Combining Ethnomathematics, Thematics, and Connectedness in a Mathematics Learning Model for Elementary School

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Abstract

Background: Curriculum renewal requires teachers to always innovate in learning. The teacher can combine various ways as long as it suits the needs and characteristics of learning. The trivium curriculum in ethnomathematics contains the concepts of literacy, matheracy, and technoracy which can be combined with thematic and connected approaches. Ethnomathematics can be used in learning because it contains contextual mathematical concepts that exist in culture. The thematic approach can make students learn several subjects at once in the appropriate theme. Connectedness can make students learn several concepts at once in a subject. The combination can make students learn many things at one time in an integrated and meaningful way because it is based on the culture they know.

Objectives: This research is aimed at developing a learning model that combines the trivium curriculum in ethnomathematics, thematic approaches, and connectedness in mathematics. In addition, research was also conducted to determine the quality of the developed model.

Methods: The development is carried out using the Plomp model which is limited to four phases (without implementation). The respondents consisted of 15 elementary school lower grade teachers as resource persons for problem identification, two lecturers and two elementary school principals as expert evaluators and practitioners, one teacher and ten 3rd grade students at an elementary school in Banyuwangi as pilot respondents. Data collection was done by interviews, observation, tests, and questionnaires. Data analysis is a combination of quantitative and qualitative methods.

Results: The results of the initial investigation show that learning, especially in the lower grades of elementary school, still requires strengthening basic literacy, combines with play activities, learning media, and mother tongue assistance to understand students' learning concepts. The support of several education experts is used to strengthen the results of the investigation so that a learning model can be designed that includes syntax, social systems, reaction principles, support systems, and the impact of learning. Development is carried out based on a design made to produce a learning model along with learning tools. Learning tools are developed by the existing culture in the development area, namely Banyuwangi Indonesia. After the development results are declared valid, practical, and effective by experts and practitioners ($V_a\text{content} = 4.66$, $V_a\text{construct} = 4.52$, $IP = 4.67$, and $IE = 4.57$), then a trial is carried out to determine the implementation of the learning model. The results show that the learning model developed is practical and effective in being tested in learning ($IO = 4.22$, and good criteria on *IA*).

Conclusions: The development resulted in a new model called the Ethnomathematics-Thematic-Connected (ETC) model. based on the assessment of experts and practitioners, the ETC model is declared valid, practical, and effective. Based on the experimental practice, the ETC model is stated to be practical and effective. So that the ETC learning model can be said to have good quality and can be used for learning on a larger scale. In addition, the ETC model can also be used in areas other than Banyuwangi by using a cultural base according to the learning area.

***Keywords**:* learning model. ethnomathematics, trivium curriculum, thematic approach, connected model.

1. Introduction

Education at the elementary level is the foundation for the next level which should be strengthened and introduced to the use of basic concepts in everyday life. This is realized in the 2013 curriculum in the form of an integrated thematic approach [1]. Thematic learning is a way or strategy or learning approach designed by connecting various curriculum areas and integrating various competencies from several subjects in a theme or learning process by combining several interesting activities that allow students to move actively and provide meaningful learning [2] [3] [4] [5] [6]. It can be used in elementary education because it matches the characteristics of students at the level of concrete operational cognitive development [7]. The thematic approach allows literacy to grow progressively, in the form of strengthening related vocabulary, use of spelling and writing sentences more often so that it can guide connected ideas to be followed easily [2].

Implementation of the "*merdeka*" curriculum, freeing up learning at the elementary level to organize learning content using subject or thematic approaches, with the proportion of learning burden divided into intracurricular learning and projects to strengthen the *Pancasila* student profile [8]. The *Pancasila* student profile is a lifelong profile of Indonesian students who are competent, have character, and behave according to the values of *Pancasila* [9]. It has six competencies and is formulated as key dimensions that are interrelated and strengthening, namely: (1) faith, fear of God Almighty, and noble character; (2) global diversity; (3) cooperation; (4) independence; (5) critical reasoning; and (6) creative. The achievement is carried out through a project, which is cross-disciplinary learning to observe and think of solutions to problems in the surrounding environment [9]. This is in line with the concept of integrated thematic learning which integrates various competencies from across disciplines and allows the growth of literacy as one of the learning outcomes.

The OECD defines literacy as "the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts" [10]. UNESCO explains that a person is called literate if he has a good understanding of reading and writing short statements about his daily life [11]. Reading and writing are the basis of various literacy which is expected to be mastered by students and ideally have been achieved in learning at the elementary level.

Learning at the elementary level, especially in the lower grades, still emphasizes the very significant concept of literacy [10]. However, that does not mean that students cannot be given other knowledge. It’s just that if the concept of literacy has not been understood, then other knowledge will be difficult to understand. For this reason, literacy is still needed as a basis for other literacy and can be combined with various other lessons at school in the form of themes that are presented continuously and dynamically. To make it easier to understand, reading and writing literacy can also be present from local wisdom or culture that is close to students’ daily lives.

Assessment of student literacy began to be carried out intensively in line with the implementation of the minimum competency assessment (AKM), which is an assessment of basic competencies needed by all students to be able to develop their capacity and participate positively in society [12]. AKM measures two basic competencies, reading literacy and mathematical literacy (numeracy). Numeracy is the ability to think using concepts, procedures, facts, and mathematical tools to solve everyday problems in various types of contexts that are relevant for individuals as citizens of Indonesia and the world [12]. Numeracy in the AKM shows that mathematics is also basic learning that is important to understand according to its use to solve problems in various fields. A way is needed so that mathematics can be understood more simply.

Not all ways to understand students about mathematics can give maximum results. Understanding is also influenced by the characteristics and basic abilities of students. Difficulties in learning mathematics experienced by students include understanding the complex relationship between everyday language and mathematical language and its mathematical representation [13]. This happens because mathematics is a foreign language and not the first language for most students (unknown since learning to recognize languages except counting small integers), which is learned almost entirely at school and is not spoken at home [14], also because students cannot relate the new knowledge they have received with other knowledge [15]. In addition, students need direction in using appropriate mathematical language and understanding how to map words into symbolic forms and representations of mathematical concepts [16].

The *merdeka* curriculum emphasizes that in activities involving mathematics, students are expected not only to build their mathematical knowledge but also to hone skills such as reasoning, communicating, applying, solving problems, and others, so that they get a complete and meaningful mathematical experience [17]. For this reason, mathematics subjects in the *merdeka* curriculum are organized into five process elements, including mathematical reasoning and proof, problem-solving, communication, mathematical representation, and mathematical connections [18], which are compatible with the five standardized processes set NCTM for school mathematics [19].

Five elements of content in mathematics learning are also defined, including numbers, algebra, measurement, geometry, as well as data and probability analysis [18] which are further reduced to content standards with six scopes of learning mathematics in elementary schools [20]. Six scopes appear to be separate, but in their application, the connection between concepts can always be found. Such as the concept of numbers in arithmetic operations, the concept of numbers in measuring and estimating object attributes, interpreting data in measurements, and so on.

Connectedness is one element of the process, namely mathematical connection. "A mathematical connection is a link (or bridge) in which prior or new knowledge is used to establish or strengthen an understanding of relationships between or among mathematical ideas, concepts, strands, or representations" [21]. Mathematical connections show the importance of linking mathematical concepts with various fields so that students get meaningful learning outcomes and reduce students learning difficulties in mathematics.

This shows that mathematics learning can be done using the connected model, which is a learning model that combines the details of a discipline, focusing on interconnections in each field of study, with content that is connected from topic to topic explicitly [22][23]. One of the problems that contain mathematical connections can be found in culture. Mathematics learning needs to be linked to culture because "mathematics is a compilation of progressive discoveries and inventions from cultures around the world during the course of history" [24].

Mathematics and culture are often interconnected and make school mathematics closely related to the society in which mathematics is taught [25]. "A culture based mathematics is a salient component to pedagogical practices because it affords educators real-life practices with cultural implications embedded with mathematical concepts" [26]. Culture-based mathematics learning is one of the interesting, fun, and innovative learning alternatives because it allows contextual meaning based on students' experiences as members of a cultural community so it is expected to support the literacy movement [27].

The mathematical concepts that can be identified in culture are known as ethnomathematics, i.e. "the mathematics practiced by cultural groups, such as urban and rural communities, groups of workers, professional classes, children in a given age group, indigenous societies, and so many other groups that are identified by the objectives and traditions common to these groups" [28]. Ethnomathematics can strengthen the roots of understanding mathematics through the process of knowing and assimilating the dominant culture as long as its cultural roots are also strong [28].

One of the uses of ethnomathematics is as "an approach of teaching and learning mathematics which builds on the student's previous knowledge, background, the role his environment plays in terms of content and method, and his past and present experiences of his immediate environment and the approach could be in a practical way" [29]. This is reinforced by the development of the trivium curriculum concept by Ubiratan D'Ambrosio which is based on three concepts, including literacy, matheracy, and technoracy [28] [30]. Literacy is the ability to process and use information in everyday life in writing and orally, which includes reading, writing, arithmetic, representing, using media and the internet.

Matheracy is the ability to interpret and analyze signs and codes, propose and use models and simulations in everyday life, and describe abstractions based on real representations. While technoracy is the ability to use and combine instruments, both simple and complex, including one's own body, then evaluate the possibilities and limitations as well as their adaptation to various needs and situations.

The concept of the trivium curriculum shows that ethnomathematical-based learning can contain various concepts in mathematics or contain interrelationships between subjects that can be identified from a culture. It is also in line with the achievement target of AKM. Reading literacy in AKM is following with the concept of literacy in the trivium curriculum, while numeracy is compatible with the concept of matheracy. This is the basis for developing a new learning model that combines the trivium curriculum in ethnomathematics, thematic approaches, and connectedness in an appropriate cultural theme.

The learning model is a description of a learning environment including teacher behavior when the model is used [31] or a conceptual framework that describes systematic procedures in organizing learning experiences to achieve learning goals [32]. It also contains strategies, techniques, methods, materials, media, and assessment tools, which are used as guidelines to achieve learning objectives [33]. The learning model has three characteristics, including goals, phases, and foundations [34]. The learning model is designed to help students develop critical thinking skills and gain an in-depth understanding of specific materials. A series of steps (phases) in the learning model aims to help students achieve specific learning objectives. The existence of this learning model must be supported by theory and research on learning and motivation.

A learning model contains syntax; a social system; the principle of reaction; a support system; instructional impact and accompaniment impact [31]. The syntax is a learning step, each step is called a phase. The social system shows the expected interactions between teachers and students and the norms that must be followed. The principle of reaction shows the attitude and behavior of the teacher to respond to student activities in learning. Support systems are elements that are conditioned to support the implementation of the learning model. The instructional impact is learning outcomes that are achieved by directing students to the expected learning objectives. The accompaniment impact is an impact that appears unplanned and is another learning result obtained from a learning process as a result of creating a learning atmosphere that is experienced directly by students without direction from the teacher.

The development of learning models needs to be done by paying attention to the environment that is close to students, one of which is culture. *Indonesian* culture is very diverse and interesting to explore and study the knowledge contained in it. One of them is the *Banyuwangi* culture. *Banyuwangi* is one of the regencies located at the eastern tip of the island of Java. The indigenous people of *Banyuwangi* are known as the *Using* tribe(some write as *Osing* or *Oseng*). The *Indonesian* dictionary states that the term *Using* can be interpreted as an ethnic group that inhabits the *Banyuwangi* area of East Java or the Javanese dialect spoken by the *Using* tribe [35]. The *Using* tribal community is part of an agrarian society with agriculture as the main livelihood system.

