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Improving Student's Ability to Understand Chemical Representations through the Implementation of a Web-Based E-Module on The Periodic System of Elements Materials

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Abstract: Improving Students' Ability to Understand Chemical Representations through the Implementation of a Web-Based E-Module on The Periodic System of Elements Materials. The study's objective was to improve learner's ability to understand chemical representation and learning outcomes by implementing web-based E-Module on periodic system of elements material. The type of research is development research (R & D) with a four steps model (4D) but only limited to the third stage namely develop stage. This research is a part of the development stage, namely limited trials using a quantitative descriptive method with the type was *pre experimental with one group pretest-posttest design.* This research was carried out in SMA Al-Islam Krian Sidoarjo region with the subject of the study, to be specific 18 students of class XI MIPA. The research data was obtained from the test of learning outcomes. Data was analysed by *Wilcoxon test* and *N-gain.* The result showed that the learner's ability to understand chemical representation was improve after using Web-Based E-Module proceeded with Wilcoxon test because the data was not normally distributed and obtained the Asymp. Sig. (2-tailed) value was 0,000. Based on N-gain score was obtained a range 0,69 – 1 with medium or high criteria. Therefore, the implementation of web-based E-Module can be an alternative solution to improve the learner's ability to understand chemical representation.

Keywords: Web, E-Module, chemical representation.

Abstrak:Peningkatan Kemampuan Peserta Didik untuk Memahami Representasi Kimia melalui Implementasi E-Modul Berbasis Web pada Materi Sistem Periodik Unsur. *Penelitian ini bertujuan untuk meningkatkan kemampuan peserta didik memahami representasi kimia dan hasil belajar dengan mengimplementasikan E-Modul berbasis web pada materi sistem periodik unsur. Jenis penelitian ini merupakan penelitian pengembangan (R & D) dengan model 4D namun hanya terbatas pada tahap ketiga yaitu tahap pengembangan (develop). Penelitian ini merupakan bagian dari tahap pengembangan yaitu uji coba terbatas dengan menggunakan metode deskriptif kuantitatif dengan jenis pra-experimental one group pretest-posttest design. Penelitian dilakukan di SMA Al-Islam Krian Sidoarjo dengan subjek penelitian sebanyak 18 siswa kelas XI MIPA. Data penelitian diperoleh dari tes hasil belajar. Data dianalisis dengan uji Wilcoxon dan N-gain. Hasil penelitian menunjukkan bahwa kemampuan peserta didik dalam memahami representasi kimia meningkat setelah menggunakan E-Modul Berbasis Web yang dilanjutkan dengan uji Wilcoxon karena data tidak berdistribusi normal, dan mendapatkan nilai Asymp. Sig (2-tailed) sebesar 0,000. Berdasarkan nilai N-gain diperoleh nilai 0,86 dengan kriteria tinggi. Oleh karena itu, implementasi E-Modul berbasis web mampu menjadi solusi alternatif untuk meningkatkan kemampuan peserta didik dalam memahami representasi kimia.*

Kata kunci: *Web, E-Modul, representasi kimia*

- **INTRODUCTION**

One of the subjects in Natural Sciences that studies the composition and properties of atoms to molecules of an element is chemistry. Therefore, the physical properties of a chemical element cannot be directly experienced through vision, so learning chemistry requires a learning environment that can help visualise the material so that students can easily understand it (Herawati &; Muhtadi, 2018). If chemistry can be represented on three level namely macroscopic, submicroscopic, and symbolic, it will be easy to understand. (Adadan, 2013). But in fact, The submicroscopic level of chemistry is frequently ignored or studied separately in certain materials, whereas chemistry instruction has typically been restricted to symbolic and macroscopic representations. (Nastiti et al., 2012). The imbalance in students' understanding of concepts at all three levels of representation will cause students to experience difficulties in relating chemical concepts to everyday life (Jansoon et al., 2009). Various research results say that (Low Chapman, Ross L. and Sloan, Terry R., 2007).

The student's ability to comprehend the representation used determines their comprehension of chemical concepts. Visual, verbal, and mathematical representations are all forms of representation (Nirmala et al., 2020). The level of symbolic representation consists of images, numbers, letters and symbols that represent phenomena. Symbolic representation plays an important role in chemistry because it can help describe macroscopic and submicroscopic levels. The symbolic level is a difficulty for students because it is *invisible* and abstract while the minds of students rely on sensory motor information of their five senses (Firdaus et al., 2020).

