Validity of science teaching aids based on project based learning

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Abstract. Integrated science learning is a complex learning activity, which focusses on the understanding of the concept of science in the fields of physics, biology, and chemistry as unity. Improving the quality of integrated science learning is very important to achieve the expected learning goals in the curriculum. This quality improvement needs to be done especially by preparing prospective teachers in having cognitive abilities and skills in teaching. One effort done is developing science teaching aids base on project based learning. This development was carried out as a unity of understanding concepts and experiments, so the students as prospective teachers have better competence. Development carried out based on project based learning, so the students are expected to have high ability and creativity because they are actively involved starting from the planning to evaluation stages. The stage in designing these science teaching aids was carried out by using Plomp development model in prototyping phase, especially at the stage of expert review. Data analysis was performed by using percentage techniques. The design result shows that science teaching aids are valid. Thus, these teaching aids can be used in learning to analyze the practicality and effectiveness.

1. Introduction
Science learning is a learning activity that integrates understanding of the concepts of physics, biology, and chemistry as a whole. That is, learning is not only focused on discussing the study of a concept in a particular scientific field, but must also be able to see its relevance from other scientific perspectives in the field of science. For example, when discussing physical concepts, the biological and chemical concepts of the material are also discussed and their relevance is shown. This is done because every process or phenomenon in life generally shows cohesiveness between one field of science with another. Therefore, in the curriculum used by schools, these subjects are known as Integrated Science.

The learning of science is not only carried out in junior high schools, but also in university through science for junior high schools courses. This course is a compulsory subject formulated by the Department of Physics, Universitas Negeri Padang since 2016 until 2019 as an alternative for preparing Physics students to have competence to teach Integrated Science. Science for Junior High Schools (IPA) lectures are not only in the form of discussion on science materials for junior high schools, but it also analyze the science concepts in an integrated manner. In addition, this course also provides skills for students as prospective science teachers to teach materials science to students with a more attractive and easy to understand. Thus, the implementation of this course is emphasized in the process of delivering the concept of science through the activities of teaching in front of the class using the methods, media
The learning that is carried out also needs to be directed in the context of facing the era of the industrial revolution 4.0, where education aims to produce creative, innovative and competitive human resources. Education 4.0 is the answer to the challenges of the industrial revolution 4.0 where humans and technology must be able to create creative and innovative new opportunities. According to Fisk (2017), there are 9 trends in the world of learning, namely diversity of time and place in learning (diverse time and place), individual learning (personalized learning), freedom to choose how to learn (free choice), project based learning (Project based), field experience, data interpretation, diverse assessment (exams will change completely), the involvement of students (student ownership), and mentoring [2].

The diversity of time and place in learning as stated by Fisk (2017) means that students have the opportunity to learn anytime and anywhere. This learning can be done through distance learning and independently. Furthermore, the trend in education 4.0 according to Fisk is individual learning, where students learn according to their abilities. This means, students with higher competencies will be challenged with more difficult tasks and students who have difficulty in learning will be given the opportunity to practice more until they reach the competencies they should. Through this individual learning, students will get positive experiences and will increase their confidence in their competencies.

Furthermore, students have the freedom to determine how they learn to achieve the objectives of the subjects being taught. They can learn by using different tools, programs and techniques. In this era, students have to adapt to project-based learning. In project-based learning they are trained to have skills in organizing, collaborating, and managing time. In learning students are also provided with direct experience through exercises. In the curriculum, direct experience is given to students through internships, mentored projects and collaborative projects. Students’ abilities in the learning process also need to be measured through various assessment techniques where their knowledge can be assessed during the learning process and its application is tested while working on the project.

Furthermore, the ability to interpret data also becomes an important part of the learning process. This becomes an important part of the curriculum because students are required to have the ability to apply theoretical knowledge in the form of numbers and make conclusions based on logic and data trends.

Overall, the involvement of students in determining learning material also becomes important in order to assist in the design of current and useful curriculum. In addition, assistance or guidance to students is also very important to build student learning independence. This is the basis for student success.

There are several analyzes conducted in the initial study of science for junior high schools lectures to determine the needs of these courses. The analysis consists of analysis of learning material, task analysis, analysis of the lecture process, and analysis of student characteristics. Based on the results of the analysis conducted by Sari (2018) [3], it was concluded that the availability of teaching materials is quite diverse and the tasks given are quite helpful for students in understanding the material. However, the availability of media or teaching aids in science learning is still lacking. In addition, students have not practiced in implementing project-based learning as one of the educational references of 4.0 as stated by Fisk. This causes students to have limitations in their creativity, especially as prospective teachers. To overcome the lack of availability of teaching aids and student creativity, it is necessary to develop the science teaching aids for junior high schools. This development aims to increase the creativity of students in designing learning media in order to prepare them to become innovative teacher candidates. Thus, learning science in schools can be carried out optimally despite the limitations of tools or media.

