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To cite this article: R Ambarwati *et al* 2020 *J. Phys.: Conf. Ser.* **1563** 012036

Developing mathematical reasoning problems type two-tier multiple choice for junior high school students based on ethnomathematics of jember fashion carnaval

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Abstract. Reasoning is the foundation of learning mathematics. If students' mathematical reasoning abilities are not well-constructed, students who learn mathematics will consider these abilities only as material based on a series of procedures and imitate examples without knowing their meanings. The purpose of this research is to produce an effective product used in the classroom learning process, in this case, Web-Based Two-Tier Multiple-Choice questions. The TTMC questions to be used are specified to the mathematical problems of two-variable linear equations with complex mathematical situations for concluding. At the first tier of the TTMC, students are asked to choose answers to questions related to the context being discussed, in this case, the SPLDV concept, while at the second tier, students choose the reasons from the answers they have chosen at the first-tier questions. At the first tier, students are expected to use their understanding in solving various problems, while the second tier is more appropriate to be used as a benchmark for the extent of student reasoning in solving problems at the first tier. Utilization of the JFC cultural festival as a context in learning mathematics based on ethnomathematics is expected to help students in Jember and its surrounding areas to obtain an optimal understanding of mathematical concepts because culture plays an important role to be integrated into mathematics learning. This research is categorized as valid (3.85 out of 4.00) based on the assessment from the validators. The problem of two-tier multiple-choice mathematical reasoning in this study is categorized practical (90.3%) based on observation on teacher activities and suggestions from practitioners. The problem of two-tier multiple-choice mathematical reasoning in this study is categorized effective based on student test results (77.27%), observation on student activities (88.02%), and student response results (84.5%).

1. Introduction

Culture plays an important role in the growth and development of civilization. Culture also has a significant influence on the emergence of a new idea or thought which is a form of refinement of the results of thinking that has long existed. This is what underlies many thoughts concerning the need for integrated culture in every aspect of life, especially in terms of how mathematics is taught to students. However, along with the development of thinking that mathematics is an activity of human thought [1] or human activity [2], the integration of mathematics and culture is a necessity. This is what drives the emergence of a specific point of view in mathematics that places culture as a starting point in learning mathematics, namely ethnomathematics.

Considering about culture and the efforts to integrate culture in mathematics learning, Jember regency (Jember) as the main support of Indonesian tobacco production also holds tremendous cultural potentials. One of these potentials is Jember Fashion Carnaval (hereinafter is adequately referred to as JFC). JFC is one of the annual cultural festivals held in Jember and is the fourth carnival of the seven largest carnivals in the world [3]. JFC is packaged like a public market where the surrounding community is given wide enough access to participate in the entire series of shows. JFC is believed to make a significant contribution in several aspects such as tourism and economy, including in education. This is quite reasonable since some previous studies have included that the element of culture could be used as a foundation in mathematics learning.

As a part of cultural development, human reasoning also experiences rapid development, too. In mathematics education, for example, the old thinking in which mathematics was once believed to be the result of the transfer of knowledge from teacher to student is now experiencing significant changes. The old paradigm confirming mathematics as an idea or ideas that can only be transferred through the spoon-feeding process [4], now turns into a process of self-construction. Gravemeijer [5] stated that it is the time for mathematics learning to change its orientation to "students constructing" rather than just "teaching by telling".

Mathematics learning needs to start with giving problems as contextual as possible which will facilitate the transition from telling to finding out [6]. The use of the JFC culture festival as a context in learning mathematics is expected to help students in Jember and surrounding areas to be able to obtain an optimal understanding of mathematical concepts. In conducting this research, the researcher develops two-tier multiple-choice (TTMC) mathematics problems that were not only expected to increase students' understanding of the system of linear equations with two variable (*sistem persamaan linear dua variabel*, SPLDV) concept, but also to measure the level of students' reasoning skills. TTMC is one type of multiple-choice questions consisting of two tiers in which the first tier requires students to choose answers to problems related to the context, in this case, the SPLDV concept, while the second tier requires students to choose the right reason from the answers students have chosen at the first-tier questions [7]. If at the first tier students are required to use their understanding in solving problems, the second tier is more appropriate to be used as a benchmark for the extent of student's reasoning in solving problems at the first tier. This is in line with the idea of Nizar [8] who states that assessment during mathematics lesson needs to be more emphasized on reasoning rather than just solving problems. If this is applied regularly, the pressure faced by students in solving all problems given in class can be slightly reduced [9]. Such reasonable thinking will guide students in developing their critical thinking skills [10].