The traditional rituals and skills performed by the *Using* tribe are part of the language system, knowledge, society, living tools and technology, livelihood, religion, and art that enrich the cultural treasures of the *Using* community. One of them is knowledge about the ancient units of calculation for local rice. There are units of account for the *Using* community, such as: *"killing* (smallest volume equivalent to half a *bentel* bond), *bentel/sakgegem* (smallest bond volume adjusted to the size of the farmer's hand), *ringgi* (unit volume of 5 *bentel* bonds), *sewelen/sak welen* (unit volume from 6 *ringgi* bonds), *sancing/sak encing* (unit volume from 12 *ringgi* bonds), *sagem*/*sak agem* (unit volume from 25 *ringgi* bonds), and *belibon* (units of account for rice bonds)." [36]

In other studies, it is also known that in the *Using* traditional house there are concepts of two-dimensional and three-dimensional shapes, similarity and congruence, transformations, and fractals [37]. In the *Gandrung Jejer Jaran Dawuk* dance, it can be seen that there are basic mathematical concepts, such as counting, number patterns, angles and their types, and cardinal directions [38]. While in the traditional game *patheng dudu*, it can be seen the concepts of polyhedrons, polygons, counting, comparisons, measurements with standard and non-standard units, angles and their types, relationships between lines, statistics, sets, distances, time, and functions [39].

The existence of mathematical concepts in *Using* culture can be integrated into learning to support students' abilities in various literacy, especially mathematics. One way to integrate culture into learning can be done through the development of learning models, as has been done in several previous studies. The mathematics learning model based on multicultural education has been developed by Danoebroto from the five dimensions of James Banks' multicultural education which consists of (1) cultural integration in mathematics content; (2) construction of mathematical knowledge through context and cultural understanding; (3) pedagogic equality; (4) reduce prejudice; and (5) empowering conducive school culture [40]. While the results of another study show that teaching the thematic model based on local wisdom will be a connection for students in achieving understanding to determine appropriate actions when dealing with various global challenges [41].

Based on the previous discussion, research was conducted on the development of the Ethnomathematics-Thematic-Connected (ETC) learning model. In general, this learning model can be used in various cultural spheres. However, in this study, the development of the ETC learning model is limited within the scope of *Banyuwangi* culture.

2. Objectives

This research is aimed at developing a learning model that combines the trivium curriculum in ethnomathematics, thematic approaches, and connectedness in mathematics. In addition, the research is also aimed at determining the quality of the developed model through its validity, practicality, and effectiveness.

3. Methods

This development research aims to determine product quality and provide insight into the application of frameworks in various domains of educational product development [42], as well as develop research-based solutions to complex problems in educational practice [43]. The product in question is the ETC learning model. Achieving the quality of a product in education contains four criteria, including relevance, consistency, practicality, and effectiveness [42] [44]. Relevance or content validation is the novelty and compatibility between each product component and the supporting theory. Consistency or construct validation is consistency between product components. Practicality includes two assessments, the assessment of experts and practitioners who state that the developed product can be applied (Intended-Perceived/IP), and assessments from teachers and students who state that the developed product is easy to use in real terms (Intended-Operational/IO). Effectiveness includes two assessments, assessments from experts and practitioners who state that the product provides results as expected (Intended-Experiental/IE), and assessments from teachers and students who state that the product provides results as expected after use (Intended-Attained/IA).

	Quality aspects		
	Validity	Practicality	Effectiveness
Represen-tations	Intended (ideal + formal): • State-of-the-art • Internally consistent	Consistency between • Intended ↔ Perceived • Intended ↔ Operational	Consistency between • Intended ↔ Experiential • Intended ↔ Attained

Figure 1 Relationship Aspects of Quality and Representation [42]

Intended is an expectation, perceived is a condition that is felt, operational is a condition that is carried out, experiental is experienced, and attained is an achievement.

This research was conducted using the Plomp model which was limited to the fourth phase. Plomp shows a model for designing education [45] which contains 5 phases, including (1) initial investigation; (2) design; (3) realization/construction; (4) test, evaluations, and revisions; and (5) implementation. The research was carried out according to the flow in Figure 2.

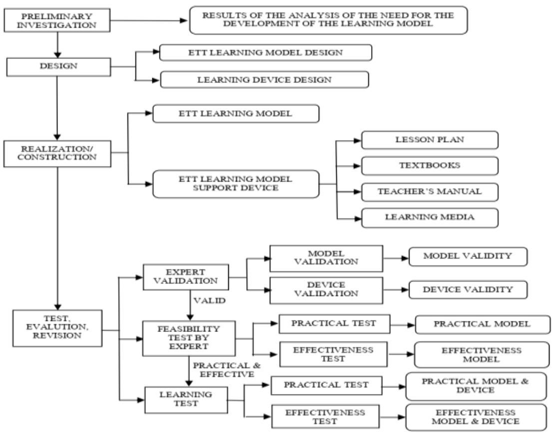

Figure 2 Development Research Flow

In the first phase, the activities of problem identification, needs analysis, and theoretical studies supporting model development were carried out. Identification is done to find out the problems of learning in elementary schools in Banyuwangi before, such as learning models that have been used; teacher and student learning responses; obstacles to the use of learning models; how to overcome obstacles; and students' understanding by using the previous learning model. The identification was carried out through interviews in five elementary schools based on the *Using* tribe, i.e. SDN Kenjo, SDN 1 Sukojati, SDN 1 Gumirih, SDN 3 Boyolangu, and SDN 1 Pesucen. The interview respondents were three lower grade teachers in each school.

Needs analysis consists of the analysis of student conditions and curriculum analysis. Analysis of student conditions was carried out according to the results of problem identification. Curriculum analysis contains the curriculum used, the expected competency achievements of students, materials, and tasks as evaluations for students. The curriculum used in this analysis is the 2013 curriculum and the *merdeka* curriculum. Furthermore, relevant theoretical studies are carried out for the development of learning models.

In the design phase, the components of the learning model consist of syntax, social systems, reaction principles, support systems, instructional impacts and accompaniment impacts. A learning device design is also made that includes lesson plans, student textbooks, and teacher manuals. Furthermore, the design is made into a product in the realization phase. The products are ETC learning model books, supporting tools for three lessons, as well as product assessment instruments.

The fourth phase begins with product validation of model books and learning support devices, as well as testing the practicality and effectiveness of the experts. Test the validity, practicality, and effectiveness of the ETC learning model and device using a questionnaire instrument. The assessment was carried out by two expert lecturers majoring in mathematics education from two universities with competencies in learning mathematics, developing learning models, and/or ethnomathematics. It was also carried out by two principal practitioners of two elementary schools in Banyuwangi, with competence in learning in elementary schools and understanding the implementation of the 2013 curriculum and the *merdeka* curriculum.

The analysis of validation, practicality and expert effectiveness was carried out according to the formula for determining validity (V_a), intended-perceived (IP), and intended-experiental (IE) developed by [45]. V_a, IP, and IE criteria refer to the following three figures.

Interval	Validity Level Criteria
$1 \leq V_a < 2$	Invalid
$2 \leq V_a < 3$	Not valid
$3 \leq V_a < 4$	Quite valid
$4 \leq V_a < 5$	Valid
$V_a = 5$	Very valid

V_a : Validity
Source : Hobri (2009:78)

Figure 3 Validity Level Criteria

Interval	Criteria for the Level of Implementation of the Model by Experts
$1 \leq IP < 2$	Very low
$2 \leq IP < 3$	Low
$3 \leq IP < 4$	Currently
$4 \leq IP < 5$	High
$IP = 5$	Very high

IP: Intended Perceived
Source : Hobri (2009:79)

Figure 4 Intended-Perceived Criteria

Interval	Model Effectiveness Level Criteria
$1 \leq IE < 2$	Very low
$2 \leq IE < 3$	Low
$3 \leq IE < 4$	Currently
$4 \leq IE < 5$	High
$IE = 5$	Very high

IE: Intended Experiental
Source : Hobri (2009:83)

Figure 5 Intended-Experiental Criteria

Products that have reached a minimum level of good validity, high intended-perceived (IP), and high intended-experiental (IE), are then tested to determine the intended-operational (IO) and intended-achievement (IA). The trial was conducted at SDN 1 Giri because it was in the *Using* culture. SDN 1 Giri is also an area that represents the condition of the village (west direction) and the city (east direction). So students at SDN 1 Giri represent these two environmental conditions. Respondents are 1 teacher and 10 grade 3 students.

The data from the experimental observation of the ETC model is used to determine the reliability of the observation instrument with the concept of percentage of agreements according to the rules of [46]. After that, the data were analyzed based on the intended-operational (IO) determination formula developed by [45], and the IO criteria were determined based on Figure 6. The ETC learning model is said to be practical if IP is consistent with IO.

Interval	Criteria for Model implementation Level by Observers
$1 \leq IO < 2$	Very low
$2 \leq IO < 3$	Low
$3 \leq IO < 4$	Currently
$4 \leq IO < 5$	High
$IO = 5$	Very high

IO: Intended Operational
Source : Hobri (2009:78)

Figure 6 Intended-Operational Criteria

Intended-attained (IA) is determined based on the data on the results of problem-solving, the frequency of student and teacher activities, the teacher's ability to manage the class, and student responses. Analysis of the results of problem-solving was carried out to determine the value of the student mastery level (TPS) with the criteria in Figure 7.

Interval	Criteria for Student Mastery Level
$0 \leq TPS < 40$	Very low
$40 \leq TPS < 60$	Low
$60 \leq TPS < 75$	Currently
$75 \leq TPS < 90$	High
$90 \leq TPS \leq 100$	Very high

TPS: Student Mastery Level
Source : Hobri (2009:85)

Figure 7 Student Mastery Level Criteria

Data from observation of student and teacher activities are used to determine the average frequency and the average percentage of time [45]. The criteria for the ideal time for student and teacher activities are contained in Figure 8.

Category Aspect	Ideal Time	Tolerance Interval for Achieving Ideal Time	Criteria
Teacher Activity			
a. explain the material/provide information	25% AT	$20\% \leq AIT \leq 30\%$	two of the three aspects of categories (a, b, c) are met and category b must be met
b. observing student activities, motivating, giving instructions, guiding student activities	75% AT	$70\% \leq AIT \leq 80\%$	
c. Irrelevant treatment	0% AT	$0\% \leq AIT \leq 5\%$	
Student Activities			
a. listen/pay attention to the explanation of the teacher/other students, answer questions	25% AT	$20\% \leq AIT \leq 30\%$	three of the five aspects of categories (a, b, c, d, e) are met and categories c, d must be met
b. Reading, observing pictures/learning objects	15% AT	$10\% \leq AIT \leq 20\%$	
c. Taking notes, doing exercises/solving problems, summarizing, doing learning activities, presenting learning outcomes	30% AT	$25\% \leq AIT \leq 35\%$	
d. discuss/ask questions between students and teachers as well as between students	30% AT	$25\% \leq AIT \leq 35\%$	
e. do activities that are not relevant	0% AT	$0\% \leq AIT \leq 5\%$	

AIT : Achieving Ideal Time
AT : Available Time (on every lesson)
Source: (Hobri, 2009:90)

Figure 8 Criteria for Ideal Time for Student and Teacher Activities

Learning management result data were analyzed based on the teacher ability score (NKG) formula (NKG) developed by [45] with the criteria in Figure 9.

Interval	Criteria for Teacher Ability in Managing Learning
$1 \leq NKG < 2$	Not very good
$2 \leq NKG < 3$	Not good
$3 \leq NKG < 4$	Pretty good
$4 \leq NKG < 5$	Good
$NKG = 5$	Very good

NKG: Teacher Ability Score
Source: Hobri (2009:92)

Figure 9 Criteria for Teacher Ability to Manage Learning

Teachers can manage to learn if they achieve a minimum NKG of good. The student response data determines the achievement of learning objectives if a positive response is obtained from ≥80% of students who become learning respondents [45].

The ETC model is effective based on the IA if: ≥80% of students who take part in learning can achieve a problem-solving score of at least 75; the ideal percentage of time for student and teacher activities is achieved; the teacher's ability to manage to learn is at least good; there are ≥80% of students' positive responses to the components of the model and learning activities. Furthermore, the ETC model is effective if there is consistency between IE and IA.

