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Development of a Digital Module for Classification of Materials and Its Changes Topic to Improve the Multi-Representation Ability of Junior High School Students

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Abstract

Multi-representation ability is one of the abilities that must be possessed by students, especially in science subjects to be able to understand the topics, at the chemistry level, multirepresentation abilities are divided into three, they are macroscopic, submicroscopic, and symbolic abilities. This study aims to develop a digital module for the classification of the change topics to improve the multi-representation ability of junior high school students. This research method follows development research (R&D) with the ADDIE model (analysis, define, design, develop, evaluation) with a sample of 100 class VII students at SMP Negeri 1 Kedungjati and SMP Negeri 2 Kedungjati in April 2022. The method of data collection by observation, interviews, and documentation, for data collection instruments with a questionnaire sheet. Data analysis techniques include questionnaire validity test, question validity test, questionnaire reliability test, question reliability test, digital module feasibility test, digital module practicality test and digital module effectiveness test. The conclusion of this study was that a digital module of material classification and its changes were developed based on multi-representation for class VII students whose feasibility, practicality and application could increase the classical completeness of the test, the average test scores obtained by students, and increase the multi-representation ability of students.

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INTRODUCTION

Natural Science is one of the important subjects in junior high school, because science related to everyday life is science. This natural science cannot be equated with social science because it is related to research to find the science. In the era of rapidly developing technology like now, it is very difficult to find learning models so that students are interested and can receive lessons well, because the lack of interest in reading books from students makes students today different from students in the past who were not familiar with technology. This phenomenon makes education in Indonesia a big challenge to solve this problem, especially teachers in providing interactive learning models for their students.

Teaching and learning activities in schools are inseparable from the learning model used by an educator for their students, success in teaching in class is closely related to the learning process during class, the more conducive and comfortable students are in class, the results and achievements of students will increase, because in the observations made by researchers, students feel bored if they are only given the task of reading and then memorizing subject concepts and feels foreign to them, especially in science subjects at the junior high school level. The learning model chosen must be in accordance with the preferences of students and follow the times so that students are also interested in learning and utilizing the technology provided in the current era of education. (Abdullah, 2015)

Learning conditions are more interesting if the material presented by the teacher is easy to understand, students need a learning media. The use of media in the learning process is an intermediary that carries messages or information with instructional purposes or contains teaching purposes. Learning media can increase students' learning motivation and can stimulate students to remember what they have learned in addition to providing new learning stimuli. Good media will also activate learners in providing feedback, feedback and also encourage students to do the right practices.(Achmad, 2020)

Students through teacher guidance can build a more meaningful understanding and understanding of chemical concepts. In addition, active learning can improve students' metacognitive skills by enriching the learning experience and transferring knowledge. One of the supports in this learning is learning with macroscopic, microscopic, and symbolic representations known as multi-representation-based learning. (Danxia et al, 2018)

Multi-representation-based learning is a form of representation that combines text, real images, and graphics, so that the learning process creates three levels of understanding. The three levels of understanding include (1) the macroscopic level, which is real and contains visible and real chemicals. (2) the microscopic level, real but invisible and consists of the particulate level used to describe the movement of electrons, molecules, particles or atoms. (3) the symbolic level, consisting of various types of image and algebraic representations. (Doleck, 2017) In general, chemistry learning occurs at two levels of understanding, namely macroscopic and symbolic, while the microscopic level is studied separately from the two thinking levels above. Students tend to memorize material with macroscopic and symbolic levels that are abstract (in the form of a description of words or pictures). In this case, it has a drawback, namely that students are not able to imagine how the process or structure of a substance that undergoes a reaction is. (Elliana et al, 2020)

METHODS

The research and development method is a research method used to produce certain products and test the effectiveness of these products. The research design used in this research is the research design of the ADDIE model development according to Dick and Carry. This includes 5 stages, namely the Analysis stage, Design (Design), Develop (Development), Implementation (Implementation), Evaluation (Evaluation). The analysis stage is useful for determining, defining, and analyzing the needs in the learning process as well as collecting various information related to the product being developed, after getting the problems from the analysis stage, then the design stage is carried out. This design stage aims to design a multi-representation-based digital module that can be used in science learning in junior high schools. The next stage is the develop stage. This development stage aims to produce a digital module that has been revised based on expert input and trials to students. There are two steps in this

stage, namely expert validation and small-scale trials, the results will be improved so that the digital module product can be declared valid. After a limited trial and the instrument has been revised, the next stage is the implementation stage. The purpose of this stage is to implement and disseminate multi-representation-based teaching materials. In this study, only limited implementation was carried out, namely by disseminating and promoting the final product of this digital module on a limited basis to science teachers in schools.