2. Literature Review

2.1. Ethnomathematics

Ethnomathematics was first coined by Ubirata d'Ambrosio in 1985. It is an idea that can change the perception of many educators about the importance of cultural integration in the context of mathematics learning. Ethnomathematics is also believed to have a significant impact on mathematics and mathematics education [11] since students have more access to gathering their mathematical ideas and applying their knowledge. Some studies have been carried out in several countries that confirm how ethnomathematics improves several aspects of mathematics learning. For example, Ascher [12] revealed that the Malekula people in Oceania had long been familiar with geometry and topology in their drawing art, and Presmeg [13] suggested that there was a mathematical element in the flag of the South Korean state. Ethnomathematics echoes are also increasingly prevalent in Indonesia in which a lot of research puts culture as the main topic in learning mathematics in a classroom. Abdullah, Mastur, & Sutarto [14] explored the local culture of Demak, Hariastuti [15] based her mathematics learning on the Osing traditional house in Banyuwangi, and Hartoyo [16] which highlighted the culture of the Dayak community in the learning process. Likewise, research conducted by Kholil & Apriyono [17], Nuh & Dardiri [18], and Putri [19] addressed respectively the Tanoker Ledokombo Jember learning village, Riau Malay community, and Rebana art in mathematics learning.

2.2. Jember Fashion Carnaval (JFC)

JFC is one of the annual cultural festivals held in Jember and is the fourth carnival of the seven largest carnivals in the world [3]. Commencing from Dynand Fariz's creative ideas to further popularize the fashion to be accessible to many people, the idea of organizing a street carnival [3] emerged. JFC has its uniqueness that further emphasizes local or world culture and is modernly packaged in a fashion parade. This is what distinguishes JFC from similar carnivals such as Rio de Janeiro Carnival and Trinidad and Tobago Carnival, which both highlight the sexuality of the performers [20]. Besides, JFC is packaged like a public market that surrounding communities are given ample access to attend the entire series of events. By seeing the considerable enthusiasm of the people of Jember and surrounding areas for the whole series of JCF activities, JFC is believed to make a significant contribution in some aspects such as tourism and economy, including in education. This is quite reasonable since some previous studies have included that the element of culture could be used as a foundation in mathematics learning.

2.3. Two-Tier Multiple Choice (TTMC)

The multiple-choice question is one of the instruments that aim to assess certain required skills for certain objectives such as research subject observation. This type of question displays the answer to the given problem along with some other incorrect answers as distractors. Those answers are then arranged in such a way, as in the form of numbering A, B, C, and so on such that students can freely choose the right one.

Considering the strengths and weaknesses of the use of multiple-choice from several studies, it has finally emerged some alternative forms assessment. Although many have succeeded in developing different types of assessments using multiple-choice, it is not uncommon for some to still maintain this form of assessment by making some adaptations. One of its adaptations is a two-tier multiple-choice (TTMC). In general, TTMC seeks to combine two tiers of multiple-choice questions into one unit. Treagust [7] mentioned the first tier of TTMC requires students to choose answers to problems related to the context, while the second tier of TTMC requires students to choose the right reason from the answers students have chosen in the first tier question.

In the beginning, TTMC was dedicated to knowing how logical thinking is formed in a person's mind. This is what inspired Tobin and Capie [21] to develop the TTMC instrument called the Test of Logical Thinking (TOLT). This instrument is specifically designed so that it could be easier to identify someone's reasoning ability. Five types of reasoning can be easily measured by using TOLT. Those reasonings are controlling variables, proportional reasoning, probabilistic reasoning, correlation reasoning, and combinatorial reasoning.

Some studies about the use of TTMC have been done and remarkable result also emerged. Chen, Lin, and Lin [22] remark TTMC as a form of test that reliable, valid, easy to assess and better in measuring student understanding. TTMC can be used to find out the appropriate number of students to get different concepts [23] and very helpful in assessing and measuring how students think [24]. The TTMC also confirms quite convincing results in measuring students' understanding in the fields of physics, astronomy, biology, chemistry, and physics, such as the application of TTMC in the field of image formation by flat mirrors [22], moon phases [25], ionization energy [26], and simple electrical circuits [27].