4. Results

The results are described according to the four steps of Plomp development.

Investigation

In the investigation, the identification of information on previous learning problems was carried out to produce a rational formulation of the importance of model development; analysis of student conditions and curriculum; and appropriate theoretical studies to develop learning models. The results show that generally learning in low grades cannot be directly focused on discussing mathematical concepts because it requires character strengthening, such as greeting when entering class, praying before and after learning, how to sit properly, and how to read and write correctly, and so on.

So far, teachers do not understand the learning model used. teachers only carry out direct learning and/or group activities. In lower classes, learning is generally carried out directly because it is considered more practical with a maximum of 15 students, and mode effective because all students can focus on the material presented by the teacher. Groups are formed if needed and only consist of two people (students at the same seat).

In the 2013 curriculum, learning in lower grades uses a thematic approach. Some teachers are constrained in understanding the mathematical concepts in the theme. Thematics are considered to make students not focus on understanding the material because learning seems forced. Students' understanding of the material is less attached so it becomes a burden in the next class. The teacher overcomes obstacles by giving more portions of mathematics, teaching specifically (not using themes), adding math exercises from student worksheets or other books (not in thematic concepts), and giving story questions to familiarize students with understanding sentences in the exercises. However, the learning outcomes have not reached expectations. Learning outcomes still vary according to students' basic abilities and literacy.

Generally, students are not only constrained by understanding mathematics. Around 50% of students still have problems in reading and writing (except at SDN 1 Pesucen where students already have quite good literacy due to learning support from the early childhood education level). Students who are not fluent in reading and writing always have difficulty understanding learning information. This is an additional task for teachers, especially in lower classes to improve student literacy.

Literacy is also influenced by the condition of lower grade students who are still accustomed to communicating in their mother tongue (*Using* language). So learning must be in two languages (Indonesian and *Using* language). Unfortunately, many mathematical concepts tend to be more easily conveyed in Indonesian. The teacher tries to make students understand mathematics in simple language.

Low-grade students also need learning conditions that are not too serious because they get bored easily. teachers must be creative in managing learning by inserting fun activities. To overcome abstract mathematical understanding, the teacher uses objects around students such as pebbles, broomsticks, seeds, leaves, and others. Some teachers use traditional games, such as *dakon*. In the concept of angles, the teacher uses hand movements to show angles and their types. These conditions indicate that low-grade students still need learning activities while playing. This is following Vigotsky's theory that there are three key elements in learning, including aspects of play, language, and socio-culture [47]. This means that learning can be done through games, by the language and culture that is close to students' daily lives.

Media needs at the elementary level according to Piaget's theory of cognitive development [48] where children aged seven to eleven years are at a concrete operational level, whose logical thinking begins to develop using classification or categorization based on similarities and differences, but is only applied to real things. Children also begin to have reversibility, which is the ability to change the direction of thought so that it can return to its original understanding. For example, finding subtraction through addition operations. However, children's thinking is still focused on things that are concrete and can be seen.

Cultural integration as a learning medium is adjusted to the conditions of students who still use their mother tongue. Each culture composes its language, classifies it, has an explanation of the story, has its way of connecting ideas through discourse, and has several main sources to validate its explanation [49]. Culture develops ways, styles, and techniques for doing things as well as responses to the search for explanations, understanding, and learning about how and why things are done [50]. Vigotsky states that intellectual development can be understood only in the historical and cultural context experienced by children, and it depends on the sign system (the symbols created by a culture that help people think, communicate, and solve problem) that a person follows [51].

Culture contains a variety of knowledge, one of which is mathematics. Bishop identifies six types of everyday mathematical activities that are cross-culturally involved, including counting, locating, measuring, designing, playing, and explaining [49]. The mathematics that can be identified from culture is known as ethnomathematics according to the definition presented by [28]. In addition, ethnomathematics can also be understood as a form of research on the history and philosophy of mathematics [24], as well as an approach to learning mathematics [29].

In some cases the results of ethnomathematical identification can almost be translated directly into curriculum materials, enrichment content, activities based on the use of mathematical culture, and new applied examples for students to work on [52]. Otherwise, the use of ethnomathematics in the classroom will depend on the information learned from field research. The implementation of ethnomathematics in learning is reinforced by the trivium curriculum developed by Ubiratan D'Ambrosio. This curriculum is based on three concepts, including literacy, matheracy, and technoracy [28] [30]. The concept of literacy and matheracy is compatible with AKM. so that the implementation of the trivium curriculum in learning can support efforts to strengthen literacy and numeracy.

Learning was hampered by the COVID-19 pandemic which caused the learning process to not be optimal, resulting in a learning loss. The government through the Ministry of Education stipulates the implementation of the curriculum to restore learning [8] which is developed by an educational unit with the principle of diversification according to its conditions, regional potential, and students. In elementary education, the organization of learning content can be arranged by the teacher with a subject or thematic approach to get maximum results. This can be done also in math subjects.

In the *merdeka* curriculum, it is stated that the achievement of learning mathematics has relevance to the profile of Pancasila students [20], including developing independence, critical reasoning, and creativity. Mathematics learning contains six content standards, which are the minimum criteria that contain the scope of the material to achieve graduate competence in the path level, and types of education [18]. The six content standards contain links to the corresponding concepts. So that these concepts can be taught using mathematical connections which is one of the standard processes of mathematics subjects. It is a learning program that enables students to (1) recognize and use connections between mathematical ideas; (2) understand how mathematical ideas are interconnected and related to producing a unified whole; (3) recognize and apply mathematics in contexts outside of mathematics [20].

The *merdeka* curriculum structure at the elementary education level also mentions the five principles of learning as a process of student interaction with teachers and learning resources in a learning environment [8]. The first is learning is "designed by considering the stage of development and current level of achievement of students according to learning needs and reflects the characteristics and development of diverse students so that learning becomes meaningful and fun". This principle is supported by Gagne who states that the delivery of important material is carried out sequentially starting from the prerequisite material [53].

Ausubel and Vigotsky state that meaningful learning or understanding can be achieved through linking new information with previous knowledge [53] [54]. Piaget explained that cognitive development is a process that occurs actively when children build systems of meaning and understanding of reality through experiences and interactions [53]. Bruner states that learning that is done by reinventing (not discovering new things) can provide meaningful achievements [53] [54], and knowledge is built from experience [47] so it takes mastery of simple skills to perform more complex skills [53].

Meaningful learning can be realized through the interrelationships between the concepts contained in the connected model. The connected model is based on the theory of connectivism. Dunaway states that connectivity is a learning theory in and of itself, but to be an effective learning theory it requires metalliteration (a framework that integrates various types of literacy) and transliteration (reading, writing, and interacting skills across various programs) [55]. Metalliteration and transliteration are the integration of literacy with other abilities such as mathematics and technology. This fits into the trivium curriculum in ethnomathematics

The second principle states that "learning is designed and implemented to build capacity to become lifelong learners". This is supported by the theory of Dewey that there must be a long-life education [56]. Comenius supports the theory that learning must be done early and lasts a lifetime [47].

The third principle is that "the learning process supports the development of competencies and characteristics of students holistically". This means that learning must be carried out according to the level of student understanding. Piaget supports this by stating that there is a sequence of cognitive development that requires children to be at a certain stage of development to be able to learn new concepts [47]. New ideas and knowledge must be presented at a level and style appropriate to the child's way of thinking, learning must be adapted to individual needs and presented in new situations to trigger assimilation and accommodation [47]. Meanwhile, Vigotsky stated that the learning process can occur if the child completes a task that has not been studied as long as the task is still in the zone of proximal development [47] [51] [53].

The fourth principle is “relevant learning, which is learning that is designed according to the context, environment, and culture of students, and involves parents and the community as partners”. Dewey supports this principle by stating that education should be based on real-life situations including social interactions with others [47]. Gagne stated that the process of receiving information in learning occurs through interactions between students’ internal and external conditions which are then processed to produce outputs [53]. Piaget stated that all children are born with an innate tendency to interact and understand their environment to produce patterns of behavior or thinking called schemas, which can be obtained through a process of adaptation (assimilation and accommodation) with the environment [47].

Vigotsky supports the theory of the need for scaffolding in learning from teachers or other students [51], and the need for collaboration between students to obtain the same understanding [47]. While Bruner said that one of the experiences that can build knowledge can be obtained from the culture [53]. In addition, learning requires scaffolding and social interaction [54].

The fifth principle is “continuous future-oriented learning”. Piaget supports the opinion that children continue to construct and reconstruct reality to improve understanding through the integration of simple concepts into more complex concepts [47]. Thus, children will experience thriving and sustainable learning.

Based on the above theories, a learning model was developed that links the trivium curriculum with thematic and connected approaches to learning mathematics within the *Banyuwangi* culture, which is called the Ethnomathematics-Thematic-Connected (ETC) learning model. The ETC model can be defined as a model in mathematics learning that was developed by containing the concepts of literacy, matheracy, and technoracy, implemented thematically with at least one other subject, and connected from at least two mathematical concepts. The cultural base used is the *Banyuwangi* culture which consists of the *Using* traditional house, *Gandrung Jejer Jaran Dawuk* (GJJD) dance, and the traditional game of *patheng dudu*. The development of supporting devices for the ETC model is carried out at the 3rd grade level of elementary school.

Design

The design of the ETC model includes syntax, social systems, reaction principles, support systems, and learning impacts. The syntax is designed as in Figure 10.

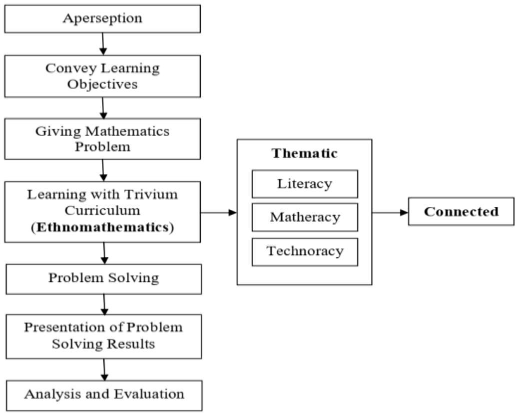

Figure 10 Syntax Design of the ETC Learning Model

Next, a social system is designed according to learning needs. If learning is done in groups, the teacher can form small groups that are effective for learning. So that there can be an interaction between students and/or between students and teachers. If learning is done individually, the teacher can design classical learning. So that there is an interaction between students and teachers to get scaffolding.

Based on the design of the social system, teachers are expected to react as facilitators, consultants, and mediators. The teacher acts as a facilitator in preparing learning tools, facilities, and learning resources according to the lesson plan, as well as creating a learning atmosphere in a cultural context. The teacher acts as a consultant in the activity of conditioning students to fit the lesson plan and providing the necessary scaffolding. While the teacher acts as a mediator in the activity of giving students direction during the process of presenting the results of problem-solving, analysis, and evaluation so that the activities run according to the lesson plan.

The support system is designed in the form of classroom settings, learning systems, learning tools, learning facilities, and learning media. Classes are designed so that students can interact during learning independently or in groups. Learning tools are designed in the form of lesson plans, student books, and teacher manuals. The lesson plan is designed for three lessons according to the cultural context used. Learning facilities are designed to assist in the implementation of lesson plans. While the learning media is designed according to learning needs.

The learning impact contains two components, the instructional impact and the accompaniment impact. In general, the impact of learning cannot be designed but can be expected. The expected instructional impact of learning with the ETC model is an increase in students' ability to solve cultural-based mathematical problems and their mathematical connections. While the expected accompaniment impact is that students are more familiar with the culture, can work together in solving problems, can account for the results obtained, are accustomed to processing information obtained from a problem to get the right solution, and support the achievement of the Pancasila student profile, especially in the independent, critical and creative thinking dimensions.