RESULTS AND DISCUSSION

This research is a kind of R&D that aims to produce a science teaching material for class VII SMP in the form of a multi-representation-based digital module. The respondents of this study were students of SMP Negeri 1 Kedungjati and SMP Negeri 2 Kedungjati with 100 students from each school. This research was conducted for two months with 6 meetings. This research was conducted through a research and development (R&D) approach with the ADDIE model consisting of analysis, design, develop, implementation, evaluation. The characteristic of this digital module is that the display is different from the usual module, because this digital module can display video, sound and animation directly and can be operated by students while working on it. This digital module also provides a virtual practicum that is integrated directly with the phet colorado application, so that it can provide a stimulus to students and improve students' multi-representation abilities. In addition, in the material and content aspects of this digital module, it presents questions and problems at microscopic, macroscopic, and symbolic levels so that the multi-representation ability of students has increased.

Before testing the use of digital modules by teachers and students, the product developed by the researcher was validated first by media experts, material experts. This validation is carried out to obtain data on the feasibility of the product being developed. Validation by expert lecturers aims to obtain information, criticism and suggestions so that the digital module developed by the researcher becomes a good and quality product. The validation carried out by the researcher includes the validation of the digital module validation of the effectiveness test questions and the validation of non-test instruments, namely the student response questionnaire, the teacher's response questionnaire and the practicality questionnaire of the developed digital module. The results of the validation by media experts are presented in Table 1, Table 2, and Table 3.

Table 1. Digital Module Validation by Media and Material Expert Lecturer Validator

No	Aspect	Total Score
1	Instruction	12
2	Content eligibility	65
3	Procedure	8
4	Question	11
	Total score	96
	Score percentage	83.5%
	Average score	4.17
	Category	Good

Table 2. Validation of Digital Modules by Validator of Teachers

No	Aspect	Total Score
1	Instruction	10
2	Content eligibility	65
3	Procedure	8
4	Question	11
	Total score	94
	Score percentage	81.7%
	Average score	4.08
	Category	Good

Tabel 3. Validation of Digital Modules by Teachers Validator Mapel IPA

No	Aspek yang dinilai	Skor Total
1	Instruction	10
2	Content eligibility	67
3	Procedure	8
4	Question	11
	Total score	96
	Score percentage	83.5%
	Average score	4,17
	Category	Good

Source: Primary Data

The ability of students at the microscopic level has a high category of R11 from the steps of the module and student worksheet results which indicate that they are quite able to solve problems but they are not able to analyze chemical reactions,

this can happen because junior high school students have not been given complete the topics as well as at the high school level. This submicroscopic ability is presented in a simulation video showing the occurrence of acid rain starting from the process of acid rain, compounds produced from acid rain and then continuing with the effects produced by acid rain and their relation to chemical reactions resulting from acid rain. The results of the students' work are very good, students are able to explain the questions presented and are able to explain them in the google classroom forum.

Carlgen (2013) say that the symbolic (or icon) level of representation is a representation for identifying identities substances involved in chemical reactions) using qualitative and quantitative symbolic language, such as chemical formulas, diagrams, drawings, equations, stoichiometry, and mathematical calculations. At this level of ability, students have a little difficulty memorizing chemical formulas which are considered foreign to junior high school students, but with sources of information from books and the internet, students are able to work on the questions and problems presented in the module and student worksheet. The ability of this symbolic level is found in problems regarding compounds of acids, bases, and salts, students are required to be able to distinguish compounds that include acids, bases and salts. With a simple explanation, for example, if a compound formula contains the element H then the compound is an acid, whereas if the compound formula contains the element OH then the compound is mass, but if neither is present, the compound is a salt. Citrasukmawati (2020) also suggest the explanation is supported by practical activities using litmus paper and universal indicators by proving the pH produced from the compounds being tested. In addition, in the digital module there is also a Colorado phet link regarding a universal pH virtual lab that can be directly accessed and supports students' understanding of compounds classified as acids, bases, and salts. So that from these activities students can improve the ability of multi-representation of students.

