

## Merging Flipped Classroom Model with the Ethnomathematics Approach: A New Flexibility Learning Model

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This research focuses on developing a learning model that focuses on flexibility as well as meaningful and student-centered learning. The development of this model is a solution to the challenges of the Education 4.0 era. The problem found in the learning process is that the developed learning model does not facilitate students to follow flexible learning. Students are also not facilitated with learning that brings the context of students' local culture and traditions into learning activities. Another problem is that the learning model used so far has not been tested for model quality, namely valid, practical, and effective. Referring to these problems, the research was conducted through a design research approach with Plomp's development study-model type. The new learning model developed combines the concepts of the flipped classroom and ethnomathematics called the ethno-flipped classroom model. The quality of the developed model was tested using Nieveen's concept through validity, practicality, and effectiveness. The results showed that the ethno-flipped classroom model was valid, practical, and effective. This research obtained an ethno-flipped classroom model syntax consisting of six stages, namely Flexibility, Culture Experience, Cooperative, Elaboration, Collaboration, and Evaluation .

**Keywords:** ethnomathematics, flexibility, flipped classroom, new learning model

As a basic science subject, mathematics plays a crucial and advantageous role in the advancement of science and technology. Students can study math by developing their logical, analytical, and practical thinking skills as well as their positivity and creativity. Mathematical learning in schools develops knowledge of numbers and operations, algebra, geometry, measurement, data, and probability. Problem-solving, reasoning and proof, communication, connection, and representation are all parts of the standard method used as a benchmark for enhancing students' mathematical abilities in classroom mathematics instruction (National Council of Teachers of Mathematics, 2000).

The NCTM material content and process standards are supported by Indonesia's mathematics learning objectives, which require students to understand mathematical concepts, explain the relationship between concepts, and apply concepts or algorithms practically, logically, systematically, effectively, efficiently, and in accordance with learning outcomes. Based on these mathematics learning objectives, students should be able to apply the mathematical concepts they have learned to solve mathematical problems in their environment, particularly those related to tradition, culture, and community life within the context of where they live (Ministry of Education and Culture, 2013). Current mathematics learning also uses a new paradigm of learning that presents meaningful and student-centered mathematics learning (Polman et al., 2021).

Facts obtained in the field show that the learning model applied by mathematics teachers, especially mathematics teachers on Nias Island, North Sumatra Province-Indonesia has implemented student-centered learning through cooperative learning. However, the learning model used by teachers so far has not been properly validated regarding the suitability of the syntax in the model and its application in the field. Additionally, the learning approach is inefficient and ineffective at assisting pupils in developing their mathematical skills. The failure to put learning into practice, which would have brought pupils closer to fulfilling learning experiences, demonstrates this. One of the objectives of mathematics education nowadays is meaningful learning. The Sustainable Development Goals (SDGs) initiative, which is focused on achieving quality education for all people, includes meaningful learning as one of its objectives. Community involvement in sustainable development concerns is facilitated by Education for Sustainable Development (ESD), one of which is the promotion of educational quality while fostering local culture (Hill et al., 2020; Zidny et al., 2020).

Based on this, it is critical to produce learning innovations that are thoroughly validated, practical to use, and successful in developing student learning abilities, particularly mathematics competencies. One of the learning solutions that can be established is the use of flexible learning and providing additional possibilities for students to explore, as well as presenting informal challenges that are close to the traditions and culture of students. Nias Island itself is an island in North Sumatra Province and has ethnic and cultural homogeneity. The Nias community is a Nias community that lives in the coastal area, located in Gunungsitoli City, Nias Island, North Sumatra Province. The Nias community, especially the Nias community, is one of the indigenous people groups where they still carry out culture and traditions in their daily lives. The dominance of ethnic groups within the Nias community, namely the Nias tribe (*Ono Niha*) is also one of the reasons why their traditions and culture are still carried out today.

Students' motivation and interest will rise when learning is applied to problems based on real-world situations and drawn from their own cultures and traditions. It is not novel to use culture in relation to mathematics because mathematics is a common knowledge subject and a product of culture (Madusise, 2015; Marsigit et al., 2018). The ethnomathematics approach makes it easier for students to model concepts, processes, and procedures produced by their surroundings. The ethnomathematics approach also helps students become more familiar with events that occur in everyday life (Prahmana et al., 2021). Investigating data gathered from occurrences that occur in students' everyday lives will improve both their ability to reason mathematically and their creativity (D'Ambrosio & Rosa, 2017; Rosa & Orey, 2017).

Based on this description, a valid, practical, and effective learning model can be developed by using the integration of ethnomathematics context in mathematics learning. The learning model developed should refer to the flexibility that students feel when carrying out learning. One of the effective learning models used is this flipped classroom model (Latorre-Coscolluela et al., 2021; Lo, 2018). The flipped classroom model integrates the outside-of-class and inside-of-class learning phases into a single learning cycle (Ramadhani, 2020; Ramadhani et al., 2019; Ramadhani & Fitri, 2020). The flipped classroom paradigm allows students to connect not just with their peers but also with teachers and material information (Attard & Holmes, 2020; Fernández-Martín et al., 2020). Students can investigate the information offered by the teacher while still collaborating with one another to boost students' confidence, curiosity, motivation, and adaption to using technology in learning (Abeysekera & Dawson, 2015; Akhtar & Bahadur, 2021).