Based on research conducted by (Martini, 2021) said that the ability of students to identify symbolic representations in chemistry learning still needs improvement because the average score is still low, for example in questions about electron filling based on Hund's rule and Aufbau's rule. This statement is in accordance with pre-research data on September 23, 2022 at one of the high schools in the Krian area, Sidoarjo Regency with 30 respondents of MIPA program students, showing that students' ability to understand chemistry is still quite low, as evidenced by the results of chemical representation ability tests. The chemical representation ability test sheet is used to determine students' understanding of the Periodic System of Elements material with the average score obtained is still very far from the KKM target of 35.5%. Students have difficulty on questions about writing electron configurations, determining the quantum number value of an element and naming elements. These difficulties result in learners constantly memorizing as the learning process progresses, with memorization can be a barrier to meaningful learning. (Li & Arshad, 2014)

The periodic system of elements is one of the chemistry topics that is considered difficult by most high school students because it requires a lot of memorisation, making students feel difficult and bored when learning the material (Bintiningtiyas et al., 2016). The periodic system of elements is difficult to understand partly because of the many complex ideas and the tight learning time of only two to three meetings (Rahmatsyah & Dwiningsih, 2021). According to the findings of a conversation with a high school chemistry teacher in the Mojosari region, obtained the score of students on the material of the periodic system is very heterogeneous. Students who score above KKM have a percentage of 10% of student efficacy while students who get the right score in KKM are quite a lot but there is still a lot to improve. The learning media used are still conventional,

namely PPT and blackboard, and still use the teacher centre model in learning. In fact, the needs of students are still not met by the learning media used daily. One method for helping students in understanding chemical concepts is the use of learning materials (KUSUMAWATI, 2019).

Handouts, books, Flipper Books, audio-video, interactive multimedia, comics, and modules are just a few examples of the media for education that can be used as tools for learning. According to (Rohman & Lusiyana, 2017) modules are an example of learning media that have been systematically organized so that they may be used as teaching resources for students. The E-Module can be operated by students using PCs equipped with software that allows E-Module access (Handayani et al., 2021). When compared to traditional learning, this electronic module can make learning more comfortable for students and increase learning efficiency.

The creation of E-Modules can be integrated into Web-based learning and is easily accessible to students. Worldwide website (WWW) technology is used in making Web-based E-Modules so that it does not take up storage space on devices and can be accessed by students anywhere as long as there is an internet connection (John, 2020). Web-based learning media can increase the enthusiasm of students to learn independently anytime and anywhere (Nurul et al., 2021). Web-based learning media has some benefits because of free learning time and can increase students' confidence (Arianggara et al., 2021). In addition, Web-based learning has advantages such as accurate and consistent content with the learning level of learners, looks interesting, and is always up to date (Deejring, 2014). However, updating and integrating e-learning with the content management system (CMS) would improve its effectiveness (Huda & Dwiningsih, 2021).

Based on all of these references, the author has belief that developing a Web-Based E-Module is crucial for improving students' comprehension of the material related to the chemical representation of the periodic system of elements. Later, teachers can use this website to teach students about the periodic system of elements.

• METHOD

Research Design

The implementation of the web-based E-Module is part of the development stage in the R&D model which has produced a product with a very valid category based on the results of the validation sheet from the aspects of material substance, learning design, appearance (visual communication), graphic design, and language and getting very good responses from students at the trial stage. This implementation is a limited trial stage that uses a pre-experimental descriptive quantitative research method with a one-group pretest-posttest design. By implementing the product on one trial group, a research design is developed, and the results obtained (posttest) will be measured after completion. Then the data obtained is compared and analysed with the data before using the product as a pretest component (Rusdi, 2018).

Research Objectives

This study was conducted at SMAS Al-Islam Krian in the Krian District of the Sidoarjo Regency in May 2023. The study's target population is the 18 students in class XI MIPA who will be tested and who have received lessons on the periodic system of elements.

Data collection

The data collection process uses the test method. this research data is quantitative data obtained from the results of processing pretest and posttest question sheets.

Procedure

The stages of giving students a pre-test before using the web-based E-Module were followed during the research process, the researcher distributed the web-based E-Module link and directed students to operate it. Researchers implemented the web-based E-Module at each meeting (two meetings) as treatment in this study. The last step ended by giving a posttest to students which could be accessed through the web-based E-Module integrated with Google Form.

Research Instruments

A learning outcome test sheet served as the research instrument. Questions on the pretest and posttest of the learning outcome test may include chemical representations. The results of the tests will reveal whether students' understanding of chemical representations has improved or decreased.

Data Analysis

Pretest and posttest scores as learning outcome data were analysed with a normality test, to determine whether or not there were differences in student learning outcomes before and after using the e-module The normality test is a trying strategy in measurements that is utilized to find out regardless of whether an information is typically disseminated. Due to the small number of data, the Shapiro-wilk test was used in this research. The decision-making process for the normality test is based on the SPSS tool.