Students with low submicroscopic level multi-representation abilities, based on the results of the study, there are some students who have not been able to solve problems or problems in the module at the submicroscopic level, this can be seen from the results of the work on showing a video simulation of the occurrence of acid rain, this can occur due to a lack of understanding and paying attention to the video presented so that students not right in doing the problem well. In addition, in working on the evaluation questions, there were 23 students who were still wrong on question number 13, which is a question to measure the multi-representation ability of students at the submicroscopic level.

Students with high macroscopic level representation skills, the nature of the macroscopic representation is real and can be observed directly. Example: color, shape, temperature, and others. Students can make observations or lab activities in various sources of information and can be submitted in the form of reports, discussion activities, presentation activities, and so on. This ability is produced quite well which can be observed from the work of students' practicum activities through practical activities to distinguish between physical changes and chemical changes. From these practicum activities, students are able to analyze and conclude the practicum activities carried out and are able to distinguish the phenomena of physical changes and chemical changes from these activities so that they are able to improve students' macroscopic level representation abilities. Well-prepared tables and or figures must be of significant feature of this section, because they convey the major observations to readers. Any information provided in tables and figures should no longer be repeated in the text, but the text should focus on the importance of the principal findings of the study. In general, journal papers will contain three-seven figures and tables. Same data can not be presented in the form of tables and figures. The results of the study are discussed to address the problem formulated, objectives and research hypotheses. It is higly suggested that discussion be focused on the why, how , what else of the research findings can happen and to extend to which the research findings can be applied to other relevant problems. Explain your your research contributions to science.

Students with low macroscopic level multi-representation abilities, based on the results of the study, there were several students who had not been able to solve the problems or problems in the module at the macroscopic level. This ability is measured by simple practicum activities carried out by students,

an error in this is due to the limited supervision of researchers to students, so that there are difficulties for students in carrying out practicals so that there are errors in distinguishing chemical changes and physical changes. This research has previously prepared a video tutorial instrument for practicum activities so that it is hoped that students will be able to carry out practical activities independently, but there are already many students who already understand the video tutorial so that the results of research on students' multi-representation abilities at the macroscopic level have increased.

Students with low symbolic level multi-representation abilities, based on the results of the study, there were several students who had not been able to solve the problems or problems in the module at the symbolic level. This ability is measured by simple practical activities carried out by students which are carried out directly or virtual. There is an error in this case because there is still limited supervision by researchers to students, so there are difficulties for students in carrying out practicals so that there are errors in distinguishing chemical changes and physical changes. This research has previously prepared a video tutorial instrument for practicum activities so that it is hoped that students will be able to carry out practical activities independently, but there are already many students who already understand the video tutorial so that the results of research on students' multi-representation abilities at the macroscopic level have increased.

