DEVELOPMENT OF A PERIODIC ELEMENTARY SYSTEM MODULE FOR BOARDING SCHOOL STUDENTS IN IMPROVING VISUAL INTELLIGENCE

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Abstract. *The periodic system of elements is one of the complex chemical materials. Based on prior research, it has been observed that the academic performance of boarding high school students demonstrates a comprehension that is confined to the macroscopic level. Visualization of chemical representation level requires high visual intelligence. Therefore, researchers developed a module of periodic system of elements as an independent learning tools for boarding high school students to improving visual intelligence. This study intention is analyze the validity, practicality, and effectiveness of the module. The type of research used is the ADDIE method with five stages, namely Analyze, Design, Develop, Implement, and Evaluate. The module in terms of content and construction showed a very valid category with the percentage for the media characteristics aspect is 86,66%, while the percentage for the suitability aspect with the visual intelligence indicator is 94,98% the percentage for content validity, while the construct validity for the linguistic aspect is 86,66%, the percentage for the presentation aspect is 94,64%, and the percentage for the graphical aspect is 94,98%.. The results of observations of module implementation show a very practical category with the percentage in terms of ease of use, was 95.5%. In terms of usability, the percentage was 97.3%. In terms of helpfulness, the percentage was 93.3%.. The module is very effective to improve students' visual intelligence with an n-gain value of 0.753434. The results showed that the periodic system of elements module is feasible to use as a solution to improve students' visual intelligence.*

Keywords: *Module, Periodic System of Elements, Boarding High School, Visual intelligence, Chemical representation*

INTRODUCTION

Improving the quality of human resources can be supported through education. One formal educational institution that focuses on improving the quality of human resources in spiritual and knowledge aspects is a boarding school [1].

Boarding schools are alternative institutions that combine the Islamic boarding school and public school education systems. The aim of this institution is to provide balanced understanding of religion and science and technology [2]. Boarding school education in this global and digital era should ideally be active in fostering competitiveness in the development of science, but still maintaining the moral development that has long been a characteristic and a major achievement of Islamic boarding schools. One of the sciences included in the boarding school curriculum is natural science (science), where in this research the researchers focused on chemistry. However, the large number of subjects taught compared to regular schools makes the cognitive load at this school higher, especially in chemistry learning.

It is known that learning chemistry requires an understanding of abstract concepts which encourage students to always think more complexly [3]. Therefore, chemistry learning will be more effective if it is delivered through clear visualization. Understanding visualization will be easier if students have high visual intelligence, namely the ability to transform information or problems through visual

information which is then combined into an idea or theory of problem solving [4].

One of the materials in chemistry subjects that requires an understanding of the microscopic level of representation is the periodic system of elements, which is the basic material in studying chemistry [5]. To stimulate and even increase visual intelligence, a stimulus is needed [6]. The stimulus can be in the form of a module. Modules are independent learning media that are not tied to the learning process so they can be used anytime and anywhere [7].

In this case, the module can also be used as a learning medium that can display concrete visualizations of abstract concepts [8]. However, in reality there are no adequate modules to convey visualization of abstract concepts, especially in periodic system of elements material [9]. Thus, research is needed related to the development of periodic system of elements modules in increasing visual intelligence that meets the validity, practicality and effectiveness of the module in increasing students' visual intelligence. The aim of this research is to describe these three aspects.

METHOD

The stages and methods used by researchers are research and development of the ADDIE model which consists of five main stages, namely analysis, design, development, implementation, and evaluation.

The target of this research were class X students in boarding high school which is one class consists of 22 students. The data collection technique in this research consists of three techniques, namely questionnaire data, observation data and test data. Questionnaire data techniques are used to determine the validity and practicality of the periodic system module. The instruments used in the questionnaire are content validity instruments and media constructs developed, namely modules and student response questionnaire instruments. Observation data techniques on students are used to determine the practicality of the periodic system module. The instrument used to collect observations by observers uses an observation sheet which consists of several student activities during use of the module. Test techniques are used to determine the effectiveness of the periodic system module in improving visual intelligence in the form of pretest and posttest sheets. The pretest and posttest instruments were prepared using the C5 cognitive level which is adjusted to the cognitive level of high visual intelligence. Validity techniques are also used to see the validity of the instruments used, the development of the instruments used include validity questionnaires, student response questionnaires, observation sheets on student activities, and pretest and posttest sheets.

