

## **Development Framework of Ethnomathematics Curriculum through Realistic Mathematics Education Approach**

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**Abstract :** *The relationship between ethnomathematics and mathematics education is still widely questioned and criticized regard the focus attention on the culture can be trigger negative connotation occurs for some group of people. Besides, the problem how to find the contextual problem for the realistic mathematics education approach also needs to require attention. Integration those two theories, researcher tries to develop framework ethnomathematics based on Realistic Mathematics Education approach by seeing how the ethnomathematics able to reach formal mathematics in Realistic Mathematics Education approach. By identifying the strength and weakness both theories from previous studies, it is shown that the ethnomathematics can reach the formal mathematics as a based activity to support the contextual problem in realistic mathematics education approach.*

**Keywords:** *Ethnomathematics, Formal Mathematics, Realistic Mathematics Education (RME) approach*

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### **I. Introduction**

By linking the culture in the process of teaching and learning, learning becomes more meaningful. Especially in mathematics learning, contextual learning highly relevant to the cultural community and its make learning interesting and fun for the children. Neither Curriculum 2006 (School-Based Curriculum) nor Curriculum 2013 in Indonesia accentuate the improvement of student' ability towards culture and students' centerapproach [1,2]. As mention by Danoebroto [3], internal issues in Indonesia relate with the conflict of SARA (ethnic, religion, race and group), inequity and crisis identity are the problems for Indonesia as multicultural country. In order to solve this problem, public awareness start from school level is very important to understand cultural diversity and respect ethnic identities oftheothers. By integrate the subjects in the school including mathematics, government expect the meaningful learning for the children and help the students to enhance their understanding in learning mathematics. In spite ofimportant it is, to bring culture-based learning into the curriculum is a difficult task for the curriculum developer. As a result of review from the criticism and contradiction of ethnomathematics by Pais[4]ethnomathematics have two categories relate with epistemological and pedagogical. As epistemological related with the positions of ethnomathematics in mathematical knowledge while as pedagogical, relate with the implication in formal education of ethnomathematical ideas. He argues that by paying attention to the contradiction of ethnomathematics can be good intention in order to keep their pedagogical aims of the teachers. As mention by Howson, etc. [5] as well, there are four barriers to curriculum development that should be paying attention for the curriculum developer. The first one is related to value barriers which are related to ideologies and interest of an individual person. It has a significant effect on developing the curriculum in mathematics education. The second one is power barriers which have significant innovation by shift the balance power. The third one is practical barriers, and the last one is psychological barriers. In the other countries, as well it is found out that the typical curriculum in schools is shallow yet overloaded, undemanding, fragmented, unfocused and incoherent. Bishop [6] also tried to restructure three important aspects in term of three levels in the curriculum based on the cultural conflict recognition. As represented in intended curriculum, mathematical knowledge should be aware with three different educational structures (formal, non-formal and informal mathematics education). Regard the implementation of mathematical knowledge in the schools and classroom, teacher should be aware with culture-blind intended curriculum, multi-cultural in the classroom and teacher as social anthropologist. And in the last regard the attained curriculum, mathematical knowledge should be aware to the learners' environment relate with what they learn outside school and theirculture. Several important things for developing a curriculum are goals of mathematics curriculum, content standard and for the supplement, instructional materials to support all ofthe standards. In Indonesia's case, though the government hasobjectives in mathematics education which is related to understanding the concept of mathematics (MoE, 2006), the reality shows that the students' performance in comprehending mathematical concepts and construct as well as solve the mathematical

representation of contextual problem still weak [7,8].

The implementation of this goal needs an appropriate learning approach to make mathematics meaningful for the students. One of the approaches which have same underlined aspect of learning mathematics at the unit level of curriculum is Realistic Mathematics Education approach [7,9]. NCTM [10] suggested the necessary implement a classroom environment by following realistic mathematics modelling tenets: develop realistic problem situation for students and employ a variety of teaching methods. To apply this approach, the teacher should know how to design the mathematical tasks for the students. Students have their own interpretation at a task given and it may look differs much from how teachers or instructional designers look at it. In line with the Freudenthal's idea [11] mathematics as a human activity, so it is good for the students to build their own knowledge.