The use of the flipped classroom paradigm allows students to collaborate and explore the subject at their leisure. While, the ethnomathematics approach offers pupils relevant education that

is connected to real-world issues based on their culture and traditions. The flipped classroom model, which can be combined with the ethnomathematics approach, is a novel learning strategy that has a substantial impact on the development of students' mathematics competencies.

The development of a learning model that presents meaningful learning, is student-centered, and offers flexibility has never been developed. Learning models that are currently developed do not present these three components in one learning syntax. Some learning models developed, such as cooperative learning, problem-based learning, project-based learning, discovery learning, and STEM models are some types of learning models that center on student activities. Meaningful learning has not been facilitated through learning models but facilitated through learning approaches. Some of them are the ethnomathematics approach and the realistic mathematics education approach. Meanwhile, learning that presents flexibility is offered by blended learning models, one of which is the flipped classroom model.

Therefore, this is the novelty of this research. This research presents a learning model that provides meaningful learning experiences through the support of cultural contexts close to students, centers on student learning activities, and provides flexibility in student learning activities. The development of learning models that bring meaningful learning and offer flexibility results in learning innovations that have great opportunities to be integrated more widely in mathematics learning in various regions in Indonesia and outside Indonesia. The development of a new learning model also requires an analysis of validity, practicality, and effectiveness to ensure that the learning model is able to provide improvements in student learning abilities, especially in mathematics. The ethno-flipped classroom model provides support in strengthening the cultural values and characters of various ethnic groups in Indonesia and outside Indonesia through flexible and interactive mathematics learning.

Based on the description of the problems presented, the facts obtained in the field, and the opportunities that will be obtained, the research questions of this study include.

1. What is the validity of the ethno-flipped classroom model developed?
2. What is the practicality of the ethno-flipped classroom model developed?
3. What is the effectiveness of the ethno-flipped classroom model developed?
- 4.

### **Method**

The components of learning model development, which include syntax, social systems, management reaction principles, support systems, as well as instructional impact and accompanying impact, must be considered. Furthermore, the construction of learning models must consider the quality of the learning model. Akker et al., (2006) stated that the quality of the learning model is based on the quality aspects according to Nieveen, namely (1) validity, (2) practical, and (3) effectiveness.

Referring to the quality of model development, the ethno-flipped classroom model was developed through a design research method with the Plomp development study-model type. The Plomp model development study comprises three stages: preliminary research, prototype, and assessment. The preliminary research stage is where you perform a needs and context analysis, a literature evaluation, and establish conceptual and theoretical frameworks. The basic research stage resulted in prototype 1, the original concept of the ethno-flipped classroom paradigm.

The prototyping stage is used to perform a cyclical and successive design process in the form of a more micro-research approach and to develop and refine the intervention model through formative evaluation (Prototype 2). At the prototyping stage, prototype 2 was analyzed for validity

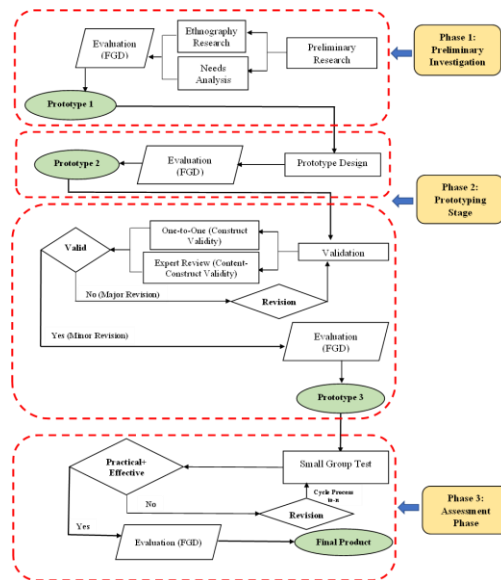
in all components, both content validity and construct validity. Content and construct validity are very important for a developed component (in this case a new learning model). The validity test process is conducted to ensure the quality of the developed components before they are implemented in the field. The first validity procedure is the content validity test. According to Akker (1999), content validity relates to how much the intervention design (in this example, the new learning model) is based on current knowledge. The syntax component, the social system component, the management reaction main component, the support system component, and the instructional and accompanying impact components of prototype 2 were validated in the content context.

According to Akker (1999), construct validity refers to the numerous components of an intervention that are consistently interrelated with one another. Akker (1999) also states that the construct validity is conducted after the content validity process has been carried out by experts. Construct validity was carried out on all the components of the ethno-flipped classroom model, namely the syntax, the social system, the management reaction principle, the support system component, and the instructional impact component and the accompanying impact. The supporting system component consists of teaching materials supporting the model and the learning management system application used in implementing the model. The instructional impact component is student learning outcomes (focused on students' informal statistical reasoning skills) and the accompanying impact component is students' self-regulated learning. The results of the validity analysis on the ethno-flipped classroom model components are called prototype 3.

