Validation of mathematical teaching material’s developed by project-based learning integrated STEM

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Abstract. The development of mathematics’ teaching material using project-based learning integrated with science, engineering, and technology (STEM) is a new thing to do. In its development, teaching materials through two series, namely the preparation and development then validation of teaching materials that have been developed. This research was conducted to determine the validity value of mathematics teaching materials based on project integrated with STEM. The data of this study were obtained from the assessment of mathematicians who acted as material experts and media experts to determine the face validation, content validation, and construct validation. The validation by 36 junior high school students was conducted to find out the value of content validity in each part of evaluation to ensure the learning objectives could be achieved. The results of the experts judgement and 36 junior high school students can be concluded that the teaching materials being developed have a high value of face validation, content and constructs. Based on these results, mathematics teaching materials that are developed feasible and valid for use in a broad scope of research or furthermore are worthy of being used in the learning process of teaching mathematics on appropriate topics.

1. Introduction
Trends in the world of education are very dynamic, this adjusts to educational needs that not only provide students with knowledge but also prepare their students to have the skills that will used after graduating from formal school. Many world trends affect the Indonesian education system. One of them that is being talked about in the education world in the 21st century learning trend. This 21st century learning requires the implementers to produce graduates who have 21st century competencies in this 21st century life. Even explicitly described in the 2013 curriculum, there is a 21st century learning shift paradigm that really must be mastered by the implementer to prepare the students who can compete in 21 century life.

One of the 21st century learning paradigm shifts is that learning is directed to encourage students to find out from various sources, not to be told. The role of the teacher is no longer a learning center. Learning is directed so that students actively seek learning experiences from offerings prepared by the teacher. The presentation prepared by the teacher is no longer conveyed only in verbal form, so that students only listen and become passive during learning. Learning experience by listening according to Dale [1] only gives 20% of the knowledge that should be obtained. So to increase students’ knowledge, the learning design provided must change the role of students in learning. Passive student roles must be directed to be active through a series of learning designs prepared by the teacher.
According to the George Lucas Educational Foundation [2] project-based learning (PjBL) is a dynamic learning approach where students actively explore problems in the real world, provide challenges, and gain deeper knowledge. The main characteristic of project-based learning is directing students and engaging students to find concepts from a scientific discipline through a constructive investigation [3]. These characteristics are very consistent with the 21st century learning paradigm. Currently research in PjBL shows that projects can increase student interest in science, technology, engineering, and mathematics (STEM) because STEM involves students in authentic problem solving, collaboration between students, and build the ability to create real solutions [4]. STEM is also one of the important issues in this 21st century life. Inadequate education in mathematics and science has led to a shortage of quality labor resulting in disparities in the global industry [5]. STEM emerged as a theme of the education reform movement to grow workers who are experts in the fields of STEM.

PjBL is included in one of the models suggested by the 2013 curriculum to be used during the learning process. But not all subject subjects can easily use project-based design in their learning. This learning is more commonly used in science subjects than in mathematics subjects. It is a challenge to use this project-based learning in teaching topics contained in mathematics. Not only PjBL, the integration of STEM in learning in Indonesian schools has not been carried out intensively. Most have just arrived at the research stage and have not been widely disseminated about STEM learning. In fact, the integration of STEM in education is something that needs to be done immediately given the high need for natural resources (HR) that master STEM in the 21st century. Based on the new needs and challenges of a process-based learning that is integrated with STEM, the teaching materials must also be developed according to these needs.

Teaching materials are all forms of material used to assist teachers in carrying out teaching and learning activities in class [6]. The use of this teaching material is intended so that students can play an active role in collecting information in accordance with the content contained in teaching materials. Teaching materials commonly used are using textbooks. However, in this case the teaching materials are mathematics teaching materials using the PjBL model and integrated STEM. This teaching material is relatively new, especially in mathematics and the possibility to be found in ordinary textbooks is very rare. So that a study is needed on the development of teaching materials that are compatible with project-based learning and can accommodate STEM learning. Then after the new teaching material is compiled, the important thing is to do the validation. Validation is done in order to produce valid teaching materials.

