural Science which studies the composition, structure, properties and changes experienced by matters both in natural processes and in planned experiments [1]. Through chemistry, the composition of substances and the use of both natural and artificial materials also important processes in living things can be recognized [2].

Chemistry is a difficult subject due to its complex and abstract concepts making many students reluctant to study chemistry [3]. Chemistry learning also tends to be passive because of the low interest and motivation of students [4]. Electron configuration is a material that is full of abstract theories and concepts. Moreover, in the learning process, many chemistry teachers only use the lecture method causing the learning of this material to be tedious [5].

Many studies have been carried out in improving students' understanding, interest and motivation in electron configuration material, including: learning electron configuration using congklak that uses congklak traditional game principles [6]. The next development is using doma (Domino Kimia literally translated into Chemistry Domino) which is a card in which there are two elements of different groups, the card will be paired with other cards that are different in the same class [7]. Besides, dacron is a game board that students can run with coins with the desired number of electrons. Coins can be divided into holes on the board according to the information on the game board [8]. Furthermore, made media that use switches that are connected to LED (Light Emitting Diode) lamps which can display motions so that they can be used to clarify the concept of charging electrons according to the Aufbau principles [9]. However, all of the above learning media can only be used in face-to-face learning. During the Covid-19 Pandemic, learning activities in schools around the world must have experienced disruption starting from technical problems in learning to psychological disorders of students and teachers. The learning activities for the 2020 to 2021 academic year use online learning systems. Therefore, learning media are developed in order to make the learning process effective.

Learning interest can be built in the learning process through the combination of the uniqueness of the learning media used and the teaching styles that are memorable for students. It is realized by many education practitioners that the use of media or aids is very helpful for the activities of the learning process both inside and outside the classroom,

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especially assisting to increase students' interest [10]. To arouse students' interest in learning, there are many ways that can be used by making the material to be studied into material that is very interesting and not tedious [11]. Regarding to that, IT-based learning media of the Aufbau electron configuration principle are developed using flash media. Macromedia Flash is a very popular program used by designers for web design or animation [12]. The advantages of using flash media are like nowadays most popular web animation technology. It is widely supported by various parties, small file sizes with good quality, low hardware requirements, and capable of creating websites, web animation, cartoon animation etc [13].

RESEARCH METHOD

This study employed R&D (*research and development*) research model which consists of the research and data collection stage, the planning stage, the product development stage, the field trial stage (small scale), the revision of trial results, the second field trial stage (large scale), the product development result and the dissemination stage. This research was conducted from September to October 2020 in SMAN (Senior High School) 1 Muara Kaman in the academic year of 2020/2021. The subjects in this study were students of class X IPA (Science Program) SMAN 1 Muara Kaman, totaling 30 students on a large scale and 6 students on a small scale. With reference to the R&D development model, the researcher took 7 development steps in this process. This was done because the research was carried out in a school and conformed to the characteristics, limitations of time, energy, and costs. The first stage in this research was the research and data collection stage, this stage was carried out to assess the situation and the environment to find out what products needed to be developed. Observations of learning activities and chemistry learning needs also interviews of several chemistry teachers were conducted in determining the electron configuration media which could be developed for learning chemistry. The second stage was the planning stage. At this stage, the assessment instruments and the design of the product making from the material design were developed. The third stage was the product development stage. At this stage, the manufacture and product validity test were conducted. The product validity stage consisted of the validation of media experts, the validation of material experts and the validation of education practitioners. The fourth stage was the field trials in a small group. The small group trial was conducted in SMA Negeri 1 Muara Kaman with the research subjects involving 6 students. The fifth stage was the revision of the first trial results. The media were revised based on the suggestions for improvement from the results of the small group trial. The sixth stage was the large group trial which was done in the same school consisting of 30 students. If there were any suggestions or improvements needed, the media would be revised and improved in order to obtain good quality media. The seventh stage was the result of the product development which was the final product of the electron configuration media in the finished form that had been revised and had been tested in the field.