Realization/construction

At this stage, the product is made according to the design. The result of the ETC learning model is called a model book which contains: a definition, supporting theory, objectives of model development, components of the ETC learning model, and evaluation. The supporting tools for the ETC model consist of lesson plans for three lessons, student textbooks, and teacher manuals. To determine product quality, validity, practicality, and effectiveness tests were conducted. So that an instrument was developed for the test. Each instrument was consulted with two supervisors and one education expert. After the instrument is declared usable, then all products proceed to the next stage of development.

Test, Evaluation, and Revision

Product quality assessments were carried out by two experts and two practitioners. The first evaluator (V_1) is an expert in mathematics learning and has developed a mathematics learning model and teaches at one of the universities in *Surabaya*. The second evaluator (V_2) is an expert in mathematics and ethnomathematics and teaches at one of the universities in *Yogyakarta*. The third (V_3) and fourth (V_4) appraisers are practitioners who serve as principals at elementary schools in *Banyuwangi*.

Analysis of the evaluation of the validity of the content of the ETC model showed a value of $V_a = 4.66$, which means that the content of the ETC model has valid criteria [45]. V_1 suggests clarifying: the implications of Gagne's theory on the second indicator, connected dan thematic characteristics on social systems and reaction principles, and characteristics of the ETC model on evaluation. V_2 suggests clarifying: the support for Comenius's theory in the ETC model and the meaning of the sentence "learning can be done individually (classical)". While V_3 and V_4 suggest writing improvements.

Analysis of the construct validity of the ETC model shows the value $V_a = 4.52$, which means that the construct of the ETC model has valid criteria [45]. V_1 suggests adding explanations related to ETC indicators in social sub-systems, thematic and connected aspects that characterize the ETC model on the reaction principle and clarifying the instructions for implementing the evaluation. While the other evaluators suggested improvements to the writing.

The implementation of the ETC model by experts shows a value of $IP = 4.67$, which means the ETC model has a high level of implementation [45]. Suggestions given by the evaluator are only for writing improvement. The evaluation of the effectiveness of the ETC model by experts shows the value of $IE = 4.57$, which means the ETC model has a high level of effectiveness [45]. V_3 suggests the need for self-reflection on student responses to components and the learning process to measure achievement. While the other evaluators suggested improvement in writing.

The validity of the lesson plan shows the value of $V_a = 4.66$, which means that the lesson plan has valid criteria [45]. V_1 suggests synchronizing learning objectives with learning outcomes on the concept of angles. V_3 suggests clarifying the problem so that the connection with the core activity appears, describes the time for students to internalize and ask questions, and completes the learning objectives with conditions and degrees. V_4 suggests adjusting the time required with the density of the material because the teaching material is quite extensive and full of practice and discussion. While V_2 suggests writing improvements.

The validity of student textbooks shows the value of $V_a = 4.6$, which means that student textbooks have valid criteria [45]. V_1 suggests adding feedback and evaluation to the textbook, clarifying the sections that include questions for practice and evaluation, synchronizing learning objectives with learning outcomes, paying attention to writing according to the correct spelling, and re-checking the involvement of angles in the definition of n −sided. V_3 stated that the textbook is very good and according to the needs of students to develop their competence and potential. While V_2 and V_4 suggest writing improvements.

The validity of the teacher's guidebook shows the value of $V_a = 4.73$ which means that the teacher's guidebook has valid criteria [45]. V_1 suggests mentioning the content of the trivium curriculum in the teacher's manual, writing down intervals according to math rules, and explaining the size of right angles in student textbooks. V_3 stated that this book was very helpful for teachers in carrying out ethnomathematical learning. V_4 stated that this book was good and by the flow of the lesson plans and textbooks. While V_2 suggests writing improvements.

The results of improving the model and learning tools are then re-examined by the evaluator. After being declared usable, a learning trial was conducted at SDN 1 Giri on 4, 7, 11, and 14 June 2022. The first trial contains the concept of the trivium: (1) understanding the GJJD dance through reading and video (literacy); (2) determining the angle and its type and making a table from the angle and type data in the GJJD dance movement (matheracy); (3) practicing the first part of GJJD dance (technoracy). This lesson includes Indonesian language, dance, and mathematics subjects which are integrated into traditional dance themes. In the mathematics learning outcomes, the characteristics of two-dimensional shapes are focused on the introduction of angles and their types, while the activities of comparing, presenting, analyzing, and interpreting data are focused on the introduction of tabular forms. So that the achievement of learning mathematics is conveyed in a connected manner from the concept of angles and statistics.

Learning with the ETC model on the first day is not optimal because there are three videos that students must watch, many practice questions do not match the time available, and there are students who are not yet fluent in reading so the teacher needs to pay more attention, understanding the concept of angles and their types are not accompanied by visualization in textbooks, and students need scaffolding in solving problems. So that the final four phases of the syntax (problem-solving, presentation of results, analysis, and evaluation) cannot be carried out.

Figure 11 First Learning Trial

Based on these conditions, improvements were made to learning devices. These improvements include: (1) the practice of dance moves does not show videos but is enough from reading and teacher directions; (2) reducing practice questions; (3) adding visualization of the introduction of angles and their types in textbooks; (4) provide scaffolding for the identification of the angle type of the image; (5) write a conclusion about the angle and its type at the end of the exercise; (6) introduce table writing with the turus before identifying the types of angles; and (7) provide problem-solving sheets containing scaffolding. Then it is planned to repeat the first lesson after the third lesson.

The second lesson contains the trivium concept: (1) understanding the *Using* traditional house through reading and practice questions (literacy); (2) recognizing the types of quadrilaterals and determining the amount of money needed in an activity (matheracy); and (3) making a miniature of *Using* traditional house (technoracy). This lesson includes Indonesian subjects, natural and social sciences (IPAS), fine arts, and mathematics to be integrated into the *Using* house theme. In the mathematics learning outcomes, the characteristics of the two-dimensional form are focused on the types of quadrilaterals. While the learning outcomes of problem-solving are focused on determining the amount of money needed to buy *gedhek*. So that mathematics subjects are delivered in a connected manner from the concept of quadrilaterals and economic mathematics.

Figure 12 Second Learning Trial

Learning with the ETC model on the second day has been maximized. All syntax phases are met and students can solve problems with several variations of answers. Because the initial learning was not conducive, the teacher changed the order of the learning steps by making a miniature of *Using*'s house first so that students focus on learning. Some of the improvements made include: (1) reducing practice questions about the Using traditional house; (2) adding a rectangular learning media visualization; (3) giving a number to the question of identification of rectangular shapes; and (4) providing problem-solving sheets and clarify scaffolding. The second lesson is not repeated, but device improvements are used in the implementation process.

The third lesson contains the concept of the trivium: (1) understanding the game *patheng dudu* through reading (literacy); (2) measure the side length of a polygon and/or the edge length of a polyhedron, add up all side lengths and/or edge length, and write down the measurement results in tabular form (matheracy); and (3) playing *patheng dudu* (technoracy).

Figure 13 Third Learning Trial

This lesson contains Indonesian and mathematics subjects to be integrated into traditional game themes. The mathematics learning outcomes are focused on the length of the side surface of the *dudu* in centimeters, the results of measuring the length of the sides of the *dudu*, as well as presenting and analyzing data in tabular form. So that mathematics subjects are delivered in a connected manner from the concepts of measurement, numbers, and statistics.

Learning with the ETC model on the third day has been maximized. All syntax phases are met and students can solve problems with a variety of answers according to the selected *dudu*. Some of the improvements include: (1) changing the phrase "each *dudu*" to "one *dudu*" in the problem; (2) removing the exercise on the two-dimensional shape; (3) creating worksheets for measuring the length of the sides of the *dudu*'s surface and problem-solving sheets containing a table of measurement results; and (4) adding an explanation of decimal numbers in the textbook. The third lesson is not repeated, but improvements to the device are used in the implementation process.

The first lesson was repeated with the trivium concept: (1) understanding the GJJD dance through reading and teacher direction (literacy); (2) determining the angle and its type and making a table from the angle type data in GJJD dance movement (matheracy); (3) practicing the first part of the GJJD dance without tools and videos (technoracy). The integration of the three subjects in the theme, the connection to mathematics, and learning outcomes have not changed.

Figure 14 Repeat the First Learning Trial

The repetition of learning with the ETC model has been maximized. Students can solve problems by determining the type of angle in the GJJD dance movement, as well as making a table using a turus.

Learning observations with the ETC model were carried out by one lecturer and one elementary school teacher. The results of the three learning observations according to the model are used to determine the reliability of the instrument as well as the intended-operational value. The reliability of the instrument shows the results of $R = 90.91\%$, which means that the observation sheet is said to be reliable [57]. While the intended-operational shows a value $IO = 4.22$ which means that the implementation of the model has high criteria [45].

The effectiveness of the ETC model is determined through expert judgment, the results of student problem solving, observation data on student and teacher activities, the ability of teachers to manage classes, and student responses to learning. Problem-solving performed by students showed an average of 91.80 in the first learning (repetition) with a very high level of mastery, in the second learning of 88.83 with a very high level of mastery, and the third learning of 80.05 with a high level of mastery [45].

Observations of students in learning show that the activities of listening/paying attention to explanations require 23.05% AT; reading textbooks/other teaching materials requires 14.98% AT; notes explanation and solving problems requires 31.92% AT; discussion/asking requires 25.15% AT; and activities not relevant to learning require 4.90% AT. So the ideal percentage of student activity time has been fulfilled. Observations of teachers in learning show that the activities of: explaining material/providing information require 28.21% AT; observing student activities, motivating, giving instructions, and guiding student activities require 70.05% AT; and activities that are not relevant to learning require 1.75% AT. So the ideal percentage of teacher activity time has been fulfilled.

The analysis of the results of observations of learning management with the ETC model in three lessons (after repetition) shows the value of $NKG = 4.04$, which means the teacher's ability to manage learning with the ETC model includes good criteria [45]. Student responses to learning show the average percentage of positive responses for all aspects is 98.33%, meaning that the learning objectives are achieved [45].

Because: (a) the average level of student mastery of the three lessons is high; (b) the ideal percentage of time for student and teacher activities is achieved; (c) the ability of teachers in managing to learn to achieve good results; and (d) there are 98.33% of students who give a positive response to the components of the model and learning activities, so the ETC model is effective based on the intended-attained.

Since the results of the content and construct validation assessment match with the specified conditions, the ETC model meets the requirements for the validity of a product. In addition, there is consistency between IP and IO which makes the model practical to use, as well as consistency between IE and IA which makes the model effective to use. This is under the explanation of Nieveen in the research methods section above [42] [44].

Because the validation test (V_a) of the ETC model and learning tools shows valid results; the value of intended-perceived (IP) and intended-operational (IO) show practical results; and the value of intended-experiental (IE) and intended-attained (IA) showed effective results, then the ETC model was declared to have good quality and was feasible to use [42] [44].

5. Discussion

Curriculum development needs to be followed by the development of learning support models and devices. This is under the results of previous studies which stated that school curricula, including mathematics, need to be translated into mathematical ideas, procedures, and practices between different mathematical systems to help students analyze the relationship between traditional and non-traditional learning in a learning environment [58].

The Ethnomathematics-Thematic-Connected (ETC) learning model is a model in mathematics learning that contains the concepts of literacy, matheracy, and technoracy [28] [30], implemented thematically with at least one other subject [2] [3] [4] [5] [6], and connected between at least two mathematical concepts [22] [23]. The ETC learning model was developed based on the need to meet the achievement targets of learning mathematics in the *merdeka* curriculum so that mathematics learning has relevance to the profile of Pancasila students which is aimed at developing independence, critical reasoning abilities, and student creativity [18].

The ETC learning model can be developed in various cultures, but in this study, the Banyuwangi culture was used. Cultures in various regions contain diverse learning concepts, including mathematics. This is supported by the opinion of [59] which states that culture can be used to explore mathematical concepts as a transformational effort to bring mathematics closer to reality and people's perceptions.