2. Methods
The Teaching materials are developed following the development stage in the Research and Development research model. According to Borg & Gall [7] research and development procedures basically consist of two main objectives, namely developing products and testing the effectiveness of products. Borg & Gall [7] proposed 10 general steps that must be taken in the R & D approach, but in this research it was only done until the fourth step, namely the steps of preliminary field testing. In the preliminary field testing step, validation of teaching materials and small scope testing is carried out. Validation of teaching materials is a process to determine the value of the validity of the teaching material. The validity of instructional materials is seen from three aspects, namely face validity, construct validity and content validity by material test experts, media experts and small scope trials on 36 students of Bandung City junior high school grade IX-A to find out the validity of teaching material evaluation items.

The data collected during the study was an assessment sheet for teaching materials including assessment of content validity, face validity, and construct validity, as well as conclusions about learning material. Data processing regarding content validity, face validity and construct validity is done by Q-Cohran Test using IBM SPSS Statistics 21 software. In addition, determining the validity of the items in the evaluation section of teaching materials uses AnatesV4 software.
3. Result and Discussion

3.1. Development of teaching materials

The steps taken adapted the three steps of development according to Borg & Gall [7], namely as follows. First, research steps and information gathering, at this stage research activities is doing by literature research about teaching materials that must be developed, collect the information related to STEM through observation, and prototypes of STEM teaching materials are carried out, then case studies to find out characteristic of the student on which teaching materials will be implemented. Figure 1 and Figure 2 show the prototype of the STEM teaching material.

Second, planning steps, at this stage the activity of formulating the objectives to be achieved at each meeting is carried out and the initial design development of teaching materials is designed. Third steps to develop preliminary form of product, at this stage the activity is to compile an activity concept map, integrate STEM fields in each activity, until the drafting of new teaching materials is completed. Figure 3 and Figure 4 show the results of the development of integrated PjBL-STEM teaching materials.

Figure 1. Prototype cover of STEM teaching materials.

Figure 2. Prototype task of STEM teaching materials.
Figure 3. Task 1st PjBL-STEM teaching materials. Figure 4. Task 4th PjBL-STEM teaching materials.

Preliminary field testing, the last step in this study, at this stage validation by experts and testing in a small scope is done.

3.2. Validation of teaching materials

3.2.1. Face validity. The face validity of a teaching material is related to the linguistic structure of the every activity from teaching material that has been compiled. Table 1 shows the data from consideration of the face validity PjBL-STEM teaching materials from ninth activity on by two experts, namely the expert of material test and media.

| Activity | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|----------|---|---|---|---|---|---|---|---|---|
| Expert of material Test | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| Expert of media | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Linguistic revision | R | R | R |

Information: 0: invalid; 1: valid; R: revised

Then the results of consideration of face validity by two validators were analyzed using Q-Cochran statistics. The hypothesis of test is formulated as follows.

H₀ : All experts / validators provide uniform answers
H₁ : Not all experts / validators provide uniform answers

Table 2. The result of Q-Cochran test.

| N  | Cochran’s Q | df | Asymp.Sig. |
|----|-------------|----|------------|
| 9  | 1.000       | 1  | .317       |
Table 2 shows the data from the Q-Cochran data test. The results of the face validity PjBL-STEM teaching materials by two experts, namely the expert of material test and media using SPSS 21. The Q-Cochran values (x) is 1.00 less than the value $\chi^2=3.84$ ($1.00 < 3.84$) in the chi square table with $\alpha = 0.05$ and $df = 1$, then $H_0$ is accepted. In other words, all experts provide uniform answers. Based on face validity, the PjBL-STEM teaching materials that have been developed are valid.

3.2.2. Face validity. The content validity of a teaching material is related to the linearity of the material in each activity with indicators of competency from the teaching materials that has been compiled. Table 3 shows the results of the data considering the validity of the contents PjBL-STEM teaching materials by two experts, namely the experts of material test and media.

| Activity                  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---------------------------|---|---|---|---|---|---|---|---|---|
| Expert of material Test   | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| Expert of media           | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Linguistic revision       | R | R |   |   |   |   |   |   |   |

Information: 0: invalid; 1: valid; R: revised

Then the results of consideration of contents validity by two validators were analyzed using Q-Cochran statistics. The hypothesis of test is formulated as follows.