The data collection technique in this study utilized survey , observation and test technique. The data collection using survey techniques was done by providing validator questionnaire sheets and student response sheets. The validator questionnaire sheets were given to the lecturers who had expertise in media and material development. The validator questionnaire sheets were also given to the teachers as education practitioners. This validator questionnaires aimed to determine the validity of the media. The student response questionnaires were given to students who were the subject of the research, this student response questionnaires aimed to determine the practicality of the learning media. Through student response questionnaires, the researcher could find out students' responses to learning media that had been developed. the results of students' responses were also used as materials for consideration for revising and improving the developed media. Furthermore, the observation techniques, the observations were conducted during the learning process. The observations were done to determine the activities of teachers and students in the trial and learning process. In the learning process, the observations were assisted by 2 observers who observed the teacher and students' activities related to the implementation of the learning process. The last was the test technique, the tests were given to the students in the form of pretest and posttest multiple choice questions aimed to determine the ability of students' mastery of concepts and problem solving skills before and after learning using the media. The results of this test were also used to determine the effectiveness of the developed media. Furthermore, the data analysis techniques used in this study are as follows:

a. Learning Media Validity

The media quality data or qualitative descriptive data in this study were obtained based on the results of experts and education practitioners' assessment. The assessment was done through the validation questionnaire sheets for learning media and materials using the Likert scale and comment / suggestion column. The assessment was based on two things, namely materials and media which were presented in the form of assessment aspects. The assessment aspects of the media included the size, the packaging design, the content design and the language of the learning media. While the assessment aspects of the material covered the content appropriateness, presentation appropriateness

and linguistic appropriateness. The data on the quality of the learning media from the assessment of two experts and practitioners were then presented in the form of assessment scales and descriptions of the suggestions. The validator assessment analysis technique was calculated using the following rating scales, Strongly Agree (SA) = 5, Agree (A) = 4, Undecided (U) = 3, Disagree (D) = 2 and Strongly Disagree (SD) = 1 [14]. The data from the questionnaire validation sheets obtained from the media expert, material expert and education practitioners were then analyzed using the following formula:

Based on the percentage of the validity result of the developed learning media, the criteria for the validity of the media according to [15] are determined as follows:

$$\text{Presentage}(\%) = \frac{\sum \text{validation component score}}{\sum \text{maximum score}} \times 100\ \%$$

TABLE 1. Learning Media Validity Criteria

Percentage (%)	Criteria
90 – 100	Excellent
80 - 89	Good
65 - 79	Fair
55 - 64	Poor
0 - 55	Very Poor

b. Learning Media Practicality

The data analysis technique to determine the practicality of the instructional media utilized the student response questionnaires. The response questionnaires were given to the students who were the research subjects. The student response questionnaires aimed to find out whether or not the learning media that had been used during the learning process were practical to be used. The practicality of the media could be identified based on the results of the student response questionnaire analysis given after learning activities using the media. The response questionnaires given to students used following the Likert scale , Strongly Agree (SA) = 5, Agree (A) = 4, Undecided (U) = 3, Disagree (D) = 2 and Strongly Disagree (SD) = 1 (Widyoko, 2014) . The data obtained from the student response questionnaire are calculated using the following formula:

$$\text{Presentage}(\%) = \frac{\sum \text{Total score of all students}}{\sum \text{Maximum score}} \times 100\ \%$$

Based on the percentage attained from the student response questionnaires, the criteria for the practicality of learning media are determined based on Table 2 below:

TABLE 2. Learning Media Practicality Criteria

Percentage of Student Responses	Criteria
81% - 100%	Excellent
61% - 80%	Good
41% - 60%	Fair
0% - 40%	Poor

c. Learning Media Effectiveness

The effectiveness test was conducted to determine the extent of the role of the developed learning media in assisting the students to understand the material being taught. The media developed could be said to be effective if the students' learning outcomes after participating in learning activities using the developed media had increased. The increase in students' learning outcomes was measured by using the results of the pretest and posttest then analyzed using the N-gain formula as follows [16].

$$< g > = \frac{S_{post} - S_{pre}}{\text{Maximum score} - S_{pre}} \times 100\ \%$$

Based on the results of N-gain value, the criteria for the effectiveness of learning media obtained the following result:

TABLE 3. Learning Media Effectiveness Criteria

N-gain	Category
> 0,7	High
0,3 ≤ g ≤ 0,7	Moderate
g < 0,30	Low

RESEARCH RESULT AND DISCUSSION

This research was a development research with the aim of producing a certain product called the IT-based electron configuration learning media (Flash Media). The development conducted was a type of research and development education research (R & D Education). This model consists of several stages called the stages of research and data collection, the planning stage, the product development stage, the field trials (small group), the revision of trial results, the second field trials (large group), the product development results and the dissemination stage.