In accordance with Permenpan No. 16 of 2009 concerning functional positions of teachers and credit numbers, in Chapter V article 11, one of the professional development of teachers is done through the
activities of making innovative works. This activity can be in the form of finding appropriate technology, finding or creating art, creating or modifying learning tools, and participating in developing standards, guidelines, questions, and the like. One manifestation of appropriate technology is to make or modify props. Teaching aids are means of communication and interaction between the teacher and students in the learning process that can stimulate the thoughts, feelings, concerns, interests and attention of students so that the learning process can take place optimally \cite{4, 5}.

This development is also in accordance with Anderson's revised Bloom taxonomy, where the highest level is at the level of creating. So, at this level, students are able to hypothesize, design, and produce products as a form of application of the concepts they learn. This development process is carried out by orienting to Project Based Learning.

Project-based learning is one of the model suggested in the curriculum in 2013 and is suitable for supporting the development task the project is in line with trends of education 4.0 which is proposed by Fisk \cite{9}. From the teacher's perspective, shifting to Project based learning requires accomplishing several steps, including learning to design projects that simultaneously deepen students' understanding of key course concepts, taking responsibility for curriculum design, deciding how to convey or covering less information in a course, learning to identify deficiencies in necessary prior skills and knowledge and differentiate learning according to need, developing strategies for teaching or improving students' competence, learning to manage a student – directed learning, finding and creating methods and means for evaluating students' products and performances \cite{6}.

The steps of Project Based Learning expressed by The George Lucas Educational Foundation (2005) in Trianto (2014) \cite{17} consists of six stages. These steps include Start With the Essential Question, Design a Plan for the Project, Create a Schedule, Monitor the Students and Progress of the Project, Assess the Outcome, and Evaluate the Experience.

From the steps Project Based Learning we can observe that the evaluation technique used vary namely through the assessment of the concept and its application in the project. In addition, students are also more directed towards learning independently. This is in line with the pattern of education 4.0 in the era of the Industrial revolution 4.0.

Based on the results of the analysis in the preliminary research that has been carried out and a study of educational trends 4.0, the authors develop science teaching aids based on project based learning in order to increase the creativity of students as prospective teachers. The teaching aids is developed by validating and revising so that a valid teaching aids is obtained.

2. Research Methods

This research was a part of research and development (R & D). Research and development aims to develop and produce a product in the form of materials, media, tools or strategies of learning that is used to test a theory \cite{8}. Model of development used is a model of development which is presented by Plomp (2010), which consists of preliminary research, prototyping phase, and assessment phase \cite{9}.

This research is a continuation of preliminary research that has been carried out previously. In preliminary research, the analysis of curriculum and need analysis has been done to develop teaching aids. These analysis include teaching materials analysis, task analysis, analysis of the implementation of the lectures, and analysis of student characteristics. The results of the analysis serve as a reference in developing the SMP / MTs IPA teaching aids.

The stage described in this paper is the prototyping phase. Arsyad (2013) \cite{10} states that in choosing media must pay attention to the media selection criteria, namely 1) in accordance with the objectives to be achieved, meaning that the media are chosen according to the goals set; 2) appropriate to support the content of the lessons that are facts, concepts, principles and generalizations, 3) practical, 4) flexible and enduring, grouping objectives, 5) technical quality. In this case, the science teaching aid was developed by following these criteria. The design is made in accordance with the specified indicators and based on a format that is needed by researchers.
In this phase a formative evaluation is carried out including self evaluation, expert reviews, one-to-one, and small groups, and field tests. The design procedure for formative evaluation is shown in Figure 1.

![Figure 1. The Design Procedure of Formative Evaluation (Tessmer : 1998)](image)

At the stage of self evaluation, the teaching aids was designed. Designing is done based on the results of the initial analysis or the identification of problems, the needs analysis and analysis of the concept or the content of the material, and the assessment of the literature that is required in learning. Next on stage expert review, conducted assessment and evaluation by experts of the tool aids which have been designed. The experts assess the content validity, construct validity, and the language of the guidelines for the use of teaching aids that is developed. The suggestions of the experts are used as a reference to revise the products which are developed. Suggestions from the expert are used to improve and revise products that are developed to produce the valid products.

Furthermore, at the stage of one-to-one, the products were given to students and lecturer who became tester. The result of the test is used to revise the design that has been developed. The revised result of from experts view and difficulties which are found in the first try are used as a basis for revising the product. Then, the result is tested on a small group. The results of implementation on small group is further used for revision before conducted a trial on the stage of field test. After product revisions were made based on student suggestions and comments on the small group, the results of the analysis of the teaching aids were obtained. The results of the small group revision were tested on research subjects. This trial is a field test. The teaching aids that have been tested in the field test are teaching aids that have met the quality criteria that include validity, practicality, and effectiveness.