$H_0$: All experts / validators provide uniform answers

$H_1$: Not all experts / validators provide uniform answers

Table 4. The result of Q-Cochran test.

| N  | Cochran’s Q | df | Asymp.Sig. |
|----|-------------|----|------------|
| 9  | 1.000       | 1  | .317       |

Table 4 shows the data from the Q-Cochran data test. The results of the content validity PjBL-STEM teaching materials by two experts, namely the expert of material test and media using SPSS 21. The Q-Cochran values (x) is 1.00 less than the value $\chi^2=3.84$ ($1.00 < 3.84$) in the chi square table with $\alpha = 0.05$ and $df = 1$, then $H_0$ is accepted. In other words, all experts provide uniform answers. Based on content validity, the PjBL-STEM teaching materials that have been developed are valid.

3.2.3. Construct validity. The construct validity related to the validity of the items that build the test can measure every aspect of thinking. Construction validity relates to the evaluation of motivation and interest in PjBL-STEM teaching materials. From the data of the assessment students' responses to learning that uses PjBL-STEM teaching materials, the percentage for motivation is 0.92 and the percentage for interest is 0.61. Interpretation for motivation is included in the category of very good validity and for interest included in the category of good validity [8].

3.2.4. Validity of each evaluation items. The last validity test is the validity of each evaluation item at the first meeting (P-1) and evaluation items at the second meeting (P-2). The data used is data obtained during the implementation of a small scope test on 36 students in a middle school of Bandung city. Table 5 shows the results of the recapitulation of the correlation coefficient value of each evaluation item at the first meeting (P-1).
Table 5. Recapitulation of correlation coefficient values for each item of evaluation P-1.

| Question number | Correlation | Sign.Correlation |
|-----------------|-------------|------------------|
| 1               | 0.727       | Very significant |
| 2               | 0.727       | Very significant |
| 3               | 0.727       | Very significant |
| 4               | 0.757       | Very significant |
| 5               | 0.806       | Very significant |

Table 5 shows the value of the correlation coefficient for each item of evaluation P-1. The results of correlation coefficient analysis produce a high validity category for each item. This is based on the correlation coefficient value of each item in the range 0.727 to 0.806 which belongs to the high validity category. The results of the second meeting are in table 6. Table 6 shows the results of the recapitulation of the correlation coefficient for each evaluation item at the second meeting (P-2).

Table 6. Recapitulation of the value of the correlation coefficient for each item of evaluation P-2.

| Question number | Correlation | Sign.Correlation |
|-----------------|-------------|------------------|
| 1               | 0.223       | -                |
| 2               | 0.622       | significant      |
| 3               | 0.732       | Very significant |
| 4               | 0.891       | Very significant |

Table 6 shows the value of the correlation coefficient for each P-2 evaluation item. The results of the correlation coefficient analysis show the differences in each item problem. Analysis of problem 1 is included in the low category. This can happen because all students managed to answer problem No. 1 correctly but there are differences in the final results for all students. Then problem No. 1 must be revised. The problem number 2 belongs to the category of moderate and number 3 and 4 included in the problem that has a high category.

4. Conclusion

Development of PjBL-STEM teaching materials adapts the first four steps in research and development (R & D) models Borg & Gall. The main focus in this study is in the fourth step, namely preliminary field testing. The instructional material of the integrated STEM PjBL which has finished passing the development step, was examined by the expert of material test and media to validate the teaching material. Validation results were also obtained from the results of small scope trials on 36 subjects who tried to use the teaching material in their learning. The results of the validation were obtained that the validity of the face and the validity of the contents of the teaching material was valid and feasible. Then the results of construct validity include very good to good validity. The last one, the validity of each item in the evaluation section shows the value of the dominant high validity. It can be concluded, from this study the teaching materials that are being developed are valid and feasible in a wide scope of research or furthermore suitable for use in the learning process in schools.

5. References

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Acknowledgments
The author would like to thank the Ministry of Technology Research and Higher Education for providing financial assistance to conduct this research.