The final stage is the assessment phase, which is the stage to assess the prototype 3 that has been validated both in content and construct. The assessment phase focuses on testing the practicality and effectiveness of the ethno-flipped classroom model (prototype 3). Small-group trial activities are used during the assessment stage. According to Akker (1999) the model's practicability relates to the extent to which users (and other experts) find the intervention appealing and usable in typical situations (Akker, 1991). Observing the execution of the ethno-flipped classroom model developed was used to test the program's practicability.

The efficacy of the Akker (1999) model relates to the degree to which the intervention's experiences and outcomes are congruent with the planned goals. The model's effectiveness is evaluated using three criteria: classical learning completeness (achieved by administering valid tests to students), teacher ability to manage learning (achieved through observation activities), and achievement of positive student responses (achieved through administration of valid response questionnaires). The results obtained at the assessment stage are called the Final Product. Final The product is a valid, practical, and effective ethno-flipped classroom model. The ethno-flipped classroom model, which has proven to be valid, practical, and beneficial, can now be employed in a larger field deployment. The stages of model development using Plomp's development study-model type are presented in Figure 1 below.

**Figure 1**  
*Stages of Ethno-Flipped Classroom Model Development*



The participants in this study totaled 48 people with details of 25 students (64% female and 36% male) who participated in the first small group trial activity and 23 students (65.22% female and 34.78% male) in the second small group trial activity. All participants were final year students of a public high school located in Gunungsitoli City, Nias Island, Indonesia. The selection of participants was carried out by purposive sampling by considering the criteria of ethnic and cultural dominance of students and students' initial mathematics ability.

This research was conducted for 10 months from January to November 2022. Based on the research questions presented in the Introduction, this study aims to: (1) to develop a valid ethno-flipped classroom model; (2) to develop a practical ethno-flipped classroom model; and to develop an effective ethno-flipped classroom model.

## Result and Discussion

The new learning model produced is organized around the model components proposed by Joyce & Weil (2003), namely syntax, social system, management reaction principles, support system, instructional impact, and accompanying impact. The following are the outcomes of the construction of a new learning model based on the stages of the Plomp model:

### *Preliminary Research Stage*

The preliminary research stage was conducted through two activities, namely ethnographic research and needs analysis. Preliminary research activities were carried out by conducting small-scale ethnographic research related to the use of cultural contexts that will be used in the developed model (Subki, 2022). The cultural context integrated in the ethno-flipped classroom model is the cultural context of Nias tribe, both mentifacts and cultural artifacts. Needs analysis activities are carried out by analyzing the context and problems, literature review and analysis of research results that are relevant to the development of learning models carried out. Literature study was conducted related to the effectiveness of learning theories underlying the

learning model which became the basis for the development of ethno-flipped classroom model in improving students' mathematical ability. The preliminary research found that the context of mentifacts and cultural artifacts of Nias tribe are suitable to be integrated in the syntax of the new learning model. The chosen mentifactual context is the kinship system in the Traditional Wedding Ceremony of the Nias Tribe Community "*Fatalifusö*". This context is closely related to the concept of "gotong royong" or collaboration. The concept of collaboration (called "*gotong royong*") is one of the philosophies of life of the Nias community which is still preserved today, one of which is through the "*Fatalifusö*" kinship system. Each stage of "*Fatalifusö*" contains different values and messages. In addition, each stage is also carried out by several figures who play an important role including *Salawa hada* (customary leader), *Döla-döla hada* (consisting of the customary king, village head or *salawa*, penghulu, young head, induk ina, and dubala), *Talake* or *Si'o*, or *Halöluo* or *Towi-towi bawazuasa* (acts as an intermediary to conduct deliberations or *fobanuasa*), *Sanema li* (tongue connector) and *fadono* or *ono alawe* (the family of women who provide assistance) (Laoli et al., 1985).

The results of the preliminary research are also in line with the results of the needs analysis. The needs analysis conducted by the researcher found that students need a learning design that is flexible, meaningful, and close to the cultural context and traditions of their lives. The incorporation of cultural context into learning design aids students in understanding learning materials, increases student participation in learning activities, and expands students' reasoning skills in dealing with contextual difficulties. The needs analysis also found that the theoretical study of the flipped classroom model and the ethnomathematics approach can be combined in a new learning model, taking into account students' personal factors and personal behaviors (Ramadhani et al., 2021). The results of preliminary research and needs analysis are then used to design new learning model components consisting of syntax components, social systems, management reaction principles, support systems, and instructional and accompanying impacts. The result of the initial design of the new learning model is called Prototype 1.