The process in each level of this approach can be guided by the teacher in the process of teaching-learning in the classroom to see how students` develop their idea and reach the objective of the lesson. Contextual situation used to be used in the first level of this approach which related to the students` daily life, but another problem occurs is not all the topic in mathematics can be easy to be found in the contextual problem. Besides, the problem in the first level of this approach which is used in Indonesia mostly relate to application problem rather than a contextual problem. The same reason is appearing is the teacher felt difficulty to found or develop a contextual problem for a particular topic in mathematics [12]. Consider this problem; ethnomathematics approach is the better solution to help the teacher to find out another issue should be posed at the situational level. The various cultural groups` activities are the best resource for the teacher to develop their classroom because by using ethnomathematics they able to mathematize their reality based on their daily activities [13]. While pedagogy issue is the main problem in this approach, how to teach ethnomathematics in the classroom is the big question should be considering as well where the objective of mathematics class is to reach the formal mathematics education. Based on those literature reviews, the researcher tries to consider the problem of those two theories and try to integrate them to make them complement each other. The objective of this study is to develop framework ethnomathematics based on Realistic Mathematics Education approach by seeing how the ethnomathematics able to reach formal mathematics in Realistic Mathematics Education approach. The research question to address this issue is how to integrate ethnomathematics into the process of the mathematics learning using realistic mathematics education approach.

## II. Literature Review

### 2.1 Ethnomathematics

Ethnomathematics in mathematics education can be defined as a study of the relationship between mathematics and culture. Orey and Rosa [13] put ethnomathematics as a form of the intersection set between cultural anthropology and institutional mathematics and utilizes mathematical modelling to solve real-world problems and translate them into modern mathematical language system. Ethnomathematics can be interpreted as a reaction to the cultural imperialism which is built into modernization theory [14]. Here, they mention the core concern for ethnomathematics is to come to identify the culturally embedded mathematical competencies and instead of thinking in term of importing a curriculum, to think regarding self-development. Taken the definition of ethnomathematics [15] comes to mean the culturally embedded techniques of understanding. He mainly argues the recognition and incorporation of ethnomathematics into the curriculum is essential especially for developing country [15]. There are five principles of the cultural approach to the mathematical curriculum by Bishop[16]: representativeness, formality, accessibility, explanatory power, broad and elementary. It means that (1) the curriculum should represent mathematical culture, in terms of both symbolic technology and values; (2) it should objectify the formal level of that culture; (3) it should be accessible to all children; (4) it should emphasise mathematics as explanation; and the last (5) it should be relatively broad and elementary rather than narrow and demand in its conception. Bishop defined the three components as well for enculturation curriculum which will be used in this paper as a part of considering in design the curriculum.

- The symbolic component which is covering the significant explanatory conceptualizations in the symbolic technology of mathematics, which allow principally the values of rationalism and objectivism to be explicitly explored.
- The societal component which is exemplifying society's manifold uses of mathematical explanations, and the principal values of control and progress which have developed with these uses.
- The cultural component which is exemplifying the meta-concept of mathematics as a phenomenon existing in all cultures, and introducing the technical idea of mathematical culture, with its principal values of openness and mystery.

Ethnomathematics in Indonesia used to be use recently because the focus is referring to the cultural environment that can be considered to identified various cultural tradition in Indonesia. For example, Supriadi et al [17] take Sundanese culture to teach mathematics. The problem was made by using the Sundanese culture in order to make students aware with their culture and feel more comfortable and confident in discussing the mathematical concepts. Other activities that can be referred to teach mathematics is by using traditional game. Many of the traditional game in Indonesia can be adjust and deal with mathematics concepts.

## **2.2 Utilization of Ethnomathematics in Mathematics Education**

Many of the researchers as well try to implement the ethnomathematics in their learning process. As mention by Zhang, Zhang [18], most African peoples south of the Sahara traditionally build their house with circular or rectangular bases. The result of their research mentions the different historical origins of different national cultures should be carefully excavated. In Indonesia itself, as a vast country, Indonesia generous of tribes and many diversities from the west part to the east part of Indonesia.