- If the Sig. value $> 0{,}05$, the data is normally distributed
- If the Sig. value $< 0{,}05$, the data is not normally distributed

When the data is normally distributed, it will be tested using the t test, while if the data is not normally distributed, it will be analysed using a nonparametric test, namely the Wilcoxon test. (Kasiati, 2022)

From the results of the test, the difference that indicates an increase in learning outcomes is then analysed to categorise the type of increase using N-gain. Based on (Hake, 1998) , N-Gain can be calculated using the following formula:

$$g = \frac{S_{post} - S_{pre}}{100 - S_{pre}}$$

The results of the calculation of the N-gain (g) value are interpreted in the criteria that can be seen in the table:

Table 1. Interpretation N-gain score

N-gain score restriction	Category
$g > 0{,}7$	High
$0{,}3 < g \leq 0{,}7$	Medium
$g \leq 0{,}3$	Low

(Hake, 1998)

Based on the above criteria, the E-Module is declared effective if it gets an increase in the N-gain score of $0.3 < g \leq 0.7$ or $g \geq 0.7$ with the category "medium" or "high".

- **RESULT AND DISCUSSION**

This research was conducted using a small-scale product trial with the research subject 18 students of class XI SMA Al-Islam Krian who had received material on the periodic system of elements. The trial was conducted for two days on 2nd and 4th May 2023. At the first meeting, students were given a pretest for 30 minutes which aims to determine students' initial understanding of the material of the periodic system of elements. After the operation of the media, students are given a 30-minute posttest which aims to determine students' understanding of the material. The selection of 18 learners as research subjects was adjusted to the consideration that if there were less than 10 learners, then the data obtained did not describe the target population. If it exceeds 20 students, the information needed is less useful to be analyzed in small groups (Sadiman, 2011).

First, the learning outcomes in the form of pretest and posttest scores were tested for the distribution data using normality test with the help of SPSS 25 software. The result of the normality test can be seen in the table below.

Table 2. The result of normality test

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
pretest	,275	18	,001	,852	18	,009
posttest	,250	18	,004	,832	18	,004

a. Lilliefors Significance Correction

Based on table 3. The Sig. value obtained $< 0{,}05$, so the data of pretest and posttest is not normally distributed. The next step is non-parametric statistic, namely Wilcoxon test.

Table 3. The result of non-parametric test

Test Statistics[a]

	posttest - pretest
Z	-3,727[b]
Asymp. Sig. (2-tailed)	,000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Based on the table above, it's obtained Asymp. Sig. (2-tailed) on the Wilcoxon test is 0,000. It means the value of Asymp.Sig. (2-tailed) $< 0{,}05$, So that H_0 is rejected and

there is a difference in the average of student's chemical representation abilities for pretest and posttest.

The effectiveness of the media can be seen from the increase in learning outcomes in the form of pretest posttest questions, chemical representation abilities given to students containing 10 multiple-choice questions and 5 essay questions with details of every 3 questions referring to 1 indicator. Effectiveness data was obtained from the output of a web-based E-Module trial on the learning process. The output of the trial activity is the learning outcomes of students consisting of pretest and posttest. The pretest and posttest results can be seen in chart below.