The data analysis technique for validity uses a Likert scale where there are 5 score ranges with score 1 being the lowest score in the very invalid category, score 2 in the invalid category, score 3 in the quite valid category, score 4 in the valid category, and score 5 with a very valid category. The scores obtained from the validation questionnaire sheet by the validator will be reprocessed using a formula that is interpreted in the form of a percentage. The periodic system module to improve students' visual intelligence is declared valid if the validity percentage reaches ≥ 61% [10].

Table 1 Validation score interpretation

Percentage (%)	Category
0% - 20%	Very invalid
21% - 40%	Invalid
41% - 60%	Quite valid
61% - 80%	Valid
81% - 100%	Very valid

Then for data from response and observation questionnaires, analysis techniques with the Guttman scale was used which gives a score of 1 and 0, with 1 being the "Yes" choice and 0 being the "No" choice. The scores obtained from the response and observation questionnaire sheets will be reprocessed using a formula that is interpreted in the form of a percentage. The periodic system module to improve students' visual intelligence is declared practical if the percentage of practicality reaches ≥ 61% [10].

Table 2 Interpretation of response questionnaire scores and observation of student activities

Percentage (%)	Category
0% - 20%	Very impractical
21% - 40%	Impractical
41% - 60%	Quite practical
61% - 80%	Practical

Percentage (%)	Category
81% - 100%	Very practical

Data analysis techniques for the pretest and posttest are interpreted using n-gain scores. A significant increase can be stated if the average value of the n-gain score obtained is > 0 [11]. So, the n-gain calculation can use the following formula.

$$< g >= \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}}$$

With the symbol description it is explained that <g> = normalized gain score; S_{post} = posttest value; S_{pre} = pretest score; S_{max} = maximum value. The score criteria obtained are interpreted based on the following table.

Table 3 n-gain score interpretation

Percentage (%)	Category
$g \geq 0.7$	High
$0.7 > g \geq 0.3$	Mid
$g < 0.3$	Low

RESULTS AND DISCUSSIONS

Pre-research was carried out using two instruments, namely a visual intelligence test instrument and a student assessment questionnaire instrument related to learning media. The visual intelligence test instrument includes questions containing four aspects of visual intelligence, namely imagining, conceptualizing, problem solving, and pattern searching, where students will be declared to have good visual intelligence if they exceed the assessment criteria of the four indicators of visual intelligence. Pre-research data from the visual intelligence test shows that students did not complete the three indicators of visual intelligence (below 50%), including the indicators of imagining (7.4%), conceptualizing (0%), and searching for patterns (3.7%). Based on this, students' visual intelligence needs to be improved.

The validation stage aims to assess whether the periodic system module that has been developed can be categorized as valid as a learning medium for chemistry subjects. Assessment is based on content and construct validity criteria. The validation sheet is filled in by three validators, namely a media expert validator and a chemist. Content validity focuses on providing evidence for the content of media content. Content validity was assessed by chemists regarding content content. Data from content validity includes two aspects which are presented in Table 4. This was done to obtain more accurate data regarding content validity, so that the module developed has good content quality.

Table 4 Percentage of data resulting from content validity

Aspect	Percentage	Category
Media characteristics	86,67%	Very valid
Compliance with visual intelligence indicators	94,98%	Very valid

Content validity in this research consists of two aspects, each aspect of which has assessment criteria that determine the validity of the periodic system module learning media. These two aspects are media characteristics and suitability for visual intelligence indicators. Based on content validity data by validators, the percentage for the first aspect was 86.66% and the percentage for the second aspect was 94.98%. Based on the results of data analysis on both aspects of content validity, the periodic system module developed can be declared content valid with a very valid interpretation category.

Construct validity shows the extent to which the periodic system module fulfills the theoretical construct to be measured. This research uses three aspects of assessment as measurements for construct validity which are presented in Table 5.