Some researcher uses to combine cultural approach and RME for example (1) Wijaya [19], he conducts his research in primary school level, in which a number of the lesson in linear measurement developed by using traditional games. (2) Prahmana, R.C.I., Zulkardi, Hartono, Y [20] in the primary school level for learning multiplication using the traditional game and (3) Prahmana[21], in the student teacher level for design division operation learning of Math Gasing. These three previous studies focused only on the primary school where students are engaged with concrete concept easily. While for the secondary school for example junior high school students only used to commit themselves to an abstract concept. The researchers also do not explicitly mention about ethnomathematics. They just consider the traditional game as a learning environment for the students. While as we know that many of the student's activities are related to their background of culture.

Gerdes [22] gives other example relate to geometry in drawing tradition of Tchokhwe in Angola. This tradition called Sona where the drawing was made from the sand and shaping various geometry pattern. Though so many activities of the culture can be support for the children, many researchers argue as well regarding the relationship between ethnomathematics and mathematics education. As mention by Bishop [23], what is the important for the children to learn mathematics relate the three aspects of the curriculum? Strengthen ethnomathematics to the children somehow make them cannot go beyond to the modern mathematics. Vithal and Skovsmove[14] give an example in South Africa, bring and put emphasize too much to the culture have negative connotations for some group of people. They were argued that cultural approaches to education in multicultural societies often assume that cultures are compatible and in harmony within themselves and with each other. It makes the teacher who employs cultural approaches appear not to notice conflict which does exist or in the face of conflicts simply stop using such approach [14]. To reduce the impact of using cultural approaches, Pais[4] propose to consider relate the pedagogical issue relate with the implication of ethnomathematics.

## **2.3 Realistic Mathematics Education and its implication**

The characteristic of Realistic Mathematics Education (RME) is that rich, realistic situations are given a prominent position in the learning process. The philosophy of RME approach itself based on the Freudenthal[24] stated that mathematics must be connected to reality and mathematics as a human activity. According to him, students should not be treated as a passive recipient, but rather education should guide them towards using opportunities to discover and reinvent mathematics by themselves [25].

The integration of mathematical strands or units is essential as well in this approach. It is used to incorporate applications and implies that learning strands should not be dealt with as separate and distinct entities.

In the Netherland, the implementation of RME and its impact increasing well. The implementation of RME was guided by the RME-based curriculum documents including the so-called Proeve publications and the TAL teaching-learning trajectories for primary school mathematics [26]. The secondary education as well got influenced by RME approach in their textbook. RME-based textbook series "Mathematics in Context" has a considerable market share in the USA. Not only that, RME-based "Pendidikan Matematika Realistik Indonesia" or IRME (Indonesia Realistic Mathematics Education) also spread and smoothly develop at present. Three principles of IRME like RME [27] are:

1. Guided reinvention where student has a chance to reinvent by guidance of teacher.
2. Didactical phenomenology in order to find problem that can be generalize and can be use as vertical mathematization.
3. Self-developed models to bridge between informal and formal mathematics. The model is made by the students in problem solving.

Some previous studies which focus on RME in Indonesia such as: Fiangga[28], using RME approach to help primary students understand the concept of area conservation in area measurement by using local instructional. In his study, he found out that Tangram as a real and precious media to learn shapes. Some researchers targeted the development of RME for the in-service and pre-service teacher; they try to do a project or develop such kind of training for them [27]. Based on those previous studies, the researcher only focuses on teacher or student only.

Many activities for the students come from students' activity which is related to their environment from the game and daily activity which is part of the cultural activity as well. For example, playing, make a shape (design), etc. Within students' game, we can find six universal activities by Bishop [16]. Many of the Indonesia traditional games consist of those six activities as well. For example, counting (jump rope), locating (hide and seek), measuring (marbles), designing (Tangram), playing, and explaining (more connected to communicating skill of the children). All those activities relate to mathematics activity for developing students' understanding of a certain mathematical concept. This research finds how important cultural activity for the children especially in their development aged.

Although this approach seems to be perfect pedagogical method in teaching there is some problem that should get more attention to improving such as: (1) In the situational level that used to be daily life context of the students, in the real implementation shown as application problem only not as a contextual problem. (2) Separate the culture of the students during teaching using this approach may affect their thinking [12] and the last one (3) Consider teaching resources different from the culture.