**Prototyping Stage**

*RQ1: Validity of the Ethno-Flipped Classroom Model*

Prototype-1 produced in the preliminary research was then analyzed regarding the validity of the design produced. The strength of the Nieveen-based model is referred to as the design's validity. Prototype 1's validity is defined as both construct and content validity. Expert judgment was used to undertake the content validity and Many-Facet Rasch Model (MFRM) analysis. Table 1 below provides the findings of the content and construct validity test on ethno-flipped classroom model utilizing MFRM analysis.

**Table 1**

*Results of Content and Construct Validity Test on Ethno-Flipped Classroom Model Components Using Many-Facet Rasch Model (MFRM) Analysis*

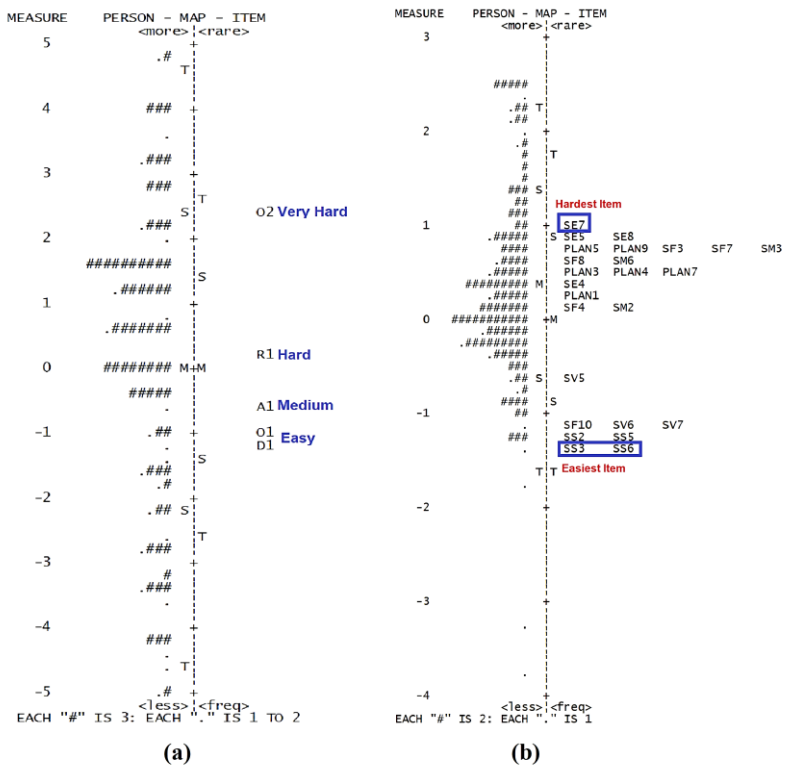
No.	Model Building Components Assessed	Total Score	Infit MNSQ	MNSQ Outfit	Infit ZSTD	ZSTD Outfit
1.	Syntax	134	0.58	0.87	-1.90	-0.30
2.	Social System	120	1.23	1.52	1.00	1.90
3.	Management Reaction Principle	117	0.87	1.32	-0.50	1.30
4.	Support System	132	0.74	0.57	-1.10	-1.50
5.	Instructional and Accompanying Impacts	131	1.26	0.94	1.00	-0.10

The valid criteria used in MFRM analysis refer to the fit statistics criteria which are evaluated based on the mean-square infit statistic (Infit MNSQ), mean-square outfit statistic (Outfit MNSQ), standardized infit statistic (Infit ZSTD), and standardized outfit statistic (Outfit

ZSTD). Infit and outfit mean-square statistics (Infit and Outfit MNSQ values) have an expected value range of 0.5 sampai 1.5. A facet element's Infit and Outfit ZSTD values are acceptable if they vary between -2 and +2 (Eckes, 2011, 2015). Based on MFRM analysis, the results of content and construct validity on all components of the new learning model (the ethno-flipped classroom model) were valid.

The validity test was followed by a construct validity test on the research instruments used as components of instructional impact (statistical informal reasoning ability test instrument) and accompanying impact (self-regulated learning non-test instrument). The item response theory-Rasch model measurement technique was used to assess construct validity (Sumintono & Widhiarso, 2015). Rasch Model Measurement Analysis is an IRT-based measurement analysis that employs the Joint Maximum Likelihood Estimation (JMLE) equation to convert raw data into interval data (logit) (Chan et al., 2016; Ramadhani et al., 2022). The following wright map of construct validity results on the instructional impact component (student learning outcomes test - informal statistical reasoning skills) and the accompanying impact component (student self-regulated learning questionnaire) are presented in Figure 2.

**Figure 2**  
 (a) Wright Map of Test Item Difficulty Levels from Construct Validity Results; (b) Wright Map of Questionnaire Statement Difficulty Levels from Construct Validity Results.