Furthermore, the ETC model can be used on a larger scale, in different cultures as long as ethnomathematics has been identified in that culture, or developed for higher education levels.

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Combining Ethnomathematics, Thematics, and Connectedness in a Mathematics Learning Model for Elementary School

by Lppm Uniba

Combining Ethnomathematics, Thematics, and Connectedness in a Mathematics Learning Model for Elementary School

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Abstract

Background: Curriculum renewal requires teachers to always innovate in learning. The teacher can combine various ways as long as it suits the needs and characteristics of learning. The trivium curriculum in ethnomathematics contains the concepts of literacy, matheracy, and technoracy which can be combined with thematic and connected approaches. Ethnomathematics can be used in learning because it contains contextual mathematical concepts that exist in culture. The thematic approach can make students learn several subjects at once in the appropriate theme. Connectedness can make students learn several concepts at once in a subject. The combination can make students learn many things at one time in an integrated and meaningful way because it is based on the culture they know.

Objectives: This research is aimed at developing a learning model that combines the trivium curriculum in ethnomathematics, thematic approaches, and connectedness in mathematics. In addition, research was also conducted to determine the quality of the developed model.

Methods: The development is carried out using the Plomp model which is limited to four phases (without implementation). The respondents consisted of 15 elementary school lower grade teachers as resource persons for problem identification, two lecturers and two elementary school principals as expert evaluators and practitioners, one teacher and ten 3rd grade students at an elementary school in Banyuwangi as pilot respondents. Data collection was done by interviews, observation, tests, and questionnaires. Data analysis is a combination of quantitative and qualitative methods.

Results: The results of the initial investigation show that learning, especially in the lower grades of elementary school, still requires strengthening basic literacy, combines with play activities, learning media, and mother tongue assistance to understand students' learning concepts. The support of several education experts is used to strengthen the results of the investigation so that a learning model can be designed that includes syntax, social systems, reaction principles, support systems, and the impact of learning. Development is carried out based on a design made to produce a learning model along with learning tools. Learning tools are developed by the existing culture in the development area, namely Banyuwangi Indonesia. After the development results are declared valid, practical, and effective by experts and practitioners ($V_a$content = 4.66, $V_a$construct = 4.52, $IP = 4.67$, and $IE = 4.57$), then a trial is carried out to determine the implementation of the learning model. The results show that the learning model developed is practical and effective in being tested in learning ($IO = 4.22$, and good criteria on IA).

Conclusions: The development resulted in a new model called the Ethnomathematics-Thematic-Connected (ETC) model. based on the assessment of experts and practitioners, the ETC model is declared valid, practical, and effective. Based on the experimental practice, the ETC model is stated to be practical and effective. So that the ETC learning model can be said to have good quality and can be used for learning on a larger scale. In addition, the ETC model can also be used in areas other than Banyuwangi by using a cultural base according to the learning area.

***Keywords**:* learning model. ethnomathematics, trivium curriculum, thematic approach, connected model.

1. Introduction

Education at the elementary level is the foundation for the next level which should be strengthened and introduced to the use of basic concepts in everyday life. This is realized in the 2013 curriculum in the form of an integrated thematic approach [1]. Thematic learning is a way or strategy or learning approach designed by connecting various curriculum areas and integrating various competencies from several subjects in a theme or learning process by combining several interesting activities that allow students to move actively and provide meaningful learning [2] [3] [4] [5] [6]. It can be used in elementary education because it matches the characteristics of students at the level of concrete operational cognitive development [7]. The thematic approach allows literacy to grow progressively, in the form of strengthening related vocabulary, use of spelling and writing sentences more often so that it can guide connected ideas to be followed easily [2].

Implementation of the "*merdeka*" curriculum, freeing up learning at the elementary level to organize learning content using subject or thematic approaches, with the proportion of learning burden divided into intracurricular learning and projects to strengthen the *Pancasila* student profile [8]. The *Pancasila* student profile is a lifelong profile of Indonesian students who are competent, have character, and behave according to the values of *Pancasila* [9]. It has six competencies and is formulated as key dimensions that are interrelated and strengthening, namely: (1) faith, fear of God Almighty, and noble character; (2) global diversity; (3) cooperation; (4) independence; (5) critical reasoning; and (6) creative. The achievement is carried out through a project, which is cross-disciplinary learning to observe and think of solutions to problems in the surrounding environment [9]. This is in line with the concept of integrated thematic learning which integrates various competencies from across disciplines and allows the growth of literacy as one of the learning outcomes.

The OECD defines literacy as "the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts" [10]. UNESCO explains that a person is called literate if he has a good understanding of reading and writing short statements about his daily life [11]. Reading and writing are the basis of various literacy which is expected to be mastered by students and ideally have been achieved in learning at the elementary level.

Learning at the elementary level, especially in the lower grades, still emphasizes the very significant concept of literacy [10]. However, that does not mean that students cannot be given other knowledge. It's just that if the concept of literacy has not been understood, then other knowledge will be difficult to understand. For this reason, literacy is still needed as a basis for other literacy and can be combined with various other lessons at school in the form of themes that are presented continuously and dynamically. To make it easier to understand, reading and writing literacy can also be present from local wisdom or culture that is close to students' daily lives.

Assessment of student literacy began to be carried out intensively in line with the implementation of the minimum competency assessment (AKM), which is an assessment of basic competencies needed by all students to be able to develop their capacity and participate positively in society [12]. AKM measures two basic competencies, reading literacy and mathematical literacy (numeracy). Numeracy is the ability to think using concepts, procedures, facts, and mathematical tools to solve everyday problems in various types of contexts that are relevant for individuals as citizens of Indonesia and the world [12]. Numeracy in the AKM shows that mathematics is also basic learning that is important to understand according to its use to solve problems in various fields. A way is needed so that mathematics can be understood more simply.

Not all ways to understand students about mathematics can give maximum results. Understanding is also influenced by the characteristics and basic abilities of students. Difficulties in learning mathematics experienced by students include understanding the complex relationship between everyday language and mathematical language and its mathematical representation [13]. This happens because mathematics is a foreign language and not the first language for most students (unknown since learning to recognize languages except counting small integers), which is learned almost entirely at school and is not spoken at home [14], also because students cannot relate the new knowledge they have received with other knowledge [15]. In addition, students need direction in using appropriate mathematical language and understanding how to map words into symbolic forms and representations of mathematical concepts [16].

The *merdeka* curriculum emphasizes that in activities involving mathematics, students are expected not only to build their mathematical knowledge but also to hone skills such as reasoning, communicating, applying, solving problems, and others, so that they get a complete and meaningful mathematical experience [17]. For this reason, mathematics subjects in the *merdeka* curriculum are organized into five process elements, including mathematical reasoning and proof, problem-solving, communication, mathematical representation, and mathematical connections [18], which are compatible with the five standardized processes set NCTM for school mathematics [19].

Five elements of content in mathematics learning are also defined, including numbers, algebra, measurement, geometry, as well as data and probability analysis [18] which are further reduced to content standards with six scopes of learning mathematics in elementary schools [20]. Six scopes appear to be separate, but in their application, the connection between concepts can always be found. Such as the concept of numbers in arithmetic operations, the concept of numbers in measuring and estimating object attributes, interpreting data in measurements, and so on.

Connectedness is one element of the process, namely mathematical connection. "A mathematical connection is a link (or bridge) in which prior or new knowledge is used to establish or strengthen an understanding of relationships between or among mathematical ideas, concepts, strands, or representations" [21]. Mathematical connections show the importance of linking mathematical concepts with various fields so that students get meaningful learning outcomes and reduce students learning difficulties in mathematics.

This shows that mathematics learning can be done using the connected model, which is a learning model that combines the details of a discipline, focusing on interconnections in each field of study, with content that is connected from topic to topic explicitly [22][23]. One of the problems that contain mathematical connections can be found in culture. Mathematics learning needs to be linked to culture because "mathematics is a compilation of progressive discoveries and inventions from cultures around the world during the course of history" [24].

Mathematics and culture are often interconnected and make school mathematics closely related to the society in which mathematics is taught [25]. "A culture based mathematics is a salient component to pedagogical practices because it affords educators real-life practices with cultural implications embedded with mathematical concepts" [26]. Culture-based mathematics learning is one of the interesting, fun, and innovative learning alternatives because it allows contextual meaning based on students' experiences as members of a cultural community so it is expected to support the literacy movement [27].

The mathematical concepts that can be identified in culture are known as ethnomathematics, i.e. "the mathematics practiced by cultural groups, such as urban and rural communities, groups of workers, professional classes, children in a given age group, indigenous societies, and so many other groups that are identified by the objectives and traditions common to these groups" [28]. Ethnomathematics can strengthen the roots of understanding mathematics through the process of knowing and assimilating the dominant culture as long as its cultural roots are also strong [28].

One of the uses of ethnomathematics is as *"an approach of teaching and learning mathematics which builds on the student's previous knowledge, background, the role his environment plays in terms of content and method, and his past and present experiences of his immediate environment and the approach could be in a practical way"* [29]. This is reinforced by the development of the trivium curriculum concept by Ubiratan D'Ambrosio which is based on three concepts, including literacy, matheracy, and technoracy [28] [30]. Literacy is the ability to process and use information in everyday life in writing and orally, which includes reading, writing, arithmetic, representing, using media and the internet.

Matheracy is the ability to interpret and analyze signs and codes, propose and use models and simulations in everyday life, and describe abstractions based on real representations. While technoracy is the ability to use and combine instruments, both simple and complex, including one's own body, then evaluate the possibilities and limitations as well as their adaptation to various needs and situations.

The concept of the trivium curriculum shows that ethnomathematical-based learning can contain various concepts in mathematics or contain interrelationships between subjects that can be identified from a culture. It is also in line with the achievement target of AKM. Reading literacy in AKM is following with the concept of literacy in the trivium curriculum, while numeracy is compatible with the concept of matheracy. This is the basis for developing a new learning model that combines the trivium curriculum in ethnomathematics, thematic approaches, and connectedness in an appropriate cultural theme.

The learning model is a description of a learning environment including teacher behavior when the model is used [31] or a conceptual framework that describes systematic procedures in organizing learning experiences to achieve learning goals [32]. It also contains strategies, techniques, methods, materials, media, and assessment tools, which are used as guidelines to achieve learning objectives [33]. The learning model has three characteristics, including goals, phases, and foundations [34]. The learning model is designed to help students develop critical thinking skills and gain an in-depth understanding of specific materials. A series of steps (phases) in the learning model aims to help students achieve specific learning objectives. The existence of this learning model must be supported by theory and research on learning and motivation.

A learning model contains syntax; a social system; the principle of reaction; a support system; instructional impact and accompaniment impact [31]. The syntax is a learning step, each step is called a phase. The social system shows the expected interactions between teachers and students and the norms that must be followed. The principle of reaction shows the attitude and behavior of the teacher to respond to student activities in learning. Support systems are elements that are conditioned to support the implementation of the learning model. The instructional impact is learning outcomes that are achieved by directing students to the expected learning objectives. The accompaniment impact is an impact that appears unplanned and is another learning result obtained from a learning process as a result of creating a learning atmosphere that is experienced directly by students without direction from the teacher.

The development of learning models needs to be done by paying attention to the environment that is close to students, one of which is culture. *Indonesian* culture is very diverse and interesting to explore and study the knowledge contained in it. One of them is the *Banyuwangi* culture. *Banyuwangi* is one of the regencies located at the eastern tip of the island of Java. The indigenous people of *Banyuwangi* are known as the *Using* tribe(some write as *Osing* or *Oseng*). The *Indonesian* dictionary states that the term *Using* can be interpreted as an ethnic group that inhabits the *Banyuwangi* area of East Java or the Javanese dialect spoken by the *Using* tribe [35]. The *Using* tribal community is part of an agrarian society with agriculture as the main livelihood system.