### III. Methodology

The researcher tries to answer the research question by identified from the previous studies relate those theories, and the following ways to reach the objective are shown below:

- a. The researcher tries to identify strength and weaknesses both theories.
- b. The researcher tries to integrate the framework based on those strength and weakness.
- c. The researcher tries to give an example of form of the integration framework to explain clearer how the framework will be works.

### IV. Result and Discussion

#### 4.1 Strength and Weakness from previous studies of Ethnomathematics

Based on the previous studies, researcher tried to summary the strength and weakness of ethnomathematics as table following:

**Table1: Strength and Weakness of Ethnomathematics**

Strength of Ethnomathematics	Weakness of Ethnomathematics
<ol style="list-style-type: none"> <li>1. By integrating an ethnomathematics perspective into mathematics curriculum → social impact in students' attitudes towards their own cultural backgrounds [11]</li> <li>2. The application of ethnomathematics as pedagogical action restores a sense of enjoyment or engagement and can enhance creativity in doing mathematics [11]</li> <li>3. To help students understand others' cultural contribution, respect to the attention to diversity, avoid of exclusion and isolation and the last show mathematics as a human activity (UNESCO, 2012).</li> </ol>	<ol style="list-style-type: none"> <li>1. Teachers used to run away with the new way of teaching especially if it's not in curriculum. In order to prevent this issue, Rosa [11] state that it is necessary to propose discussion about cultural relevance into the mathematics curriculum to help the teacher acknowledge the relationship between cultural and school mathematical knowledge.</li> <li>2. In the two views in the ethnomathematics theoretical framework (Albanese et al, 2017), the mathematization activity was arose → QRS (quantity, relation and spatial aspects of human experience → situated) but there is not enough explanation regarding the categorization of the student's performance based on the activity.</li> </ol>

From this table shows that ethnomathematics strength has a big impact on developing mathematics curriculum. The pedagogical action as well may become interested in the students and improve their creativities. But the pedagogical issue also becomes the weakness of this approach because the implementation needs a creative teacher who cares and realizes the importance of the culture and how to connect mathematics knowledge and culture. To emphasize this issue into mathematics curriculum, Adam [29] states five possibilities for an ethnomathematical curriculum can be identified as follows:

- a. Ethnomathematical curriculum is as an approach □ meaningful context because related to students think about mathematics [30]
- b. Ethnomathematics as a particular content that is distinct from the conventional mathematical concepts.
- c. Ethnomathematics is a stage in the progression of mathematical thinking that child goes through during his/her mathematics education.
- d. Ethnomathematical curriculum could be the mathematical part of the idea that all classroom is situated in a cultural context.

- e. Integration of the mathematical concepts and practices originating in the learners` culture with those of conventional, formal academic mathematics.

**4.2 Strength and Weakness from previous studies of Realistic Mathematics Education**

Based on the previous studies, researcher tried to summary the strength and weakness of ethnomathematics as table following:

**Table 2: Strength and Weakness of Realistic Mathematics Education**

Strength of Realistic Mathematics Education	Weakness of Realistic Mathematics Education
a. Provides a clear understanding to students about the relationship between mathematics and daily life as well as the usefulness of mathematics in general for humans. b. Mathematics is a field of study that can be constructed and developed by the students themselves and by others, not only by those who are called mathematicians. c. How to solve a problem or the problem should not be single, and do not have to be the same with each other. d. The process of learn mathematics is the main concern and to so, they need to find out for themselves the mathematical concepts by guidance of the teacher. e. Integrating the advantages of various learning approaches that considered to be superior as well. For example, problem-solving approaches, constructivism approaches and environment-based learning approaches. Suwarsono in Hadi (2003)	a. The test based contextual problem is not easy to be found for any mathematical topics. b. Learning process in IRME more complicated than conventional method. c. The selection of props must be meticulous so that it can help the process of students` way of thinking. Suwarsono in Hadi (2003) d. Context based approach by Indonesia curriculum may limit the implementation → contextual situation more simply utilized as an application rather than source of learning. e. Teacher finds the difficulty to make connection between another mathematics strands (integrated different mathematics strands) f. Contextual problem should have multiple solution in order to generalize but usually only 1 solution appears in the learning process. g. Due to teaching aids, based on the real principles, it should be used introduced schemes but in Indonesia sometimes only use standard method (Revina, 2017).