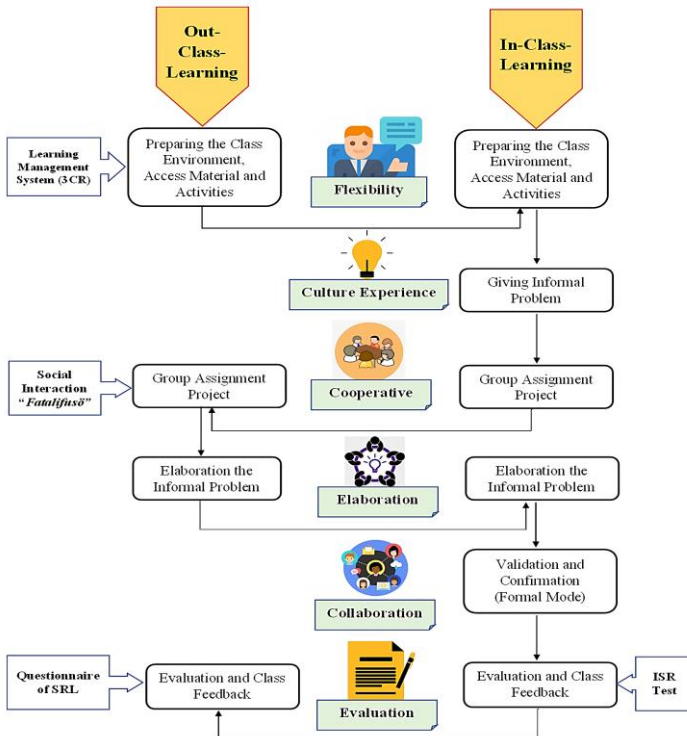


The criteria for analyzing construct validity on test and non-test instruments (item suitability or item fit) are (a) the accepted Outfit Mean Square (MNSQ) value of 0.50 to 1.50; (b) the accepted Z-Standard Outfit (ZSTD) value of -2.00 to + 2.00; and (c) the Point Measure Correlation (Pt. Mean Corr) value of 0.40 to 0.85 (Bond & Fox, 2015; Boone et al., 2014).

According to Figure 2, all items of the learning outcomes test instrument (informal statistical reasoning skills) appear to match the valid criteria utilized in the Item Response Theory-Rasch Model Measurement study. In contrast to the construct validity results on the self-regulated learning questionnaire, where there are 25 out of 50 statements that do not meet the valid criteria based on Item Response Theory (IRT) analysis through Rasch model measurement analysis. The unmet criteria appear in the Z-Standard (ZSTD) Outfit value criteria, where the accepted ZSTD Outfit value criteria are  $-2,0 < ZSTD < +2,0$ . Referring to the results of the construct validity of the self-regulated learning questionnaire (the accompanying impact component), it is concluded that the number of statements that are valid and can be used in the effectiveness test of the new learning model is 25 statement items.

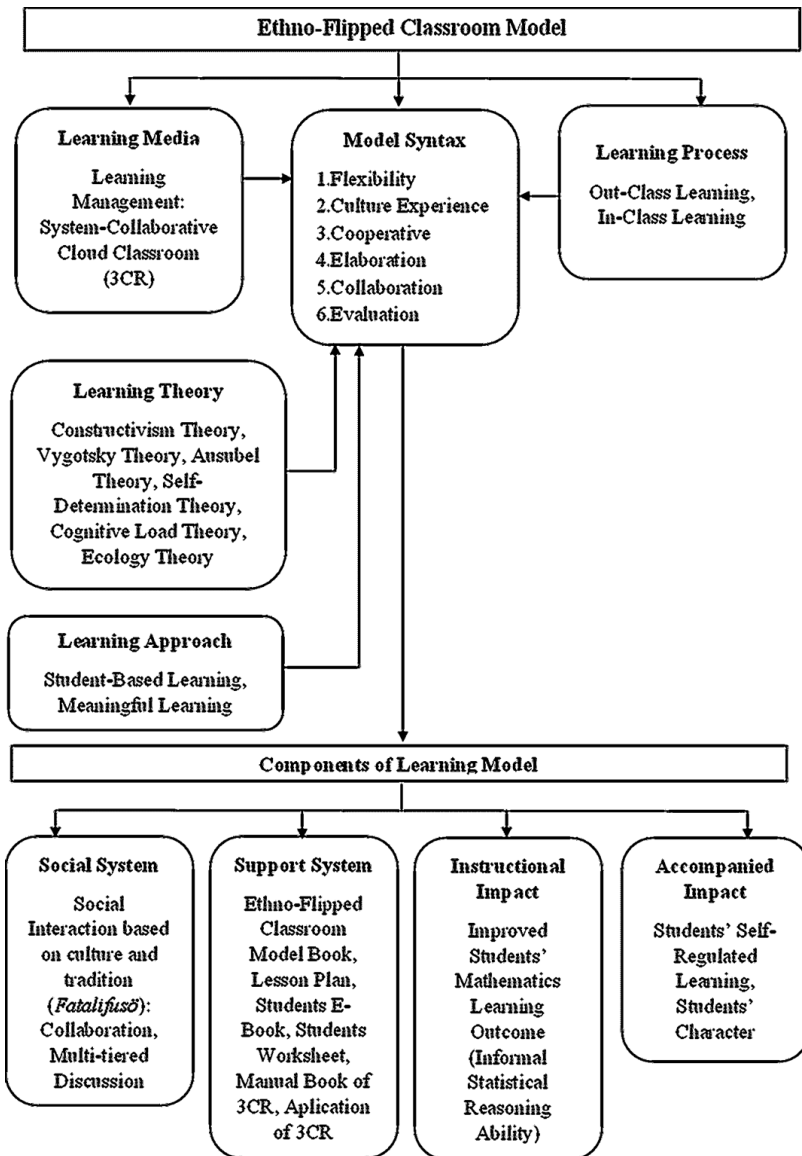
The results of the ethno-flipped classroom model design based on the components of the model at the prototyping stage are referred to as Prototype 2. The syntax design of the valid ethno-flipped classroom model (Prototype 2) is presented in Figure 3 below.