The traditional rituals and skills performed by the *Using* tribe are part of the language system, knowledge, society, living tools and technology, livelihood, religion, and art that enrich the cultural treasures of the *Using* community. One of them is knowledge about the ancient units of calculation for local rice. There are units of account for the *Using* community, such as: *"killing* (smallest volume equivalent to half a *bentel* bond), *bentel/sakgegem* (smallest bond volume adjusted to the size of the farmer's hand), *ringgi* (unit volume of 5 *bentel* bonds), *sewelen/sak welen* (unit volume from 6 *ringgi* bonds), *sancing/sak encing* (unit volume from 12 *ringgi* bonds), *sagem/sak agem* (unit volume from 25 *ringgi* bonds), and *belibon* (units of account for rice bonds)." [36]

In other studies, it is also known that in the *Using* traditional house there are concepts of two-dimensional and three-dimensional shapes, similarity and congruence, transformations, and fractals [37]. In the *Gandrung Jejer Jaran Dawuk* dance, it can be seen that there are basic mathematical concepts, such as counting, number patterns, angles and their types, and cardinal directions [38]. While in the traditional game *patheng dudu*, it can be seen the concepts of polyhedrons, polygons, counting, comparisons, measurements with standard and non-standard units, angles and their types, relationships between lines, statistics, sets, distances, time, and functions [39].

The existence of mathematical concepts in *Using* culture can be integrated into learning to support students' abilities in various literacy, especially mathematics. One way to integrate culture into learning can be done through the development of learning models, as has been done in several previous studies. The mathematics learning model based on multicultural education has been developed by Danoebroto from the five dimensions of James Banks' multicultural education which consists of (1) cultural integration in mathematics content; (2) construction of mathematical knowledge through context and cultural understanding; (3) pedagogic equality; (4) reduce prejudice; and (5) empowering conducive school culture [40]. While the results of another study show that teaching the thematic model based on local wisdom will be a connection for students in achieving understanding to determine appropriate actions when dealing with various global challenges [41].

Based on the previous discussion, research was conducted on the development of the Ethnomathematics-Thematic-Connected (ETC) learning model. In general, this learning model can be used in various cultural spheres. However, in this study, the development of the ETC learning model is limited within the scope of *Banyuwangi* culture.

2. Objectives

This research is aimed at developing a learning model that combines the trivium curriculum in ethnomathematics, thematic approaches, and connectedness in mathematics. In addition, the research is also aimed at determining the quality of the developed model through its validity, practicality, and effectiveness.

3. Methods

This development research aims to determine product quality and provide insight into the application of frameworks in various domains of educational product development [42], as well as develop research-based solutions to complex problems in educational practice [43]. The product in question is the ETC learning model. Achieving the quality of a product in education contains four criteria, including relevance, consistency, practicality, and effectiveness [42] [44]. Relevance or content validation is the novelty and compatibility between each product component and the supporting theory. Consistency or construct validation is consistency between product components. Practicality includes two assessments, the assessment of experts and practitioners who state that the developed product can be applied (Intended-Perceived/IP), and assessments from teachers and students who state that the developed product is easy to use in real terms (Intended-Operational/IO). Effectiveness includes two assessments, assessments from experts and practitioners who state that the product provides results as expected (Intended-Experiental/IE), and assessments from teachers and students who state that the product provides results as expected after use (Intended-Attained/IA).

	Quality aspects		
	Validity	Practicality	Effectiveness
Represen-tations	Intended (ideal + formal): • State-of-the-art • Internally consistent	Consistency between • Intended ↔ Perceived • Intended ↔ Operational	Consistency between • Intended ↔ Experiential • Intended ↔ Attained

Figure 1 Relationship Aspects of Quality and Representation [42]

Intended is an expectation, perceived is a condition that is felt, operational is a condition that is carried out, experiental is experienced, and attained is an achievement.

This research was conducted using the Plomp model which was limited to the fourth phase. Plomp shows a model for designing education [45] which contains 5 phases, including (1) initial investigation; (2) design; (3) realization/construction; (4) test, evaluations, and revisions; and (5) implementation. The research was carried out according to the flow in Figure 2.

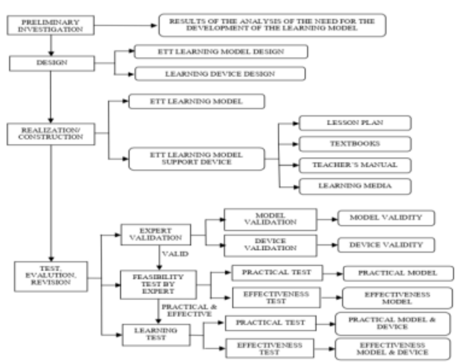

Figure 2 Development Research Flow

In the first phase, the activities of problem identification, needs analysis, and theoretical studies supporting model development were carried out. Identification is done to find out the problems of learning in elementary schools in Banyuwangi before, such as learning models that have been used; teacher and student learning responses; obstacles to the use of learning models; how to overcome obstacles; and students' understanding by using the previous learning model. The identification was carried out through interviews in five elementary schools based on the *Using* tribe, i.e. SDN Kenjo, SDN 1 Sukojati, SDN 1 Gumirih, SDN 3 Boyolangu, and SDN 1 Pesucen. The interview respondents were three lower grade teachers in each school.

Needs analysis consists of the analysis of student conditions and curriculum analysis. Analysis of student conditions was carried out according to the results of problem identification. Curriculum analysis contains the curriculum used, the expected competency achievements of students, materials, and tasks as evaluations for students. The curriculum used in this analysis is the 2013 curriculum and the *merdeka* curriculum. Furthermore, relevant theoretical studies are carried out for the development of learning models.

In the design phase, the components of the learning model consist of syntax, social systems, reaction principles, support systems, instructional impacts and accompaniment impacts. A learning device design is also made that includes lesson plans, student textbooks, and teacher manuals. Furthermore, the design is made into a product in the realization phase. The products are ETC learning model books, supporting tools for three lessons, as well as product assessment instruments.

The fourth phase begins with product validation of model books and learning support devices, as well as testing the practicality and effectiveness of the experts. Test the validity, practicality, and effectiveness of the ETC learning model and device using a questionnaire instrument. The assessment was carried out by two expert lecturers majoring in mathematics education from two universities with competencies in learning mathematics, developing learning models, and/or ethnomathematics. It was also carried out by two principal practitioners of two elementary schools in Banyuwangi, with competence in learning in elementary schools and understanding the implementation of the 2013 curriculum and the *merdeka* curriculum.

The analysis of validation, practicality and expert effectiveness was carried out according to the formula for determining validity (V_a), intended-perceived (IP), and intended-experiental (IE) developed by [45]. V_a, IP, and IE criteria refer to the following three figures.

Interval	Validity Level Criteria
$1 \le V_a < 2$	Invalid
$2 \le V_a < 3$	Not valid
$3 \le V_a < 4$	Quite valid
$4 \le V_a < 5$	Valid
$V_a = 5$	Very valid

V_a : Validity
Source : Hobri (2009:78)

Figure 3 Validity Level Criteria

Interval	Criteria for the Level of Implementation of the Model by Experts
$1 \leq IP < 2$	Very low
$2 \leq IP < 3$	Low
$3 \leq IP < 4$	Currently
$4 \leq IP < 5$	High
$IP = 5$	Very high

IP: Intended Perceived
Source : Hobri (2009:79)

Figure 4 Intended-Perceived Criteria

Interval	Model Effectiveness Level Criteria
$1 \leq IE < 2$	Very low
$2 \leq IE < 3$	Low
$3 \leq IE < 4$	Currently
$4 \leq IE < 5$	High
$IE = 5$	Very high

IE: Intended Experiental
Source : Hobri (2009:83)

Figure 5 Intended-Experiental Criteria

Products that have reached a minimum level of good validity, high intended-perceived (IP), and high intended-experiental (IE), are then tested to determine the intended-operational (IO) and intended-achievement (IA). The trial was conducted at SDN 1 Giri because it was in the *Using* culture. SDN 1 Giri is also an area that represents the condition of the village (west direction) and the city (east direction). So students at SDN 1 Giri represent these two environmental conditions. Respondents are 1 teacher and 10 grade 3 students.

The data from the experimental observation of the ETC model is used to determine the reliability of the observation instrument with the concept of percentage of agreements according to the rules of [46]. After that, the data were analyzed based on the intended-operational (IO) determination formula developed by [45], and the IO criteria were determined based on Figure 6. The ETC learning model is said to be practical if IP is consistent with IO.

Interval	Criteria for Model implementation Level by Observers
$1 \leq IO < 2$	Very low
$2 \leq IO < 3$	Low
$3 \leq IO < 4$	Currently
$4 \leq IO < 5$	High
$IO = 5$	Very high

IO: Intended Operational
Source : Hobri (2009:78)

Figure 6 Intended-Operational Criteria

Intended-attained (IA) is determined based on the data on the results of problem-solving, the frequency of students and teacher activities, the teacher's ability to manage the class, and student responses. Analysis of the results of problem-solving was carried out to determine the value of the student mastery level (TPS) with the criteria in Figure 7.

Interval	Criteria for Student Mastery Level
$0 \leq TPS < 40$	Very low
$40 \leq TPS < 60$	Low
$60 \leq TPS < 75$	Currently
$75 \leq TPS < 90$	High
$90 \leq TPS \leq 100$	Very high

TPS: Student Mastery Level
Source : Hobri (2009:85)

Figure 7 Student Mastery Level Criteria

Data from observation of student and teacher activities are used to determine the average frequency and the average percentage of time [45]. The criteria for the ideal time for student and teacher activities are contained in Figure 8.

Category Aspect	Ideal Time	Tolerance Interval for Achieving Ideal Time	Criteria
Teacher Activity			
a. explain the material/provide information	25% AT	$20\% \leq AIT \leq 30\%$	two of the three aspects of categories (a, b, c) are met and category b must be met
b. observing student activities, motivating, giving instructions, guiding student activities	75% AT	$70\% \leq AIT \leq 80\%$	
c. Irrelevant treatment	0% AT	$0\% \leq AIT \leq 5\%$	
Student Activities			
a. listen/pay attention to the explanation of the teacher/other students, answer questions	25% AT	$20\% \leq AIT \leq 30\%$	three of the five aspects of categories (a, b, c, d, e) are met and categories c, d must be met
b. Reading, observing pictures/learning objects	15% AT	$10\% \leq AIT \leq 20\%$	
c. Taking notes, doing exercises/solving problems, summarizing, doing learning activities, presenting learning outcomes	30% AT	$25\% \leq AIT \leq 35\%$	
d. discuss/ask questions between students and teachers as well as between students	30% AT	$25\% \leq AIT \leq 35\%$	
e. do activities that are not relevant	0% AT	$0\% \leq AIT \leq 5\%$	

AIT : Achieving Ideal Time
AT : Available Time (on every lesson)
Source: (Hobri, 2009:90)

Figure 8 Criteria for Ideal Time for Student and Teacher Activities

Learning management result data were analyzed based on the teacher ability score (NKG) formula (NKG) developed by [45] with the criteria in Figure 9.

Interval	Criteria for Teacher Ability in Managing Learning
$1 \leq NKG < 2$	Not very good
$2 \leq NKG < 3$	Not good
$3 \leq NKG < 4$	Pretty good
$4 \leq NKG < 5$	Good
$NKG = 5$	Very good

NKG: Teacher Ability Score
Source: Hobri (2009:92)

Figure 9 Criteria for Teacher Ability to Manage Learning

Teachers can manage to learn if they achieve a minimum NKG of good. The student response data determines the achievement of learning objectives if a positive response is obtained from ≥80% of students who become learning respondents [45].

The ETC model is effective based on the IA if: ≥80% of students who take part in learning can achieve a problem-solving score of at least 75; the ideal percentage of time for student and teacher activities is achieved; the teacher's ability to manage to learn is at least good; there are ≥80% of students' positive responses to the components of the model and learning activities. Furthermore, the ETC model is effective if there is consistency between IE and IA.