The table shows that realistic mathematics education is an appropriate method to be integrated with ethnomathematics because of the principle of this approach which put emphasize on students` creation. Different type of students` model can make them aware of another idea and point view from different angle. The same focus as well with ethnomathematics, the student comes together from the different cultural background and being put in the classroom which has variety type of students` character, culture, etc. The importance of this approach is how to make a deal in the classroom to reach the same idea to achieve the objective of the lesson. Based on table 1 and table 2 are integrating to see how these two theories can complement each other.

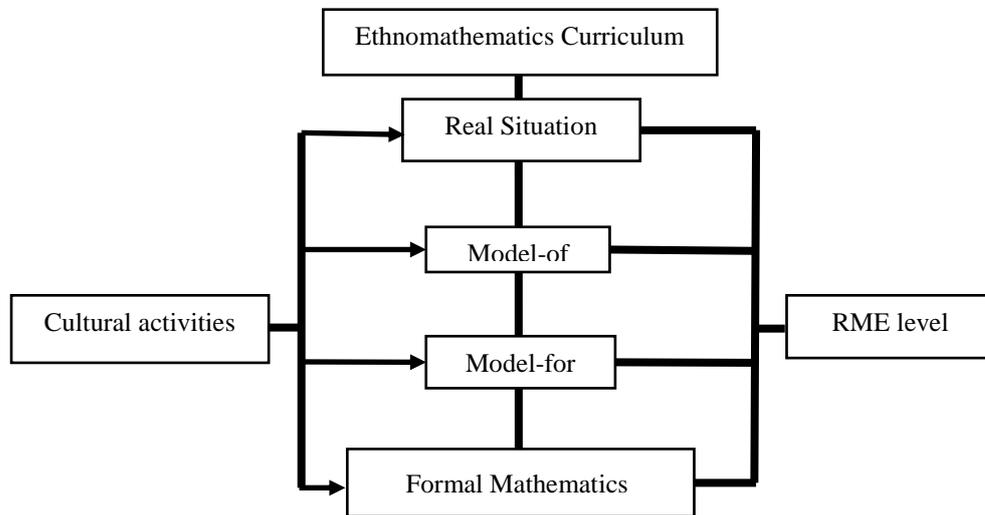
**Table 3 Integration table of Ethnomathematics and Realistic Mathematics Education**

	Situational Level		Model-of		Model-for		Formal Mathematics	
	Strength	Weakness	Strength	Weakness	Strength	Weakness	Strength	Weakness
<b>Realistic Mathematics Education</b>	Start point to make connection with students` daily life	Contextual problem as application	Concrete teaching aids, models and guidance in teaching (Hope)	Uniform and artificial model (Fact in Indonesia)	Teacher-whole class; Teacher-Individual → pedagogy (Hope)	Horizontal interaction, no explanation about the answer, time consuming (Fact in Indonesia)	Generalization mathematics strands (Hope)	Topic based lesson (Fact)
<b>Ethnomathematics</b>	Cultural context may help the teacher → difficult mathematical topic	Difficult to start teaching ethnomathematics	Based on the different culture, it will be easy to find out cultural material to be a model	How to use the different type of cultural materials	Asking students` experience (not only at school but also at home) → interaction	How to manage the class with the difference answer	Based on the different example of cultural materials can be connected to another topic	Pedagogy issue

To develop the framework based on this table 3, we need to think back to the objective of the mathematics education in Indonesia and the recent goals of the curriculum. How the curriculum in Indonesia wants to have similar characteristic with this integration of these theories.

The framework shown in Fig. 1 below is the proposed framework for the integration of ethnomathematics and realistic mathematics education. How this framework will work on and how ethnomathematics itself able to reach formal mathematics in the level of realistic mathematics education will be explained in the next section. This framework shows that ethnomathematics curriculum should start from phenomena/situation either in the mathematical domain or specific domain. Any activities though relate to the culture or daily activity, consciously or unconsciously done in daily life promotes the activity within a

culture[31]. Based on the Adam [29] as well consider what kind of ethnomathematics in the context of situational level which consists of mathematical activities from other culture and their own culture. This framework also similar idea with Bishop [6] where accommodation approaches attempts to restructuring the curriculum based on the children’s culture. Another important thing of this framework is the utilization of model. The models can serve important device for bridging the gap between informal, context-related mathematics and more formal mathematics [32,33,34,35].