Data Results Multi-representation Capability of Digital Module Work, in studying chemistry, one cannot rule out the three representations, namely macroscopic, submicroscopic, and symbolic. Chemistry learning should emphasize understanding at the submicroscopic level because this is the essence of chemistry. Chemistry describes the structure, composition, properties, and changes of matter, as well as the energy involved in these changes. Most of the discussion of chemistry leads to macroscopic aspects, changes in matter, such as the properties of matter and energy. These three levels of representation must be possessed by students in studying chemistry. The three levels of representation must be mastered by students in order to understand chemistry in depth and thoroughly (Chittleborough, Treagust, & Mocerino, 2002; Treagust, Chittleborough, & Mamiala, 2003). The three levels of representation in question are macroscopic, submicroscopic and symbolic (Mansouri, 2007). Macroscopic representations can be interpreted as chemical representations obtained through observations of phenomena that can be seen (seen) and felt by the senses or can be an everyday experience for students. The nature of the macroscopic representation is real and can be observed directly. (Kalsum, 2019) Example: color, shape, temperature, and others. Students can make observations or lab activities in various sources of information and can be submitted in the form of reports, discussion activities, presentation activities, and so on. Microscopic representation is an abstract level of representation that provides an explanation at the particulate level. Sub microscopy is closely related to the theoretical model that underlies the explanation of the dynamics of the particle (atom, molecular, and ion) level. (Hafiszah, 2020) The mode of representation at this level can express from simple things such as using computer technology, using words, two-dimensional images, three-dimensional images both still and moving (animation) or simulations. The symbolic (or icon) level of representation is a representation for identifying identities substances involved in chemical reactions using qualitative and quantitative symbolic language, such as chemical formulas, diagrams, drawings, equations, stoichiometry, and mathematical calculations. (Farida, 2020) Chemistry lessons for some students are lessons that are considered difficult to understand, less interesting, and irrelevant. One of the causes is the lack of interest and motivation of students, students feel forced or just as an obligation. In addition, the characteristics of abstract chemistry concepts also make chemistry difficult to learn. Middle school chemistry material classification and changes have not yet arrived at chemical calculations, for mathematical representations have not been given in this study. (Herawati, 2018) The results of multi-representation of digital module work are presented in Figure 1.

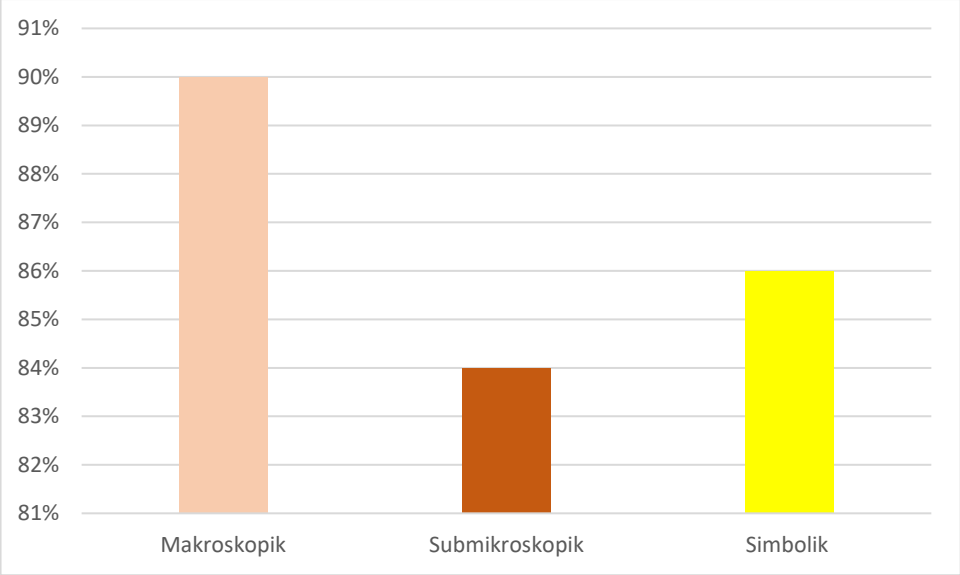

Figure 1. Data Results Students's multi-representation ability

The evaluation in this study used 20 multirepresentation-based questions that were distributed through google classroom and done by students, the questions were based on the level of chemical representation, namely macroscopic, submicroscopic, and symbolic. This question is used as an indicator of the effectiveness of the development of this digital module, if the classical mastery of students is more than 75%, the product of this digital module is said to be effective. The achievement of student scores on each question in the study at SMP Negeri 1 Kedungjati is presented in Figure 2.