a. Learning Media Validity

The validity of IT-based electron configuration learning media (Flash Media) was divided into two types of validation called the validation of instructional media experts and the validation of learning material experts. This validation was also conducted by education practitioners who were the chemistry teachers who had directly experienced teaching in the class. The learning media aspects that were measured included the media size, the packaging or the display design, the content design and the language. While the learning material aspects that were measured involved the content, the presentation appropriateness and the linguistic appropriateness. Based on the results of the validation by the material expert validator, the obtained results were 98.12% with the excellent category and very valid. Meanwhile, based on the results of the validation by the media expert validator, it obtained 88.46%. Overall, the data from the validation results from the team of experts and education practitioners are as follows:

TABLE 4. Data on the Validation Results of the Team of Experts and Education practitioners

Assessment Aspect	Score	Conclusion
Media Expert	88,46	High validity
Material Expert	98,12	High validity
Average	93,29	High validity

Based on the data from the validation results of media and material experts and education practitioners, the average value of the overall validation results from the material expert validators was 98.12%, Based on the data from the validation results of media and material experts and education practitioners, the validity of learning media conducted by media expert validator had the valid category with an average percentage of 88.46%. In accordance with the validity criteria according to (Nurhadi, 2017), this value is in the very valid criterion. Based on the results of this validation, it can be concluded that the quality of the media and material in the developed learning media has excellent validity and can be applied in the chemistry learning process of electron configuration material.

b. Learning Media Practicality

The practicality was measured through the questionnaire results of the student responses. The student response questionnaires were aimed to determine the practicality of the learning media.

TABLE 5. Data on Student Response Questionnaire Result

School	Percentage	Criteria
Small Scale	83,65 %	Excellent
Large Scale	89,48 %	Excellent
Average	86,56 %	Excellent

Based on the results of students' responses to the use of the media in chemistry learning, it showed a very good response, both on a small and on a large scale, meaning that students were very interested in the developed media. Therefore, it made the students more active during the learning process. During the learning process, students were given the opportunity to determine the electron configuration based on the Aufbau principle using the developed media. Based on the results of responses to the use of the media, the students were fond of learning by using the media because of the flash application system that can be accessed anywhere using the android device system which was very helpful for the distance learning process during the covid-19 pandemic. The students were more active in the learning process because the students were directly involved in using the media. They were also able to see simulations of the sequences of filling in the electron configuration. Besides, the students stated that by using the media, it was easier to determine the electron configuration. Thus, the students could more easily understand the Aufbau electron configuration principle material

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c. Learning media Effectiveness

The effectiveness test was conducted to determine the role of the learning media in helping the students comprehend the material being taught. The effectiveness of learning was assessed through the students' learning outcomes. The developed media could be said to be effective if the students after participating in the learning activities using the learning media showed increased learning outcomes. The increase in the students' learning outcomes was measured by using the results of the prestest and the posttest, then analyzed by using the N-gain formula (Meltzer, 2002)

TABLE 6. Data on Effectiveness Test Results

School	*Pretest*	*Posttest*	*N-gain*	Conclusion
Small Scale	25	79,17	0,72	Very Effective
Large Scale	30	84,50	0,78	Very Effective
Average	27,5	81,83	0,75	Very Effective

Based on the results of the small scale trial, it showed that the students' mastery of concepts and problem solving had increased with the interpretation of students' score in the High category. This stage aimed to determine the extent to which students could experience the increased mastery of concepts and problem solving skills in the process of developing the media. Moreover, this stage aimed to improve the media for various deficiencies before the large-scale trial was carried out. Based on the table above, it can be seen that the N-gain value is 0.78, which means that the effectiveness of the media being developed is high. The N-Gain value of 0.78 obtained is influenced by the developed media in the learning process which makes the students more active in receiving the lessons.

CONCLUSION

Based on the results of the research that has been conducted, it can be concluded that the developed learning product are suitable for use as learning media for students and teachers in high school in chemistry class on the subject of electron configuration. Since, it has met the criteria of validity, effectiveness and practicality obtained from the validity values of the media experts (88.46%) and the material experts (98.12%) with very valid overall criteria. The effectiveness of instructional media tried in SMA Negeri 1 Muara Kaman obtained N-gain = 0.75, with very effective criteria.

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