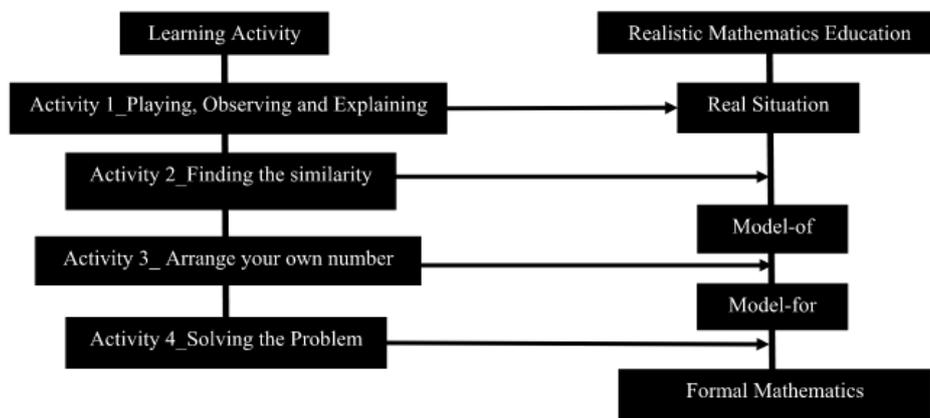


**Figure 1.** framework for ethnomathematics curriculum design

This Fig. 1 will be used for designing the classroom setting and will be revised as shown in figure 3 where ethnomathematics can be labelled in each level of RME. Revina, S [12] states that using original culture in implementation of RME more consistent with the RME theory rather than their counterpart elsewhere. The implementation of ethnomathematical curriculum is not just about the application of relevant context in learning teaching mathematics but is also about generating formal mathematics from cultural ideas.

**4.3 Integration of Ethnomathematics in the Classroom through Realistic Mathematics Education Approach**

Based on the Fig. 1 and Fig. 2 were developed to implement the framework in order to find what kind of ethnomathematics can be find in each level of RME in the classroom activity. Cultural activity that being posed in activity 1 help the students doing two of the six universal mathematics activities which are playing and explaining. Based on this real situation activity, the students will be guided to face another imaginary problem.



**Figure 2.** classroom design

Ethnomathematics curriculum that could be labelled in this level is mathematics in meaningful context[30]. The cultural game draw on students’ own experiences that are common in their environment help

them to bridge their thinking between mathematics e.g number, symbol, sign and their experience. In short, ethnomathematics that appears in this level is ethnomathematics as context.

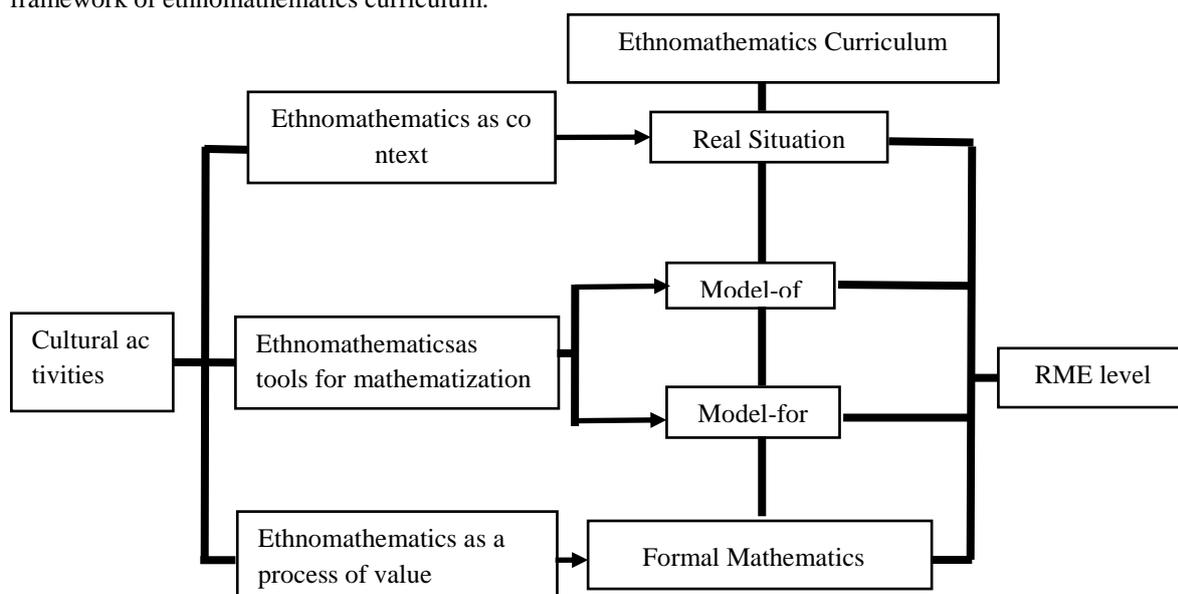
In the activity 2, which is a bridge between real situation and model-of level, the students will make their mathematics expression based on the situation in the game then they will be required to find the similarity between the mathematics expression from their data collected through observation sheet.