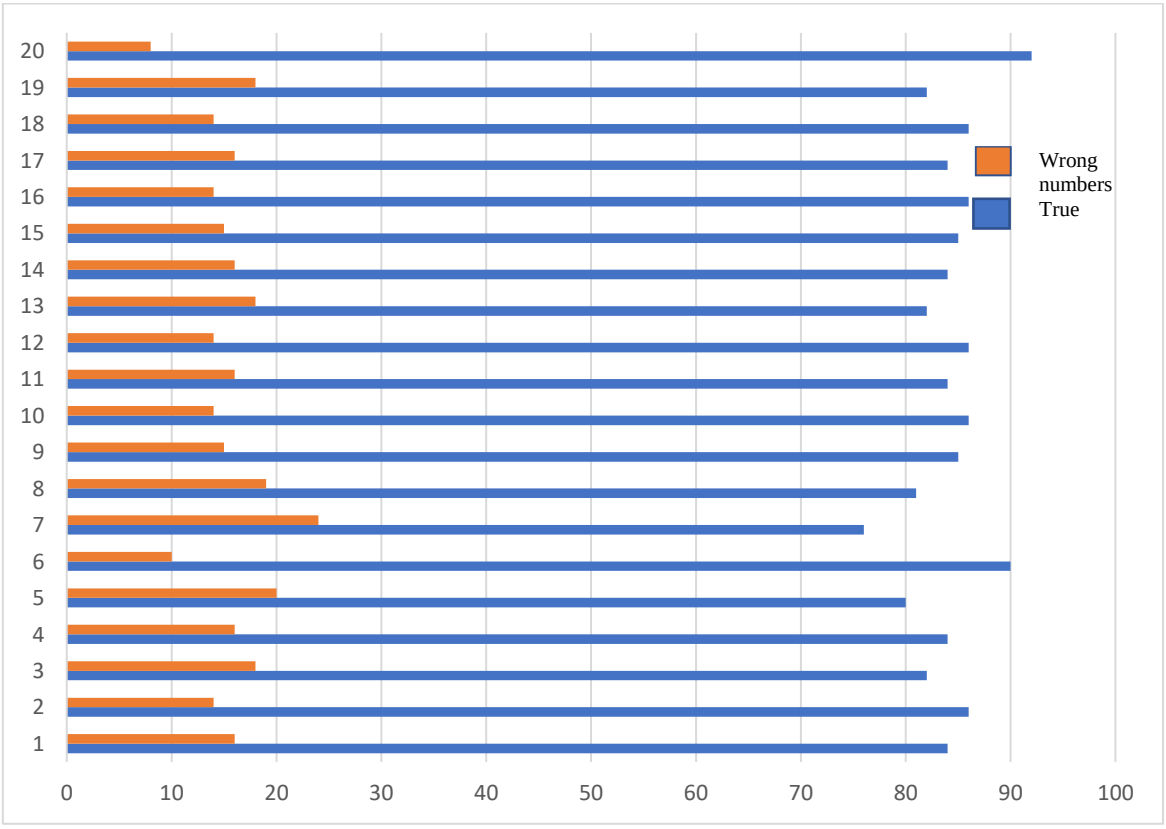

Figure 2. Achievement of SMP Negeri 1 Kedungjati student's scores on each question

Good results are also shown in the scores achieved by students at SMP Negeri 2 Kedungjati, the achievement of students' scores on each question is presented in Figure 3.