**Figure 3**  
*Syntax of the Ethno-Flipped Classroom Model*



The theoretical framework of the ethno-flipped classroom model that has been designed at the prototyping stage (Prototype 2) is presented in Figure 4 below.



**Figure 4***Theoretical of Ethno-Flipped Classroom Model*

The content and construct validation results in Table 1 and the construct validation results of test and non-test instrument in Figure 2 demonstrate that the components that comprise the ethno-flipped classroom model are valid in both content and construct. Researchers can use Rasch Model analysis to demonstrate that the constituent components of the ethno-flipped classroom model (syntax, social system, management reaction principle, support system, instructional impact, and accompanying impact) are valid and can be applied in field learning. The syntax of the ethno-flipped classroom model presented in Figure 3 depicts a succession of validated student learning activities. Student-centered learning activities through tiered discussion activities and

conducted by integrating the context of cultural mentifacts, then designed in a flexible form proved valid for implementation in the field. The validity of the ethno-flipped classroom model gained through this method demonstrates that the model is capable of facilitating a learning environment that encourages students to interact socially and promotes their competency. Furthermore, the valid ethno-flipped classroom model was further analyzed to test the practicality of its implementation in the field.

**Assessment Stage**

*RQ2: Practicality of the Ethno-Flipped Classroom Model*

The valid prototype 2 ethno-flipped classroom model (further referred to as prototype 3) was then tested in small groups. The small group trial was carried out for the initial design of the model to meet the practicality and effectiveness or not. The small group trial was conducted twice in different trial classes. The subjects who participated in the trial activities were final year students at the Science Program Senior High School level in Gunungsitoli City, Nias Island, North Sumatra Province-Indonesia. The practicality test of the model was carried out through observations of model implementation. Observations were conducted by external observers and the results of the model practicality test on the small group trial can be seen in Table 2 below.

**Table 2**

*Summary of the Practicality Test Results of the Ethno-Flipped Classroom Model in the First and Second Small Group Trial Activities*

No.	Aspects Observed	Average Aspect Score (Trial 1)	Average Aspect Score (Trial 2)
1.	Syntax	2.58	3.43
2.	Social System	2.40	3.46
3.	Management Reaction Principle	2.47	3.48
	Average Total Aspect Score	2.48	3.46
	Percentage of Model Applicability	62%	86.50%
Summary of Model Practicality Test Results		Implemented with Less Good ( $43,75 \leq KIMP \leq 62,49$ )	Very well done ( $81,25 \leq KIMP \leq 100$ ).

Based on the results of the model practicality test presented in Table 2, it is concluded that in the second small group trial, the ethno-flipped classroom model design (Prototype 3) has met the practicality requirements. The requirement for the practicality of the model is if the design of the model can at least be carried out with either ( $62,50 \leq KIMP \leq 81,24$ ) (Akbar, 2015).

*RQ3: Effectiveness of the Ethno-Flipped Classroom Model*

The valid and practical Prototype 2 was then tested for effectiveness through small group trials. The effectiveness test was conducted simultaneously with the practicality test of the model which was conducted twice in small group trials. The effectiveness of the ethno-flipped classroom model was analyzed through three criteria, including the achievement of classical student learning completeness, the achievement of teacher ability to manage learning, and the achievement of positive student responses after being given learning interventions.

*a) Achievement of Classical Student Learning Outcomes*

The analysis test of the completeness of student learning outcomes was performed on final-year students at Gunungsitoli City's Science Program High School. Small group trial activities were used for the analysis of the completeness of learning outcomes. The first small group trial took place in class A, and the second small group trial took place in class B. Participants in the first small group trial (Class A) included 25 students (64% female and 36%

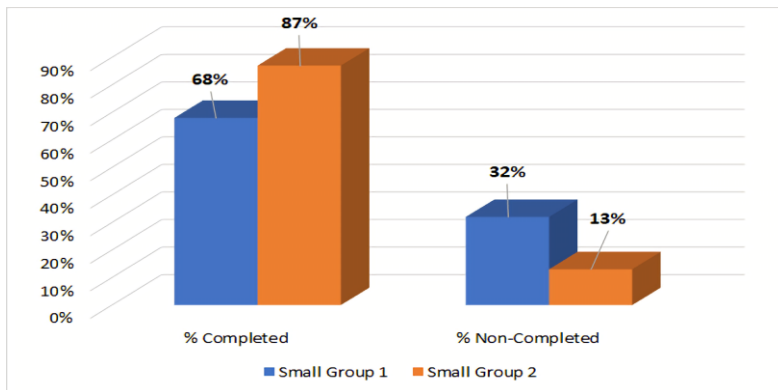
male) and participants in the second small group trial (Class B) included 23 students (65.22% female and 34.78% male).