Ethnomathematical curriculum that could be built on the idea that ethnomathematics is a stage in the development of mathematical thinking that a child goes through in his/her mathematics education a justification for this curriculum is that mathematics should start with where the students are then make connections with mathematics in their culture, and then link it to world mathematics. A curriculum of this kind may benefit student learning in terms of students being aware of the mathematics found in their own culture and seeing mathematics as a living and growing discipline. Ethnomathematics as a tool for mathematization can be labelled in this level of model-of which mean ethnomathematics help students make connection to represent their idea from context given

For the activity 3, the students are required to arrange their own number in order to create their mathematics expression. The objective of developing an ethnomathematical curriculum model is to assist students to become aware of how people mathematise or think mathematically in their culture, to use this awareness to learn about formal mathematics, and to increase their ability to mathematise in any context in the future [36]. It has also the connections between becoming critical mathematical thinkers and viewing knowledge critically in a broad sense (awareness of the sign “-”). Ethnomathematical curriculum that could be develop in this level is ethnomathematical curriculum focuses on mathematics as a process, rather than a collection of facts. The model is based on the idea that mathematics is a human creation that emerges as people attempt to understand their world. In other words, ethnomathematics can be consider as a tool for mathematization (mean to help students develop their own representation from different context).

By the result of the activity 3, in the activity 4 students are require presenting their result and they will be guided to find out the common expression as well as the same result of their answer. The four level of RME is relate to formal mathematics where the students will be going from the context bounded to be free bounded. In this stage, some of the expression are difficult to be express to the situation of the game anymore. But by using the model-for table that they made in the activity 3, students able to find the formula as a conclusion of the objective of this lesson. Ethnomathematical curriculum that can be build is the experiences will be used neither as motivation, nor as an introduction, but as part of understanding how mathematical ideas develop, how they are built into systems, how they are formulated, and how they are then applied in various ways within the culture. In this stage, teachers’ role to appreciate each students’ model as well as students will learn how to appreciate diversity of the culture and opinion among them are crucial. Valuing the diversity appears again not only relate to the students’ background but also their preference. Students start to think as a social person to consider their friend preference and discuss for the agreement as a classmate. Here ethnomathematics can be labelled as a process of value.

The following Fig. 3 is the overall how ethnomathematics can be find in each level of RME as a framework of ethnomathematics curriculum.



**Figure 2.** framework of ethnomathematics curriculum

## V. Conclusion

Bringing the Realistic Mathematics Education approach into the pedagogy for teaching mathematics within the culture helpful for the children to aware about their culture as well as reach the mathematics modern [29]. By using Realistic Mathematics Education approach also help the teacher to support students to understand the mathematical concept and the students will be analysed their level of understanding in the learning process as well. However, this framework could be explored more relate with the position either ethnomathematics as a process of value could be found in the real situation level or not and how are they relation. Next research possibility could be how to embed this ethnomathematics curriculum to the recent mathematics curriculum in Indonesia.

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