Unfortunately, the application of TTMC is not often found in mathematics. Although several studies related to TTMC have been conducted in the field of mathematics such as measuring proportional reasoning [28], concept errors in numbers [29], as well as the development of interactive mathematics learning [30], implementation has rarely been found to measure the extent to which the TTMC has greatly contributed to the learning of specified concepts, including the SPLDV concept.

2.4. Mathematical Reasoning Skills

Mathematical reasoning is an inseparable part of every mathematics learning in class. Reasoning plays an important role in solving all mathematical problems [31], helps students process their knowledge

[32], and becomes a very important skill in operating simple and complex mathematics [33]. Reasoning can also be classified as part of thinking in the form of generalization and conclusion from various ideas, including how these ideas can be connected [31]. Even, Lithner [34] defined reasoning as a line of thinking and how people think to conclude. Mathematical reasoning always involves systematic thinking logic. This is what underlies Grønmo, Lindquist, & Arora [35] in formulating six main indicators of reasoning, namely analyzing, synthesizing, evaluating, drawing conclusions, generalizing and justification.

Analyzing is more focused on identifying numbers of things in a problem and determining what important information, procedures, or strategies need to be applied to solve a problem while synthesizing is related to the process of connecting knowledge, representation, and procedures to solve the problem. Evaluating can be seen from how students set other alternatives to the strategies or solutions that have been obtained while concluding is emphasized more on making valid inferences of various information and evidence they have. Generalizing is more focused on making statements that represent more general relationships and can be applied to other cases, while justification is more focused on providing evidence and argumentation that can support the strategy, settlement, or statement having been made. From the perspective of how this mathematical reasoning can be formulated in assessments in the classroom, Sa'dijah (cited in [8]) formulated seven characteristics that characterize questions to measure the level of students' mathematical reasoning (see Table 1).

Table 1. Characteristics of questions to measure mathematical reasoning.

No	Characteristics
1	Present mathematical statements both oral, written, figure, or diagram
2	Draw conclusions, compile evidence and give reasons for the solution
3	Conclude a statement
4	Check the validity of the argument
5	Do mathematical manipulation
6	Find patterns or properties of mathematical symptoms to make generalizations
7	Propose hypothesis

3. Research Method

This research is projected to produce effective instrument to be used classroom learning process, in this case, TTMC questions. This corresponds to what is stated in research objectives, which is the main objective of this research is to develop TTMC-based problem about SPLDV based on the JFC cultural festival. The question referred to will be further developed in the form of a web-based assessment that can be used to measure mathematical reasoning. This research design is categorized as development research. This supports the opinion of Gay [36] which states that development research is not to test a theory but to develop an effective product used in schools, such as teacher training materials, teaching materials, media, or educational management.

There are several question development procedures referred to using the question development steps formulated by Gall, Gall, & Borg [37]. In establishing what will be measured in the first step, knowledge of the theory underlying the construction of the questions must be clearly and thoughtfully thought out. This includes setting what indicators are to be assessed by implementing the questions that have been developed. The second step is more emphasized on who will be the subject of research. This includes having to pay close attention to the characteristics of the subjects involved in this research. Besides, developing questions must also adhere to the construction of pre-existing questions. Therefore, the third step of research is focused more on conducting literature studies related to existing problems which can later be used in developing new questions to be tested and setting their validity and reliability.

The fourth step of this stage is to develop a prototype of the questions. This prototype is more emphasized on the initial development of the question. Henceforth, this prototype is called prototype 1. The fifth step emphasizes evaluating prototype 1 by asking experts to review prototype 1, conducting prototype 1 field tests on several research subjects, and carrying out item analysis of the results obtained.

The sixth step is to revise prototype 1 based on the results obtained from the fifth step. This sixth step will later result in a revision of prototype 1 called prototype 2 which must be re-examined and revised. The evaluation and revision cycle process will continue and be stopped when it corresponds to what will be measured. The sixth step concludes with the final prototype. The seventh step is to implement the final prototype by asking a pre-determined research subject to work on the final prototype that has been formed. The results of this implementation will be tested for validity and reliability so that the development of the questions that have been done can be used for a wider sample.

The locations of this study were two junior high schools in several regencies such as Jember, Lumajang, Bondowoso, Situbondo, Banyuwangi, Probolinggo. The test subjects in this study were eighth-grade students in these regions because they are the surrounding areas of the JFC cultural festival. Besides, the development of information technology has been quite good in the regions, so that the research development will be more optimal.