4. Results

The results are described according to the four steps of Plomp development.

Investigation

In the investigation, the identification of information on previous learning problems was carried out to produce a rational formulation of the importance of model development; analysis of student conditions and curriculum; and appropriate theoretical studies to develop learning models. The results show that generally learning in low grades cannot be directly focused on discussing mathematical concepts because it requires character strengthening, such as greeting when entering class, praying before and after learning, how to sit properly, and how to read and write correctly, and so on.

So far, teachers do not understand the learning model used. teachers only carry out direct learning and/or group activities. In lower classes, learning is generally carried out directly because it is considered more practical with a maximum of 15 students, and mode effective because all students can focus on the material presented by the teacher. Groups are formed if needed and only consist of two people (students at the same seat).

In the 2013 curriculum, learning in lower grades uses a thematic approach. Some teachers are constrained in understanding the mathematical concepts in the theme. Thematics are considered to make students not focus on understanding the material because learning seems forced. Students' understanding of the material is less attached so it becomes a burden in the next class. The teacher overcomes obstacles by giving more portions of mathematics, teaching specifically (not using themes), adding math exercises from student worksheets or other books (not in thematic concepts), and giving story questions to familiarize students with understanding sentences in the exercises. However, the learning outcomes have not reached expectations. Learning outcomes still vary according to students' basic abilities and literacy.

Generally, students are not only constrained by understanding mathematics. Around 50% of students still have problems in reading and writing (except at SDN 1 Pesucen where students already have quite good literacy due to learning support from the early childhood education level). Students who are not fluent in reading and writing always have difficulty understanding learning information. This is an additional task for teachers, especially in lower classes to improve student literacy.

Literacy is also influenced by the condition of lower grade students who are still accustomed to communicating in their mother tongue (*Using* language). So learning must be in two languages (Indonesian and *Using* language). Unfortunately, many mathematical concepts tend to be more easily conveyed in Indonesian. The teacher tries to make students understand mathematics in simple language.

Low-grade students also need learning conditions that are not too serious because they get bored easily. teachers must be creative in managing learning by inserting fun activities. To overcome abstract mathematical understanding, the teacher uses objects around students such as pebbles, broomsticks, seeds, leaves, and others. Some teachers use traditional games, such as *dakon*. In the concept of angles, the teacher uses hand movements to show angles and their types. These conditions indicate that low-grade students still need learning activities while playing. This is following Vigotsky's theory that there are three key elements in learning, including aspects of play, language, and socio-culture [47]. This means that learning can be done through games, by the language and culture that is close to students' daily lives.

Media needs at the elementary level according to Piaget's theory of cognitive development [48] where children aged seven to eleven years are at a concrete operational level, whose logical thinking begins to develop using classification or categorization based on similarities and differences, but is only applied to real things. Children also begin to have reversibility, which is the ability to change the direction of thought so that it can return to its original understanding. For example, finding subtraction through addition operations. However, children's thinking is still focused on things that are concrete and can be seen.

Cultural integration as a learning medium is adjusted to the conditions of students who still use their mother tongue. Each culture composes its language, classifies it, has an explanation of the story, has its way of connecting ideas through discourse, and has several main sources to validate its explanation [49]. Culture develops ways, styles, and techniques for doing things as well as responses to the search for explanations, understanding, and learning about how and why things are done [50]. Vigotsky states that intellectual development can be understood only in the historical and cultural context experienced by children, and it depends on the sign system (the symbols created by a culture that help people think, communicate, and solve problem) that a person follows [51].

Culture contains a variety of knowledge, one of which is mathematics. Bishop identifies six types of everyday mathematical activities that are cross-culturally involved, including counting, locating, measuring, designing, playing, and explaining [49]. The mathematics that can be identified from culture is known as ethnomathematics according to the definition presented by [28]. In addition, ethnomathematics can also be understood as a form of research on the history and philosophy of mathematics [24], as well as an approach to learning mathematics [29].

In some cases the results of ethnomathematical identification can almost be translated directly into curriculum materials, enrichment content, activities based on the use of mathematical culture, and new applied examples for students to work on [52]. Otherwise, the use of ethnomathematics in the classroom will depend on the information learned from field research. The implementation of ethnomathematics in learning is reinforced by the trivium curriculum developed by Ubiratan D'Ambrosio. This curriculum is based on three concepts, including literacy, matheracy, and technoracy [28] [30]. The concept of literacy and matheracy is compatible with AKM. so that the implementation of the trivium curriculum in learning can support efforts to strengthen literacy and numeracy.

Learning was hampered by the COVID-19 pandemic which caused the learning process to not be optimal, resulting in a learning loss. The government through the Ministry of Education stipulates the implementation of the curriculum to restore learning [8] which is developed by an educational unit with the principle of diversification according to its conditions, regional potential, and students. In elementary education, the organization of learning content can be arranged by the teacher with a subject or thematic approach to get maximum results. This can be done also in math subjects.

In the *merdeka* curriculum, it is stated that the achievement of learning mathematics has relevance to the profile of Pancasila students [20], including developing independence, critical reasoning, and creativity. Mathematics learning contains six content standards, which are the minimum criteria that contain the scope of the material to achieve graduate competence in the path level, and types of education [18]. The six content standards contain links to the corresponding concepts. So that these concepts can be taught using mathematical connections which is one of the standard processes of mathematics subjects. It is a learning program that enables students to (1) recognize and use connections between mathematical ideas; (2) understand how mathematical ideas are interconnected and related to producing a unified whole; (3) recognize and apply mathematics in contexts outside of mathematics [20].

The *merdeka* curriculum structure at the elementary education level also mentions the five principles of learning as a process of student interaction with teachers and learning resources in a learning environment [8]. The first is learning is "designed by considering the stage of development and current level of achievement of students according to learning needs and reflects the characteristics and development of diverse students so that learning becomes meaningful and fun". This principle is supported by Gagne who states that the delivery of important material is carried out sequentially starting from the prerequisite material [53].

Ausubel and Vigotsky state that meaningful learning or understanding can be achieved through linking new information with previous knowledge [53] [54]. Piaget explained that cognitive development is a process that occurs actively when children build systems of meaning and understanding of reality through experiences and interactions [53]. Bruner states that learning that is done by reinventing (not discovering new things) can provide meaningful achievements [53] [54], and knowledge is built from experience [47] so it takes mastery of simple skills to perform more complex skills [53].

Meaningful learning can be realized through the interrelationships between the concepts contained in the connected model. The connected model is based on the theory of connectivism. Dunaway states that connectivity is a learning theory in and of itself, but to be an effective learning theory it requires metalliteration (a framework that integrates various types of literacy) and transliteration (reading, writing, and interacting skills across various programs) [55]. Metalliteration and transliteration are the integration of literacy with other abilities such as mathematics and technology. This fits into the trivium curriculum in ethnomathematics

The second principle states that "learning is designed and implemented to build capacity to become lifelong learners". This is supported by the theory of Dewey that there must be a long-life education [56]. Comenius supports the theory that learning must be done early and lasts a lifetime [47].

The third principle is that "the learning process supports the development of competencies and characteristics of students holistically". This means that learning must be carried out according to the level of student understanding. Piaget supports this by stating that there is a sequence of cognitive development that requires children to be at a certain stage of development to be able to learn new concepts [47]. New ideas and knowledge must be presented at a level and style appropriate to the child's way of thinking, learning must be adapted to individual needs and presented in new situations to trigger assimilation and accommodation [47]. Meanwhile, Vigotsky stated that the learning process can occur if the child completes a task that has not been studied as long as the task is still in the zone of proximal development [47] [51] [53].

The fourth principle is "relevant learning, which is learning that is designed according to the context, environment, and culture of students, and involves parents and the community as partners". Dewey supports this principle by stating that education should be based on real-life situations including social interactions with others [47]. Gagne stated that the process of receiving information in learning occurs through interactions between students' internal and external conditions which are then processed to produce outputs [53]. Piaget stated that all children are born with an innate tendency to interact and understand their environment to produce patterns of behavior or thinking called schemas, which can be obtained through a process of adaptation (assimilation and accommodation) with the environment [47].

Vigotsky supports the theory of the need for scaffolding in learning from teachers or other students [51], and the need for collaboration between students to obtain the same understanding [47]. While Bruner said that one of the experiences that can build knowledge can be obtained from the culture [53]. In addition, learning requires scaffolding and social interaction [54].

The fifth principle is "continuous future-oriented learning". Piaget supports the opinion that children continue to construct and reconstruct reality to improve understanding through the integration of simple concepts into more complex concepts [47]. Thus, children will experience thriving and sustainable learning.

Based on the above theories, a learning model was developed that links the trivium curriculum with thematic and connected approaches to learning mathematics within the *Banyuwangi* culture, which is called the Ethnomathematics-Thematic-Connected (ETC) learning model. The ETC model can be defined as a model in mathematics learning that was developed by containing the concepts of literacy, matheracy, and technoracy, implemented thematically with at least one other subject, and connected from at least two mathematical concepts. The cultural base used is the *Banyuwangi* culture which consists of the *Using* traditional house, *Gandrung Jejer Jaran Dawuk* (GJJD) dance, and the traditional game of *patheng dudu*. The development of supporting devices for the ETC model is carried out at the 3rd grade level of elementary school.

Design

The design of the ETC model includes syntax, social systems, reaction principles, support systems, and learning impacts. The syntax is designed as in Figure 10.

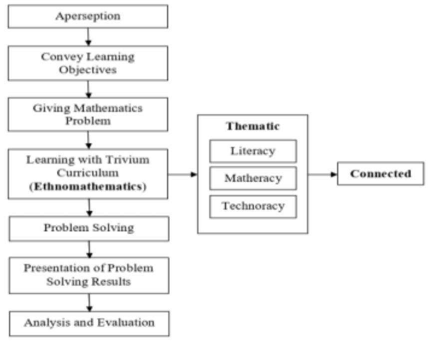

Figure 10 Syntax Design of the ETC Learning Model

Next, a social system is designed according to learning needs. If learning is done in groups, the teacher can form small groups that are effective for learning. So that there can be an interaction between students and/or between students and teachers. If learning is done individually, the teacher can design classical learning. So that there is an interaction between students and teachers to get scaffolding.

Based on the design of the social system, teachers are expected to react as facilitators, consultants, and mediators. The teacher acts as a facilitator in preparing learning tools, facilities, and learning resources according to the lesson plan, as well as creating a learning atmosphere in a cultural context. The teacher acts as a consultant in the activity of conditioning students to fit the lesson plan and providing the necessary scaffolding. While the teacher acts as a mediator in the activity of giving students direction during the process of presenting the results of problem-solving, analysis, and evaluation so that the activities run according to the lesson plan.

The support system is designed in the form of classroom settings, learning systems, learning tools, learning facilities, and learning media. Classes are designed so that students can interact during learning independently or in groups. Learning tools are designed in the form of lesson plans, student books, and teacher manuals. The lesson plan is designed for three lessons according to the cultural context used. Learning facilities are designed to assist in the implementation of lesson plans. While the learning media is designed according to learning needs.

The learning impact contains two components, the instructional impact and the accompaniment impact. In general, the impact of learning cannot be designed but can be expected. The expected instructional impact of learning with the ETC model is an increase in students' ability to solve cultural-based mathematical problems and their mathematical connections. While the expected accompaniment impact is that students are more familiar with the culture, can work together in solving problems, can account for the results obtained, are accustomed to processing information obtained from a problem to get the right solution, and support the achievement of the Pancasila student profile, especially in the independent, critical and creative thinking dimensions.