The number of participants in the small group trial activities represents the research subjects who participated in the assessment activities to answer research questions related to effectiveness. A high number of participants is not required for small-group trials. This is because the main focus of the small group trial activities will be the success of the ethno-flipped classroom model after being deployed on a small scale in the field. According to Nieveen, the effectiveness of the learning model necessitates an analysis, and the presence of participants provides answers to the influence of the application supplied and the reaction given by a small number of students (Plomp, 2013). If the learning model has been demonstrated to be valid, practical, and effective in a small group of students, the implementation can be continued in a larger group of students, known as the field test, in the following stage.

The learning outcome test given to analyze the completeness of student learning outcomes classically uses a valid informal statistical reasoning ability test. The following comparison of the average student learning outcomes in the two small group trials is presented in Figure 5.

**Figure 5**

*Comparison of Percentage of Students Achieving Learning Completeness in Small Group 1 and Small Group 2*



According to Figure 5, the percentage of students' classical learning completeness in the small group 1 trial activity was only 68%, falling short of the efficacy criteria. If the percentage of classical completion (PCC) is greater than 85%, students have met the criterion for classical learning completeness. In reference to this condition, the small group 2 trial achieved 87% classical completeness in student learning results. Based on these findings, one of the three requirements for the new learning model's efficacy has been met.

#### *b) Achievement of Teachers' Ability to Manage Learning*

Another requirement for the ethno-flipped classroom model's performance is the teacher's capacity to supervise learning. An external observer will use a reliable observation sheet to assess the teacher's capacity to manage learning in the ethno-flipped classroom approach. In the first trial of small group activities, the findings of the examination of the teacher's ability to manage learning using the ethno-flipped classroom model did not meet the "good" criterion in all elements

of observation. The observation aspects that meet the "Good" criteria are only in the aspect of syntax implementation 1 (Preparing the Learning Environment, Material Access, and Learning Activities-Introductory Activities) with a category value of 3.92; the aspect of syntax implementation 2 (Providing Informal Problems-Core Activities) with a category value of 3.83; and the aspect of observing the classroom atmosphere with a category value of 3.54. The overall average observation scores also did not meet the minimum criteria of "Good", because it only reached an average score of categories 3.83. (3.50 to 4.49) because it only reached an average category score of 3.43 ("Good Enough" criteria). The first small group trial's study of the teacher's capacity to manage learning did not fulfill the achievement criteria.

The results of the second small group trial's observational analysis of the teacher's capacity to control learning met the criteria. The teacher's ability to manage learning utilizing the ethno-flipped classroom model has met the "good" standard in all parts of observation. The average value of the overall observation has also met the minimum criteria of "Good", because it has reached the average value of the 4.30 category. (3.50 to 4.49) because it has reached the average value of the 4.30 category ("Good" criteria). The significance of applying the grammar of the ethno-flipped classroom model has grown. The teacher's ability to implement the syntax of the ethno-flipped classroom model has increased in value because the teacher has begun to adapt and become accustomed to playing the roles of facilitator, motivator, and mediator, as well as patiently waiting for the students' responses to the teacher's directions.

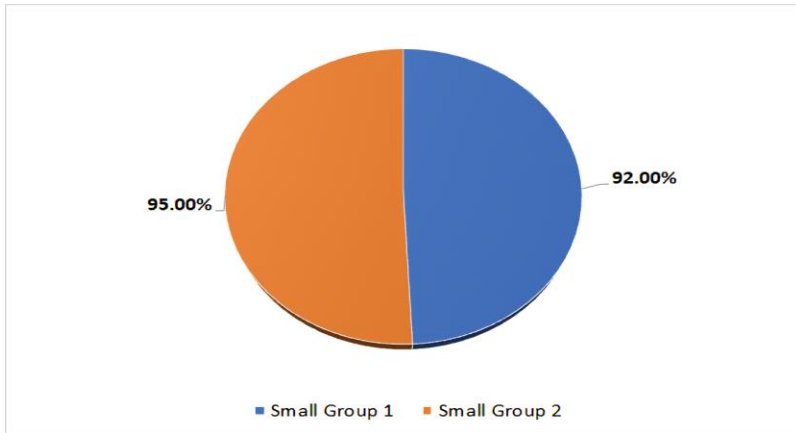
Teachers' roles in learning are critical to the successful application of learning models (Liu et al., 2018). Contact between teachers and students is also critical to ensuring that the applied learning model actualizes Vygotsky's idea that social contact influences student learning results (Dietrich et al., 2021; Kang et al., 2021; Spilt et al., 2011). Based on the observation of the teacher's ability to manage learning in the second trial activity, as well as the relationship of theory to the results and conclusions gained, the criteria for the teacher's capacity to manage learning have been met. This conclusion demonstrates that the ethno-flipped classroom approach met two of the three criteria for effectiveness.