Table 5 Percentage of data resulting from construct validity

Aspect	Percentage	Category
Language	86,67%	Very valid
Presentation	94,64%	Very valid
Graphics	94,98%	Very valid

Construct validity in this research consists of three aspects, each aspect of which has assessment criteria that determine the validity of the periodic system module learning media. These three aspects include language, presentation, and graphics. Based on construct validity data by the validator, the percentage for the first aspect was 86.66%, the percentage for

the second aspect was 94.64%, and the percentage for the third aspect was 94.98%. Based on the results of data analysis on both aspects of construct validity, the periodic system module developed can be declared construct valid with a very valid validity category.

The periodic system module has been implemented to improve students' visual intelligence. This implementation was carried out in 5 meetings, of which 4 meetings were used for learning using modules and pretests and 1 meeting for implementing the posttest. Based on these activities, data was obtained regarding the practicality of the module. This data was obtained from student response instruments and student observations while using the module

Table 6 Percentage of practicality of student response instruments

Aspect	Percentage	Category
Ease of use	95,5%	Very practical
Module usability	97,3%	Very practical
Module helpfulness	93,3%	Very practical

The data in Table 6 shows that the results of student responses showed that the periodic system module was considered very practical to use as a learning medium in improving visual intelligence and student learning outcomes, especially in material on the periodic system of elements. This is shown by the percentage gain in the ease of use aspect of 95.5% so that the module is declared easy to use based on students' perceptions during the learning process. Then, in the usability aspect, a percentage of 97.3% was obtained, which means that the periodic system module has high usability in increasing students' visual intelligence, as evidenced by the students' perceptions while taking quizzes. Furthermore, in the helpfulness aspect, a percentage of 93.3% was obtained, which shows that students feel that the periodic system module can help students understand the material and practice it to increase visual intelligence.

The following is also shown regarding practicality based on student observations by observers while using the module. In this study there were 4 observers.

Table 7 Percentage of practicality of student activity observation instruments

Aspect	Percentage	Category
Ease of use	90%	Very practical
Module usability	95,5%	Very practical
Module helpfulness	90%	Very practical

Based on Table 7, observation data on student activities shows that the periodic system module is considered very practical to use as a learning medium in improving visual intelligence and student learning outcomes in chemistry subjects, especially in material on the periodic system of elements which has many abstract concepts. This supports the results of student responses which state that the module has high practicality during the learning process. Looking at the results, observers felt that the periodic system module had a positive influence on the implementation of learning with the percentages obtained in each aspect being 90%, 95.5% and 90%.

Then, in terms of the effectiveness of using the module, it can be seen based on the analysis of the pretest and posttest results carried out by students at the beginning of learning and at the end of learning after using the module as a learning medium to improve their visual intelligence. These results were then analyzed using the n-gain method, then the n-gain values obtained by each participant were averaged to see an increase > 0. These results are attached in Table 8 below.

Tabel 8 Students n-gain result

$\bar{x}$*Pretest*	$\bar{x}$*Posttest*	N-gain
35,135	83,95	0,75

Based on the data results in Table 8, the average n-gain value is 0.75, which shows that the periodic system module is effective in improving students' overall visual intelligence. The posttest scores of students increased significantly after using the periodic system module as a learning medium during the

chemistry learning process. In this way, students' visual intelligence can be determined to have increased because there is an increase in the results of the pretest and posttest and the module is determined to be an effective medium.

Therefore, the periodic system module is assessed as meeting the appropriateness standards for learning media in the valid, practical, and effective categories. Thus, the periodic system module is declared feasible as a chemistry learning medium to improve students' visual intelligence.

CONCLUSIONS AND SUGGESTIONS

Based on the results of data analysis and discussions carried out by researchers, the conclusions of the research can be described as follows.

1. The periodic system module product in improving visual intelligence in high school boarding school students received the title valid in content and construct with average validity in the very valid category.
2. The periodic system module product in improving visual intelligence in high school boarding school students received a practical title with an average practicality in the very practical category.
3. The periodic system module product in improving visual intelligence in high school boarding school students received an effective title with an n-gain value of 0.75.

This research was only carried out at SMA Boarding Schools, so it would be better if it was also applied to regular highschools to obtain more accurate results. Then, because there is limited time (number of meetings), more meetings can be carried out so that the use of the module is more optimal.

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