4. Research Findings

4.1. Validity Data Analisis

Validity data analysis is based on the results of the learning media validation in the form of student worksheets. The validation process is carried out by handing over the media, assessment instruments, and validation sheets to validators. The selected validators were 2 mathematics education experts with pre-determined qualifications. Validator 1 (V1) is a Jember University lecturer and is an expert in the field of mathematics education and learning. Validator 2 (V2) is a Jember University lecturer and is an expert in pure mathematics. In addition to providing an assessment, the validators also provide comments and suggestions for improvements to the product being developed. The validation results are then recapitulated and analyzed. The recapitulation of the validation results is shown in Table 2.

By considering Table 2, it is obtained an overall average validation score of the worksheet of 3.85. Then based on the validity criteria, the prototype of learning media developed in this study has successfully fulfilled the criteria of the validity.

4.2. Practicality Data Analysis

Observation on model teacher activity was carried out in 6 meetings at each location. Based on the recapitulation of teacher activity observation data, it was obtained the overall average score of teacher observation results of 3 and the average percentage of teacher observation results of 90.3%. Therefore, based on the criteria of teacher activity observations, the percentage of scores meets the criteria of good. Besides, according to the results of the interview, practitioners only provide suggestions for improvement that does not entirely change the media. It can be said the learning media developed in this study meet practicality criteria. The recapitulation of teacher activity observations is presented in Table 3.

Table 2. Recapitulation of Student Worksheet Validation.

No	Indicators	Validators		Mean
		V1	V2	
Format				
1	Attractive design and suits the contents	4	4	4
2	The media format is clear and coherent	4	4	4
Content				
3	Instructions are written in a complete and clear way	4	4	4
4	Suits the syntax of the Two-Tier Multiple Choice model	4	4	4
5	Activity material helps students build understanding independently	4	4	4
6	Emphasis on mastery of concepts	4	4	4
7	The material suits the JFC Ethnomatematics theme	4	3	3,5
Language				
8	The language used is easy to understand	3	4	3,5
9	Use of communicative language	4	4	4
10	Using standard and appropriate writing conventions	3	4	3,5
Total score with EYD		38	39	38,5
Average Score		3,8	3,9	3,85

Table 3. Recapitulation of Teachers' Observation.

Stage	Indicators	Meeting Scores			Mean	Percentage (%)
		I	II	III		
Pre	Early Learning Activities	2	3	2	2,33	77,7
	Apperception	2	3	3	2,67	89,0
	Student Groupings	3	2	3	2,67	89,0
Main	Problem Presentation	3	3	3	3	100,0
	Advice on Group Discussions	2	3	3	2,67	89,0
	Problem Discussion	3	2	3	2,67	89,0
	Conclusion Drawings	3	3	2	2,67	89,0
Post	Final learning activity	3	3	3	3	100,0
	Mean	2,63	2,75	2,75	3	
	Percentage (%)	87,5	91,7	91,7	100,0	90,3

4.3. Analysis of Effectiveness Data

The test is carried out at the fourth meeting after three trials through the learning process. The test score data serves to determine the completeness of student learning both individually and classically after participating. The test score data is used to find out the students' cognitive abilities after participating in learning using designed TTMC-based problems. Of the 28 students participating in the test, 20 students successfully obtained scores above the pre-determined standard (that it 75 out of a maximum score of 100), while the rest failed. This resulted in the percentage of completeness of cognitive abilities classically of 71.43%. The incompleteness of student learning outcomes tends to be caused by personal factors, for example, students are not able to understand the purpose of the questions given, and students are wrongly performing arithmetic operations. Besides, differences in students' ability to absorb the information provided by the teacher can also affect test results. Student activity observation was carried out by 2 observers. The results of this observation are one of the supporting data for effectiveness in terms of student psychomotor. Overall, the average score obtained from the observation is 3.52 and the average percentage of scores is 88.02%. Besides, based on the students' activeness criteria, the average score meets the criteria of very active.

4.3.1 Results of Student Activity Observation

Student activity observation was carried out by two observers in three meetings. The observation scores are then recapitulated and analyzed. The recapitulation of the scores of observation is shown in Table 4.

Table 4. Recapitulation of Students' Observation.