In this article the data discussed focus on the validation results obtained at the expert review stage. The instrument used for the collection of data is a validation sheet with three aspects of assessment, namely the content validity, construct validity, and the components of language. The validation sheet is given to the expert along with the product to be validated. It is intended to obtain feedback or ratings of the products mentioned.

Data analysis uses a Likert scale with data calculation as follows:

$$V = \frac{X}{Y} \times 100\%$$

(1)

$V$ = validity value  
$X$ = score obtained  
$Y$ = the maximum score  
(modified from Riduwan, 2007:23)

The category of validity science teaching aids based on project based learning obtained can be seen in Table 1.
### Table 1. Categories of Validity

| Interval | Category       |
|----------|----------------|
| 0 – 20   | Invalid        |
| 21 – 40  | Less valid     |
| 41 – 60  | Quite valid    |
| 61 – 80  | Valid          |
| 81 – 100 | Very valid     |

(modified from Riduwan, 2007:23)

### 3. Result and Discussion

In this study the formulation or design of the science teaching aids was carried out. Designing tool aids include several stages in accordance with the stages of the project based learning, namely: determine the essential questions to give the assignment to the students in doing the activity, plan rules to make the project, create a schedule of activities in the completion of the project, monitoring the progress of the project, assessment results, and evaluation of learning experiences related to the implementation of activities and the results of projects that have been implemented. In practice, students are asked to determine the teaching aids that can be developed for each learning material in accordance with that stated in the syllabus are used.

Based on the results of the analysis in the preliminary research, the design of science teaching aids was carried out for ten topics as shown in Table 2.

### Table 2. Teaching topics

| Number | Teaching Aids          | Topics                                           |
|--------|------------------------|-------------------------------------------------|
| 1      | The human reproductive system | Reproduction System In Humans                   |
| 2      | The life cycle of ferns | Reproduction in plants and animals               |
| 3      | Taslingan (Eco-friendly Bags) | Population and Environment                     |
| 4      | The atomic structure   | Composite Particles of Inanimate And Living Things |
| 5      | The simple electroscope | Electrical And Technology Electricity In Life    |
| 6      | The series and parallel circuits | Magnetism and Technology Magnet In Life        |
| 7      | The simple electric motor | Inheritance nature of the creatures living     |
| 8      | The structure of DNA    | Environmentally Friendly Technology             |
| 9      | The simple water purification equipment | Land and the Survival of Life in Nature |
| 10     | The soil fertility testers |                                              |

The ten teaching aids are formulated through an analysis of the applicable curriculum. Furthermore, in making these teaching aids follow the steps of project based learning.

Teaching aids that have been designed then are validated by experts to determine whether these they are feasible or not to be tested in learning. Validation is carried out by two validators who are experts in the field of Natural Sciences. Based on the results of the first validation test, obtained a description of that teaching aids are designed already interesting, varied, and can support the process of learning. In addition, most of the teaching aids are quite innovative because they are not available in the laboratory. However, some teaching aids need to be refined in order to be more attractive and attractive. The final validation results of the science teaching aids after the revision can be observed in Figure 2.
Figure 2 shows that the teaching aids which are designed has been in the category of valid and very valid. The average validation result of the two validators is 84.085% with a very valid category. The results of this validation relate to the didactic, construct, and technical aspects of the product. In the aspect of didactic, validator assess the role of teaching aids which were developed in helping students to understand the concept, improvement of the quality of the process of learning, stimulation of the motivations and interests of students, guiding students in the process of learning, as well as improve the effectiveness of learning of students. Furthermore, in the aspect of construction there are some aspects that rated namely the suitability of the products that are developed with materials and basic competences were studied. The last aspect observed is the technical aspect. This aspect includes the display apparatus teaching aids, combinations of colors used, the design of which is simple and clear, as well as the ability of the teaching aids provide a stimulus for user. Based on the results of the validation obtained it can be concluded that the teaching aids that have been developed are valid for use and are in accordance with the objectives of development and material both in terms of design, content, and technicality.

4. Conclusion
Based on the results of the analysis carried out, there are ten science teaching aids developed that consist of the human reproductive system, the life cycle of ferns, eco-friendly bags, the atomic structure, the simple electroscope, the series and parallel circuits, the simple electric motor, the structure of DNA, the simple water purification equipment, and the soil fertility testers. The results of the validation of this teaching aid show that this teaching aid is in the valid category. Thus, this teaching aids can be used for trials in order to find out the practicality and effectiveness.

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