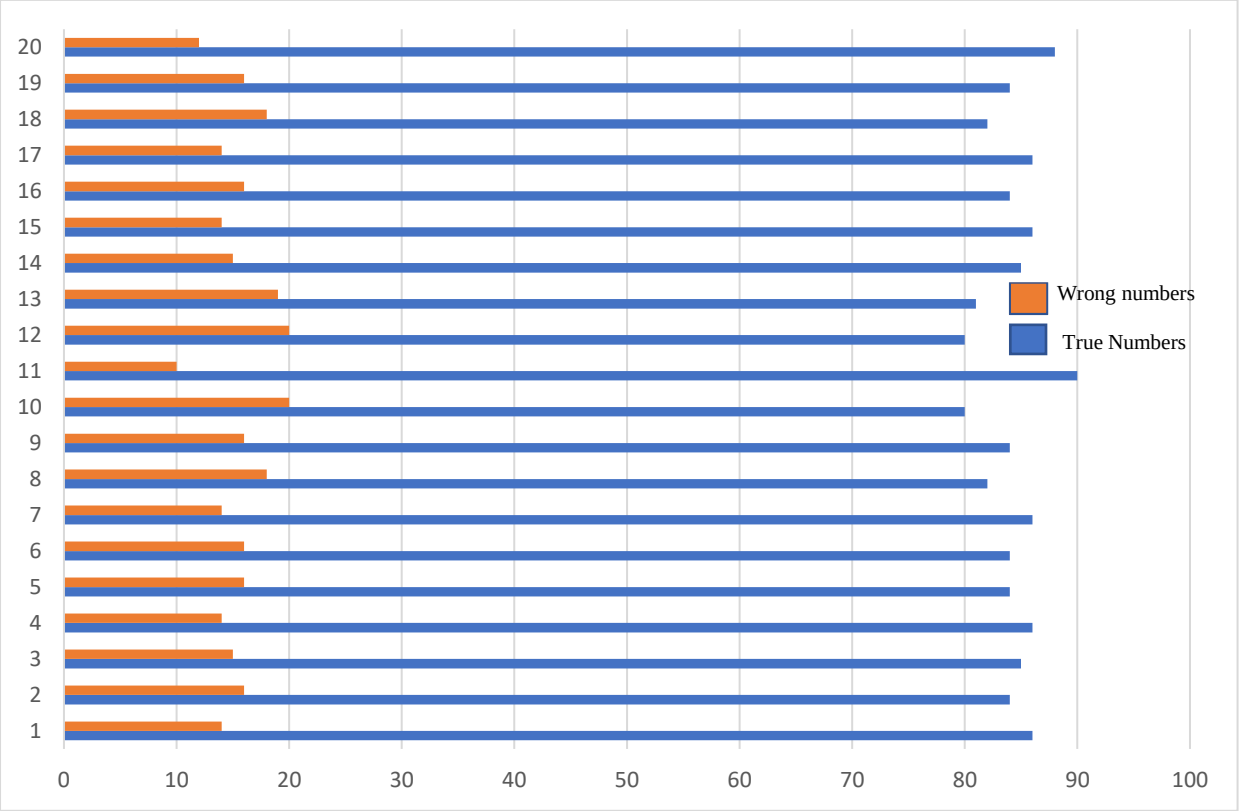

Figure 3. Achievement of SMP Negeri 2 Kedungjati student's scores on each question

Based on the results of student scores in the two schools, it can be concluded that the digital module developed affects the value of students, especially in increasing multi-representation abilities. This research is a research on the development of learning media products for the junior high school level which was carried out on March 15, 2022-20 April 2022, and took place at SMP Negeri 1 Kedungjati and SMP Negeri 2 Kedungjati. These two schools were chosen by the researchers because they are located in the same district and have the same background and average ability of students, therefore the researchers conducted initial observations to find a problem so that it could be used as an initial reference in conducting this research. Observations were carried out by conducting several analyzes, namely student analysis, learning media analysis, model analysis and learning methods, besides that the researchers also conducted interviews with science teachers in the two schools. The analysis helps researchers to find problems and find solutions in this study.

This research is a development research with the ADDIE development model (Analysis, Define, Develop, Implementation, Evaluation). This stage is the stage from the beginning of the research to the final stage of the research. The analysis stage is the first stage that must be carried out by researchers, in October 2021 researchers have conducted a preliminary analysis of research in two schools that were used as objects in this study. This initial analysis yielded several findings. On the first day, it was conducted at SMP Negeri 1 Kedungjati, researchers conducted initial observations by conducting interviews with teachers and students regarding learning activities in science subjects. The results of interviews with science subject teachers provide some information, one of which is about the ability of students to accept learning and students' motivation in learning science. In addition, the teacher also provides information about learning media, learning models during learning in the network and outside the network. The first focus explored by the researcher was how the ability of students in learning science was, from the results of

the interview, the teacher explained that in that school the ability of students in learning science was still not satisfactory, only 45% of the total sample of students were able to exceed the Minimal Competence Criteria.

The second focus of researchers is to explore how the models and methods are applied in learning activities at the school, the teacher explains that during learning activities in the classroom the teacher explains in front and notes important things to be noticed by students where it can be concluded that the teacher still dominates the activity. and has not implemented curriculum 13 well, which should allow students to actively discuss in order to create more abilities for students while the teacher only becomes a facilitator, it is different when distance learning is carried out by the teacher through the *Whatsapp* group for students to carry out tasks that must be done then the work is sent via photos, this is also not optimal because in online learning it is recommended to use interesting platforms and media so that they are able to attract and motivate students to learn, especially in science learning.