Realization/construction

At this stage, the product is made according to the design. The result of the ETC learning model is called a model book which contains: a definition, supporting theory, objectives of model development, components of the ETC learning model, and evaluation. The supporting tools for the ETC model consist of lesson plans for three lessons, student textbooks, and teacher manuals. To determine product quality, validity, practicality, and effectiveness tests were conducted. So that an instrument was developed for the test. Each instrument was consulted with two supervisors and one education expert. After the instrument is declared usable, then all products proceed to the next stage of development.

Test, Evaluation, and Revision

Product quality assessments were carried out by two experts and two practitioners. The first evaluator (V_1) is an expert in mathematics learning and has developed a mathematics learning model and teaches at one of the universities in *Surabaya*. The second evaluator (V_2) is an expert in mathematics and ethnomathematics and teaches at one of the universities in *Yogyakarta*. The third (V_3) and fourth (V_4) appraisers are practitioners who serve as principals at elementary schools in *Banyuwangi*.

Analysis of the evaluation of the validity of the content of the ETC model showed a value of $V_a = 4.66$, which means that the content of the ETC model has valid criteria [45]. V_1 suggests clarifying: the implications of Gagne's theory on the second indicator, connected dan thematic characteristics on social systems and reaction principles, and characteristics of the ETC model on evaluation. V_2 suggests clarifying: the support for Comenius's theory in the ETC model and the meaning of the sentence "learning can be done individually (classical)". While V_3 and V_4 suggest writing improvements.

Analysis of the construct validity of the ETC model shows the value $V_a = 4.52$, which means that the construct of the ETC model has valid criteria [45]. V_1 suggests adding explanations related to ETC indicators in social sub-systems, thematic and connected aspects that characterize the ETC model on the reaction principle and clarifying the instructions for implementing the evaluation. While the other evaluators suggested improvements to the writing.

The implementation of the ETC model by experts shows a value of $IP = 4.67$, which means the ETC model has a high level of implementation [45]. Suggestions given by the evaluator are only for writing improvement. The evaluation of the effectiveness of the ETC model by experts shows the value of $IE = 4.57$, which means the ETC model has a high level of effectiveness [45]. V_3 suggests the need for self-reflection on student responses to components and the learning process to measure achievement. While the other evaluators suggested improvement in writing.

The validity of the lesson plan shows the value of $V_a = 4.66$, which means that the lesson plan has valid criteria [45]. V_1 suggests synchronizing learning objectives with learning outcomes on the concept of angles. V_3 suggests clarifying the problem so that the connection with the core activity appears, describes the time for students to internalize and ask questions, and completes the learning objectives with conditions and degrees. V_4 suggests adjusting the time required with the density of the material because the teaching material is quite extensive and full of practice and discussion. While V_2 suggests writing improvements.

The validity of student textbooks shows the value of $V_a = 4.6$, which means that student textbooks have valid criteria [45]. V_1 suggests adding feedback and evaluation to the textbook, clarifying the sections that include questions for practice and evaluation, synchronizing learning objectives with learning outcomes, paying attention to writing according to the correct spelling, and re-checking the involvement of angles in the definition of n −sided. V_3 stated that the textbook is very good and according to the needs of students to develop their competence and potential. While V_2 and V_4 suggest writing improvements.

The validity of the teacher's guidebook shows the value of $V_a = 4.73$ which means that the teacher's guidebook has valid criteria [45]. V_1 suggests mentioning the content of the trivium curriculum in the teacher's manual, writing down intervals according to math rules, and explaining the size of right angles in student textbooks. V_3 stated that this book was very helpful for teachers in carrying out ethnomathematical learning. V_4 stated that this book was good and by the flow of the lesson plans and textbooks. While V_2 suggests writing improvements.

The results of improving the model and learning tools are then re-examined by the evaluator. After being declared usable, a learning trial was conducted at SDN 1 Giri on 4, 7, 11, and 14 June 2022. The first trial contains the concept of the trivium: (1) understanding the GJJD dance through reading and video (literacy); (2) determining the angle and its type and making a table from the angle and type data in the GJJD dance movement (matheracy); (3) practicing the first part of GJJD dance (technoracy). This lesson includes Indonesian language, dance, and mathematics subjects which are integrated into traditional dance themes. In the mathematics learning outcomes, the characteristics of two-dimensional shapes are focused on the introduction of angles and their types, while the activities of comparing, presenting, analyzing, and interpreting data are focused on the introduction of tabular forms. So that the achievement of learning mathematics is conveyed in a connected manner from the concept of angles and statistics.

Learning with the ETC model on the first day is not optimal because there are three videos that students must watch, many practice questions do not match the time available, and there are students who are not yet fluent in reading so the teacher needs to pay more attention, understanding the concept of angles and their types are not accompanied by visualization in textbooks, and students need scaffolding in solving problems. So that the final four phases of the syntax (problem-solving, presentation of results, analysis, and evaluation) cannot be carried out.

Figure 11 First Learning Trial

Based on these conditions, improvements were made to learning devices. These improvements include: (1) the practice of dance moves does not show videos but is enough from reading and teacher directions; (2) reducing practice questions; (3) adding visualization of the introduction of angles and their types in textbooks; (4) provide scaffolding for the identification of the angle type of the image; (5) write a conclusion about the angle and its type at the end of the exercise; (6) introduce table writing with the turus before identifying the types of angles; and (7) provide problem-solving sheets containing scaffolding. Then it is planned to repeat the first lesson after the third lesson.

The second lesson contains the trivium concept: (1) understanding the *Using* traditional house through reading and practice questions (literacy); (2) recognizing the types of quadrilaterals and determining the amount of money needed in an activity (matheracy); and (3) making a miniature of *Using* traditional house (technoracy). This lesson includes Indonesian subjects, natural and social sciences (IPAS), fine arts, and mathematics to be integrated into the *Using* house theme. In the mathematics learning outcomes, the characteristics of the two-dimensional form are focused on the types of quadrilaterals. While the learning outcomes of problem-solving are focused on determining the amount of money needed to buy *gedhek*. So that mathematics subjects are delivered in a connected manner from the concept of quadrilaterals and economic mathematics.

Figure 12 Second Learning Trial

Learning with the ETC model on the second day has been maximized. All syntax phases are met and students can solve problems with several variations of answers. Because the initial learning was not conducive, the teacher changed the order of the learning steps by making a miniature of *Using*'s house first so that students focus on learning. Some of the improvements made include: (1) reducing practice questions about the Using traditional house; (2) adding a rectangular learning media visualization; (3) giving a number to the question of identification of rectangular shapes; and (4) providing problem-solving sheets and clarify scaffolding. The second lesson is not repeated, but device improvements are used in the implementation process.

The third lesson contains the concept of the trivium: (1) understanding the game *patheng dudu* through reading (literacy); (2) measure the side length of a polygon and/or the edge length of a polyhedron, add up all side lengths and/or edge length, and write down the measurement results in tabular form (matheracy); and (3) playing *patheng dudu* (technoracy).

Figure 13 Third Learning Trial

This lesson contains Indonesian and mathematics subjects to be integrated into traditional game themes. The mathematics learning outcomes are focused on the length of the side surface of the *dudu* in centimeters, the results of measuring the length of the sides of the *dudu*, as well as presenting and analyzing data in tabular form. So that mathematics subjects are delivered in a connected manner from the concepts of measurement, numbers, and statistics.

Learning with the ETC model on the third day has been maximized. All syntax phases are met and students can solve problems with a variety of answers according to the selected *dudu.* Some of the improvements include: (1) changing the phrase "each *dudu*" to "one *dudu*" in the problem; (2) removing the exercise on the two-dimensional shape; (3) creating worksheets for measuring the length of the sides of the *dudu*'s surface and problem-solving sheets containing a table of measurement results; and (4) adding an explanation of decimal numbers in the textbook. The third lesson is not repeated, but improvements to the device are used in the implementation process.

The first lesson was repeated with the trivium concept: (1) understanding the GJJD dance through reading and teacher direction (literacy); (2) determining the angle and its type and making a table from the angle type data in GJJD dance movement (matheracy); (3) practicing the first part of the GJJD dance without tools and videos (technoracy). The integration of the three subjects in the theme, the connection to mathematics, and learning outcomes have not changed.

Figure 14 Repeat the First Learning Trial

The repetition of learning with the ETC model has been maximized. Students can solve problems by determining the type of angle in the GJJD dance movement, as well as making a table using a turus.

Learning observations with the ETC model were carried out by one lecturer and one elementary school teacher. The results of the three learning observations according to the model are used to determine the reliability of the instrument as well as the intended-operational value. The reliability of the instrument shows the results of $R = 90.91\%$, which means that the observation sheet is said to be reliable [57]. While the intended-operational shows a value $IO = 4.22$ which means that the implementation of the model has high criteria [45].

The effectiveness of the ETC model is determined through expert judgment, the results of student problem solving, observation data on student and teacher activities, the ability of teachers to manage classes, and student responses to learning. Problem-solving performed by students showed an average of 91.80 in the first learning (repetition) with a very high level of mastery, in the second learning of 88.83 with a very high level of mastery, and the third learning of 80.05 with a high level of mastery [45].

Observations of students in learning show that the activities of listening/paying attention to explanations require 23.05% AT; reading textbooks/other teaching materials requires 14.98% AT; notes explanation and solving problems requires 31.92% AT; discussion/asking requires 25.15% AT; and activities not relevant to learning require 4.90% AT. So the ideal percentage of student activity time has been fulfilled. Observations of teachers in learning show that the activities of: explaining material/providing information require 28.21% AT; observing student activities, motivating, giving instructions, and guiding student activities require 70.05% AT; and activities that are not relevant to learning require 1.75% AT. So the ideal percentage of teacher activity time has been fulfilled.

The analysis of the results of observations of learning management with the ETC model in three lessons (after repetition) shows the value of $NKG = 4.04$, which means the teacher's ability to manage learning with the ETC model includes good criteria [45]. Student responses to learning show the average percentage of positive responses for all aspects is 98.33%, meaning that the learning objectives are achieved [45].

Because: (a) the average level of student mastery of the three lessons is high; (b) the ideal percentage of time for student and teacher activities is achieved; (c) the ability of teachers in managing to learn to achieve good results; and (d) there are 98.33% of students who give a positive response to the components of the model and learning activities, so the ETC model is effective based on the intended-attained.

Since the results of the content and construct validation assessment match with the specified conditions, the ETC model meets the requirements for the validity of a product. In addition, there is consistency between IP and IO which makes the model practical to use, as well as consistency between IE and IA which makes the model effective to use. This is under the explanation of Nieveen in the research methods section above [42] [44].

Because the validation test (V_a) of the ETC model and learning tools shows valid results; the value of intended-perceived (IP) and intended-operational (IO) show practical results; and the value of intended-experiental (IE) and intended-attained (IA) showed effective results, then the ETC model was declared to have good quality and was feasible to use [42] [44].

5. Discussion

Curriculum development needs to be followed by the development of learning support models and devices. This is under the results of previous studies which stated that school curricula, including mathematics, need to be translated into mathematical ideas, procedures, and practices between different mathematical systems to help students analyze the relationship between traditional and non-traditional learning in a learning environment [58].

The Ethnomathematics-Thematic-Connected (ETC) learning model is a model in mathematics learning that contains the concepts of literacy, matheracy, and technoracy [28] [30], implemented thematically with at least one other subject [2] [3] [4] [5] [6], and connected between at least two mathematical concepts [22] [23]. The ETC learning model was developed based on the need to meet the achievement targets of learning mathematics in the *merdeka* curriculum so that mathematics learning has relevance to the profile of Pancasila students which is aimed at developing independence, critical reasoning abilities, and student creativity [18].

The ETC learning model can be developed in various cultures, but in this study, the Banyuwangi culture was used. Cultures in various regions contain diverse learning concepts, including mathematics. This is supported by the opinion of [59] which states that culture can be used to explore mathematical concepts as a transformational effort to bring mathematics closer to reality and people's perceptions.

Furthermore, the ETC model can be used on a larger scale, in different cultures as long as ethnomathematics has been identified in that culture, or developed for higher education levels.

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