Stage	Indicators	Meeting Score						Mean	Percentage (%)
		I		II		III			
		O_1	O_2	O_1	O_2	O_1	O_3		
Pre	Paying attention to learning objectives	4	2	4	3	4	4	3,50	87,5
	Agreeing on prerequisite material definition	3	3	4	3	3	4	3,33	83,3
	Groupings	3	4	3	4	3	4	3,50	87,5
Main	Gathering information from problems	4	4	4	3	4	3	3,67	91,7
	Discussing for solutions	4	4	3	4	4	4	3,83	95,8
	Discussing problems	3	3	2	3	3	4	3,00	75,0
	Reporting and drawing conclusions	3	4	4	4	4	3	3,67	91,7

Stage	Indicators	Meeting Score						Mean	Percentage (%)
		I		II		III			
		O_1	O_2	O_1	O_2	O_1	O_3		
Post	Paying attention to teachers' activity instructions	3	4	4	4	4	3	3,67	91,7
Mean		3,38	3,50	3,50	3,50	3,63	3,63	3,53	
Percentage (%)		84,4	87,5	87,5	87,5	90,6	90,6		88,02

4.3.2 Results of Student Response Questionnaires

The student response questionnaire sheet was filled out by 28 students. The student response score is then recapitulated and analyzed. The recapitulation of the student response result score is shown in Table 5.

Table 5. Data Recapitulation of Student Response Questionnaire.

No	Questionnaires	Answers		Percentage	
		Yes	No	Yes	No
1.	Are you excited while studying?	23	5	90,9	9,1
2.	Do you like the way your teacher teaches?	20	8	77,3	22,7
3.	Do you like the learning atmosphere in class?	21	7	81,8	18,2
4.	Are you excited to express opinions to friends?	19	8	72,7	27,3
5.	Are you excited to respond to the opinions of your group friends?	22	6	86,4	13,6
6.	Do you have more opportunities to discuss with friends in solving problems?	23	5	90,9	9,1
7.	Do you have more opportunities to express opinions?	20	8	77,3	22,7
8.	Can you understand the language used in the learning media?	22	6	86,4	13,6
9.	Do you like the cultural theme used?	24	4	95,5	4,5
10.	Do you agree if this learning is taught for another material?	22	6	86,4	13,6
Mean		21,6	6,4		
Percentage (%)		84,5	15,5		

From the results of the analysis of each item in the student response questionnaire questions in Table 5, it can be seen that the lowest positive answer lies in the 2nd and 7th questions, namely about the way the teacher teaches and the opportunity to express opinions, while the highest positive answer lies in the 9th question. The effectiveness of learning in terms of affective was obtained from the results of student response questionnaires. The student response questionnaire sheet was filled out by 28 students. The student response score is then recapitulated and analyzed. Overall, the average percentage of each question is that 84.5% answered "yes" and 15.5% answered "no". This indicates that overall students like and give a positive attitude to learning.

4.4. Overall Data Analysis

Based on all media development research activities that have been carried out, the data is recapitulated and then analyzed based on specified criteria. The implementation of mathematics learning by using TTMC-based problems with the theme of ethnomathematics of JFC has fulfilled the categories valid, practical and effective. Overall assessment results and criteria are presented in Table 6.

Table 6. Overall Assessment.

No	Data	Results	Criteria
1	Scores of Media Validation	3,85	Valid
2	Scores of Teacher Activity Observation	90,3%	Practical
	Cognitive Test Score	77,27%	
3	Scores of Student Activity Observation	88,02%	
	Scores of Response Questionnaire	84,5%	Effective

5. Conclusion

Based on the results of research on development that has been done, the conclusions are: (1) learning Mathematical Reasoning Problems of Two-Tier Multiple Choice Types to Junior High Students based on Etnomatematics Jember Fashion Carnaval in this study are categorized valid based on the assessment of the validators; (2) learning Mathematical Reasoning Problems of Two-Tier Multiple Choice Types to Junior High Students based on Etnomatematics Jember Fashion Carnaval in this study are categorized in this study is categorized practical based on teacher activity observations and suggestions from practitioners; and (3) learning Mathematical Reasoning Problems of Two-Tier Multiple Choice Types to Junior High Students based on Etnomatematics Jember Fashion Carnaval in this study is categorized effective based on student test results, student activity observations and results of student responses.

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