The third focus is the researcher observing how the learning media provided by students by teachers at school, the learning media provided by students are printed worksheets from publishers which are still incomplete in the materials and questions presented, so this media has not been able to support students' abilities and motivate students to study harder. The next focus is on the multi-representation ability of students and providing more information to teachers what is multi-representation ability and the importance of this ability for students to better understand chemistry at the junior high school level. learning media that is not based on multi-representation. The results obtained by the researcher can be used as an initial reference in this study and provide an idea to create a suitable learning media for students.

The second day, the initial observation of the study was carried out at SMP Negeri 2 Kedungjati. Activities at this school are not much different from those carried out in previous schools, namely what focuses are explored to support research activities. Based on observations made at this school the results are not much different, interviews conducted with teachers who teach science subjects said that the results of students' test scores were not satisfactory, only 42% of the average scores had met the Standard of minimum completeness. From the initial results of this study, it can be concluded that the school background studied is the same as the average ability of students who are almost the same. The models and methods of learning science in this school are also not much different from previous schools, because students have not been maximally active, students should discuss more individually or in groups, teachers only supervise discussion activities if there is an unsolved question. The learning media used in this school uses students worksheet made by the teacher in the form of sheets that have not much information and pictures that should be presented in an students worksheet, the researcher also asked the teacher, how do teachers provide learning during PJJ during the pandemic covid-19. The teacher explains that the teacher makes a class in google classroom then the teacher gives assignments through the platform, and is monitored through the whatsapp group, the teacher has not used e-students worksheet or digital modules in their learning activities. From the results of observations in the two schools, it can be concluded that schools really need learning media that can be used as materials, especially in distance learning, besides that because researchers focus on the ability of multi-representation of students, therefore researchers also explore information about this by asking the teacher subjects, and the result is that the multi-representation ability of students is still lacking because the media provided to students is not multi-representation-based.

The next research stage is defined, at this stage the researcher analyses the results of the initial observations where researchers can develop ideas to be used as a solution to the problems obtained. Researchers associate with a distance learning condition with learning media for students, so that researchers get ideas by making teaching materials that can be accessed easily during distance learning. The next activity, the researcher analysed several alternative media that were suitable for junior high school students and were easily accessible, the researcher decided to make a digital module that was associated with the discovery of another problem, namely the multi-representation ability of students so that researchers got the idea to create a multi-representation-based digital module. In addition, the researcher also started to analyze how to run this research and determine what platform is

suitable to be used as material for making digital modules, after that the researchers determined the live worksheet to be used as a digital module platform and combined with the WhatsApp group and google classroom.

Multi-representation of students as measured by multi-representation-based evaluation questions which are carried out at the end of the meeting in the study. These questions use multi-representational level indicators in chemistry, namely macroscopic, sub microscopic, and symbolic which are then presented on questions for students to work on. The results of this value are then analysed whether the multi-representation ability has increased compared to the results of the pre-test conducted by the researcher at the initial observation stage of the study. The results of the scores are also analysed how the ability of each level of representation, based on the results of the research at the sub microscopic level, is still relatively low, as evidenced by the students' errors in answering question number 12.

The overall research results show that students at SMP Negeri 1 Kedungjati and SMP Negeri 2 Kedungjati have been able to work on digital modules well. The feasibility of digital modules seen from student responses, teacher responses, and the practicality of digital modules shows good results, so that the digital modules developed by researchers have been tested and are feasible to be implemented to students which will be used as science teaching materials that can improve their abilities. multi-representation of students and students' learning motivation will also increase. The results of the comparison of data obtained by researchers at SMP Negeri 1 Kedungjati and SMP Negeri 2 Kedungjati are presented in Figure 4.