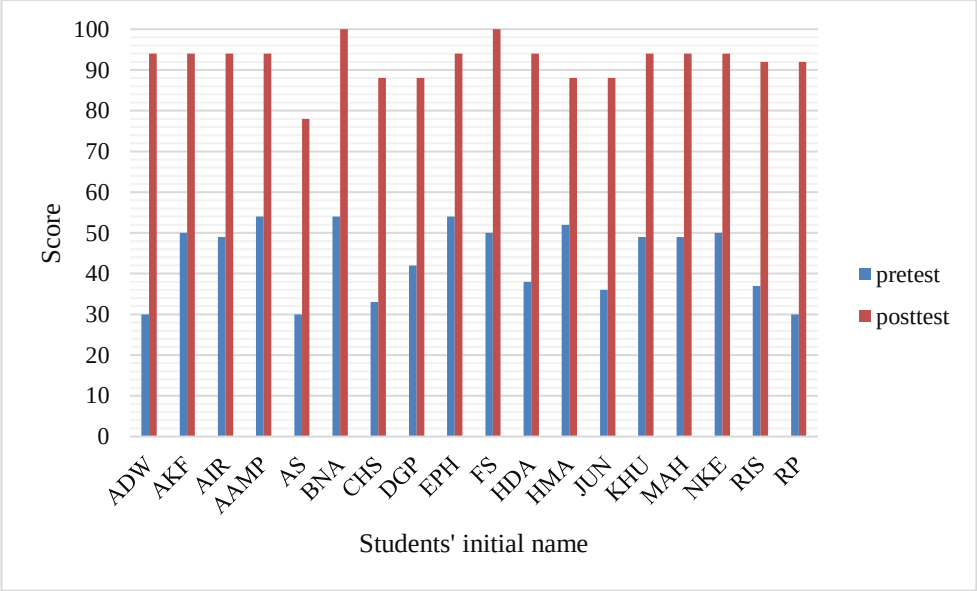

Figure 1. Pretest and Posttest Result

Based on the table above, it states that the learning outcomes of students in terms of pretest and posttest scores given to 18 students get results as many as 17 students who are complete and there is 1 student who is incomplete. Factors that influence the achievement of learning outcomes are related to factors in students. In addition to other influencing factors are motivation, interest, attitude, study habits, perseverance, socioeconomic circumstances, physical and psychological conditions (Syech, 2012). Thus, if students do not have motivation and interest, especially in reading material on learning media, then these students are not complete in learning activities.

In the web-based E-Module, illustrations in the form of images, animations and videos are included that can make it easier for students to understand chemical representations by associating various chemical symbols with the material of the periodic system of elements. The explanation is shown in figure.3

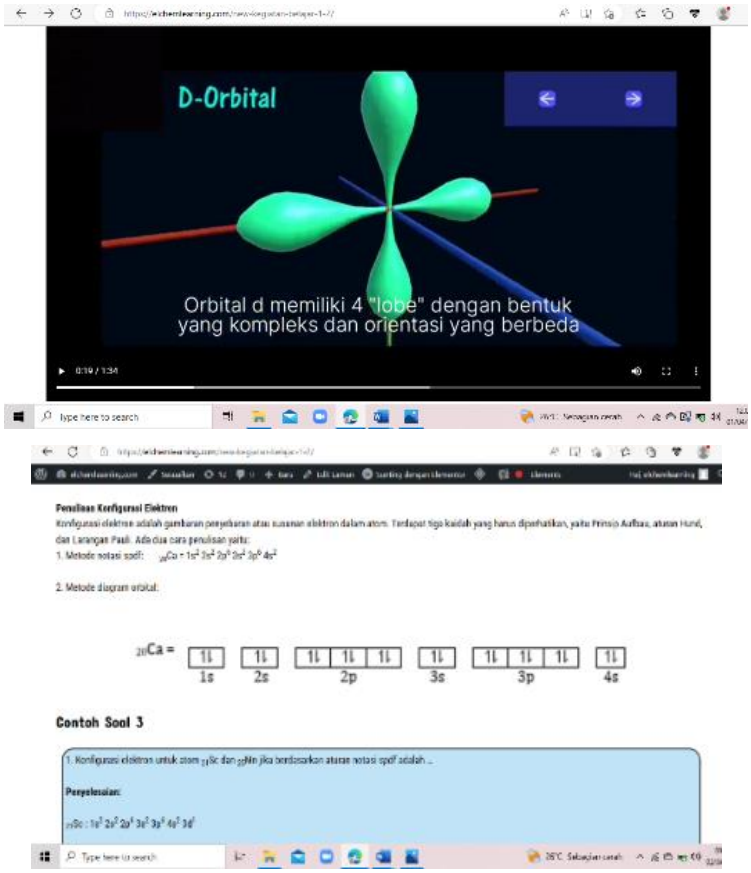

Figure 2. the display of chemical representation on e-module

Therefore, based on the results of the Wilcoxon-test analysis, it can be said that the web-based e-module built has a significant impact on students' ability to understanding the chemical representation on the periodic system of elements materials. The N-gain test was used in addition to the Wilcoxon-test to assess the success of learning and gave the following results:

Table 4. N-gain score

Pretest	Posttest	N-gain	criteria
43,72	92,22	0,86	High

Based on table 5. The N-gain score obtained 0,86 in the high category. So, we can conclude that the web-based e-module developed is effective to improving student's ability to understanding chemical representation on the periodic system of elements materials.

▪ CONCLUSION

Based on the result obtained, it is proven that the students' ability to understanding the chemical representation of SMAS Al-Islam Krian students has increased with the result of Wilcoxon test obtained Asymp. Sig. (2-tailed) 0,000. In the pretest and posttest

result obtained N-gain score 0,86 with high criteria. From the results of this analysis, it can be concluded that the web-based e-module developed is effective to improving student's ability to understanding chemical representation on the periodic system of elements materials.

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