*c) Achievement of Students' Positive Response After Receiving the New Learning Model Intervention*

Students' responses are measured and analyzed through the provision of student response questionnaire sheets. The student-answer questionnaire sheet that has been validated based on content and construct validity analysis is provided at the conclusion of the learning activities. Students are required to answer 12 affirmative statements on three different scales. The analysis of student replies in small group trial 1 reached 92%, and small group trial 2 reached 95%. These results show that students in two small group activities have a response in the "Very Good" category (Akbar, 2015). A comparison of the percentage of students' positive response achievement after receiving learning intervention using ethno-flipped classroom model is presented in Figure 6 below.

**Figure 6**

*Percentage of Student Response After Learning Ethno-Flipped Classroom Model (Small Group 1 and 2)*



Students' favorable responses reflect the influence of their activities during the learning process using the ethno-flipped classroom model. Students eagerly participated in tiered discussion exercises based on the kinship system at a traditional wedding ceremony, or "*Fatalifusö*". Students are also enthusiastic in solving informal statistical problems presented in the context of Nias culture. The ethno-flipped classroom concept creates a learning atmosphere that encourages students to actively participate in a variety of student-centered activities. Social interaction between students while in the learning environment attracts students' enthusiasm and interest to contribute to the learning process using the ethno-flipped classroom model.

The presence of a learning environment has been shown to assist students in creating knowledge, and the presence of social interactions has also been shown to help students manage cognitive load collectively (Huang et al., 2019; Prasetyo et al., 2022; Sjølie et al., 2022). This is consistent with the findings of Closs et al., (2022) research, which determined that the requirements for achieving favorable student responses were met based on the results of the analysis of student responses in the first and second trial activities in the small group. The examination of students' positive reactions revealed that all criteria for the effectiveness of the ethno-flipped classroom model had been met, as had the formulation of research problems connected to the model's effectiveness.

In terms of the attainment of the ethno-flipped classroom model's validity criteria, practicality criteria, and effectiveness criteria, the results reveal that the ethno-flipped classroom model established has met the learning model's validity, practicality, and effectiveness criteria. The findings of the effectiveness test conducted on the three criteria resulted in the final product of the new learning model, which is valid, practical, and effective.

### **Conclusion**

The findings of the construction of a new learning model revealed that the ethno-flipped classroom model matched the quality of the model development criteria established by Nieveen. The ethno-flipped classroom model's validity has been established based on both content and construct validity. All components of the ethno-flipped classroom model (syntax, social system, management reaction principles, support system, instructional impact, and accompanying impact)

met both content and construct validity criteria (based on Many-Facet Rasch Model analysis). The valid ethno-flipped classroom model also met Nieveen's model practicability criteria.

The implementation of the ethno-flipped classroom model conducted through observation activities has reached a very good implementation value after the second small group trial. Furthermore, the valid and practical ethno-flipped classroom model has also met the criteria for model effectiveness. Students can achieve classical completeness ( $PCC \geq 85\%$ ) after taking part in learning using the ethno-flipped classroom model. Based on the observation data, the teacher's ability to control learning also met the "good" criterion in the second small group trial (3.50 to 4.49) in the second small group trial activity as well. Even before the first small group trial, the students' positive reactions met the "very good" requirements. Even before the first small group trial, the students' positive reactions met the "very good" requirements.

Through three steps of Plomp's development study model and design research techniques, an ethno-flipped classroom model that is valid, practical, and effective is generated based on the outcomes of the development of a new learning model. The ethno-flipped classroom model's development outcomes also yielded a novel syntax comprised of six stages: flexibility, culture experience, cooperation, elaboration, collaboration, and evaluation. The syntax of the ethno-flipped classroom model can be implemented in the field of learning by using ethnomathematics contexts that are consistent with the traditions and culture of the pupils.

### Limitation of Study

The integration of ethnomathematics developed in the ethno-flipped classroom model design refers to the context of artifacts and cultural mentifacts of the Nias tribe found on Nias Island, North Sumatra Province-Indonesia. However, at the group assignment project level, the integration of the ethnomathematics context in the syntax only uses Nias tribal mentifacts (the kinship structure at the traditional wedding ceremony, or "*Fatalifusö*"). The social system formed based on the "*Fatalifusö*"-Nias context can be adapted to the social system of other tribes and cultures without changing the syntax of this model. The integration of the "*Fatalifusö*"-Nias mentifact context as an ethnomathematics context in the syntax of the ethno-flipped classroom model is because the Nias tribe is used as a case study in developing and analyzing the quality of the ethno-flipped classroom model design.

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