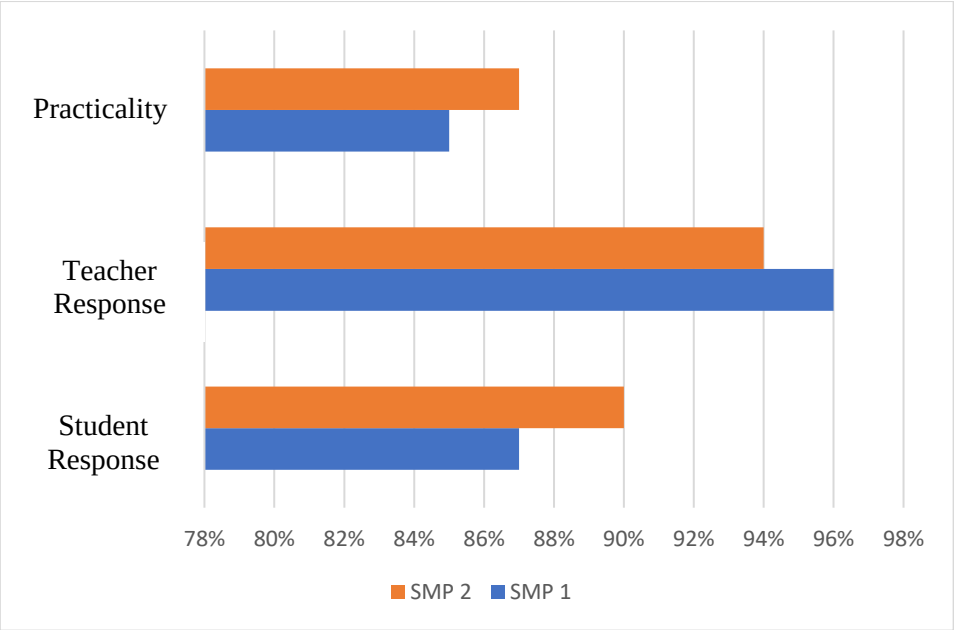

Figure 4. Comparison of the Feasibility Percentage Results for Digital Modules

The profile of students' multi-representation abilities resulting from this study has increased. To obtain data that supports this profile, the researchers analyzed the results of working on digital modules, filling out questionnaires, and working on multi-representation-based questions. Based on the results of the research, the profile of students' multi-representation abilities has increased.

The effectiveness of the digital module developed by the researcher is shown from the feasibility of the digital module, the practicality of the digital module, classical completeness of more than 75%, and an increase in the profile of students' multi-representation abilities. Based on the research results, this multi-representation-based digital module is effectively used as teaching material in junior high schools, especially in class VII. The results in the two schools that were used as research subjects showed the same thing, although there were still many shortcomings from this research activity, for example, the obstacles to learning carried out remotely which required several conditions where some students had not been able to undertake to take distance learning, but if there are these problems,

researchers have backup students to replace students who have obstacles in working on digital modules.

The last stage in this research is the evaluation stage, the purpose of this activity is to collect data and compare it with the standard goals to be achieved, so that researchers can use it as a basis for decision making. This evaluation stage collects research data from the analysis stage to the implementation stage, whether there is something lacking and needs to be improved, and the stage where the determination stage is to disseminate digital module products or still needs to be improved after large-scale trials are carried out. In addition, this evaluation stage also has a function, namely to find out how well a person's level of mastery of the competencies has been determined and to find out what difficulties a person experiences in their activities so that a diagnosis can be made and the possibility of providing remedial teaching.

CONCLUSION

1.1 The distinctive feature of this module is that it is in digital form, which is done with an internet network so that it can be done anywhere flexibly, this digital module contains videos that can improve the understanding of material classification and its changes to students, besides that this digital module is also equipped with A simple virtual lab that can be directly accessed by students. This module also presents questions and problems that can improve students' multi-representation abilities

1.2 The feasibility of this digital module can be seen from the results of the distribution of student response questionnaires, teacher response questionnaires, and practicality questionnaires for digital modules. Based on the results of the study, the three questionnaires showed good and very good after being analyzed, therefore the developed digital module has been tested for feasibility.

1.3 The profile of students' multi-representation abilities can be shown from the results of working on digital modules and test results based on students' multi-representation. Based on the results of research in two schools, the profile of the multi-representation ability of students has increased as evidenced by the results of classical mastery of students in working on digital modules and tests of more than 75%, so that with the development of this digital module product, the multi-representation ability of SMP Class VII students increases.

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