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# Development of Critical Thinking Instruments and Student Curiosity in Number Theory Course

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**Abstract**

This study aims to develop and test the validity and reliability of instruments that can measure critical thinking and curiosity of students in Number Theory course. This research is Research and Development (R&D) with ADDIE model, which consists of 5 stages, namely: analysis, design, development, implementation and evaluation. Data was collected from students who had taken the Number Theory course 40 students and 5 lecturers as expert validators. The instruments developed are in the form of tests and questionnaires consisting of several main indicators for each construct measured. Data collection instruments in the form of critical thinking test validation sheet and curiosity attitude with Likert scale. Data analysis techniques using inferential statistical analysis, namely by testing validity and reliability using the Q-Cochran statistical test . From the results of validation from experts about the validity of the construct and content obtained. The results showed that for construct validity obtained Asymp. Sig = 0.144 greater than $\alpha = 0.05$, thus $H_0$ is accepted and $H_1$ is rejected and for content validity obtained Asymp. Sig = 0.287 is greater than $\alpha = 0.05$, thus $H_0$ is accepted and $H_1$ is rejected, it is concluded that the students' mathematical critical thinking instrument is valid. The results of the validity and reliability test to students were obtained. For five test, all of them valid because $r_{xy} \geq r_{kritis} = 0.203$. For the reliability of the question, it was obtained $R_{11} = 0.807$ and $r_{kritis} = 0.203$, meaning $R_{11} \geq r_{kritis}$, the conclusion is that the question is reliable and has a very high reliability. For the curiosity questionnaire, the validity of the items by looking at the Corrected Item-Total Correlation. If there is an item whose value is below 0.2, it is said that the item is invalid. Of the 40 items, it can be said that all are valid because the Corrected Item-Total Correlation value is above 0.2 and for reliability, Cronbach's Alpha is obtained at $0.91 \geq 0.05$, which shows that the questionnaire instrument is reliable and has a very high category. The results showed that the critical thinking instrument and curiosity questionnaire are valid and reliable. This instrument can provide information about improving critical thinking skills and curiosity attitudes of students in Number Theory courses and the results can provide a basis for further research on the relationship between critical thinking, curiosity, and learning outcomes in mathematics or other disciplines.

**Keywords**: Instrument Development, Critical Thinking, Curiosity, Number Theory

***Abstrak***

*Penelitian ini bertujuan untuk mengembangkan dan menguji validitas dan reliabilitas instrumen yang dapat mengukur kemampuan berpikir kritis dan rasa ingin tahu mahasiswa pada mata kuliah Teori Bilangan. Penelitian ini merupakan penelitian dan pengembangan (R&D) dengan model ADDIE, yang*

*terdiri dari 5 tahap, yaitu: analisis, desain, pengembangan, implementasi, dan evaluasi. Data dikumpulkan dari mahasiswa yang telah mengambil mata kuliah Teori Bilangan sebanyak 40 mahasiswa dan 5 orang dosen sebagai validator ahli . Instrumen yang dikembangkan berupa tes dan angket yang terdiri dari beberapa indikator utama untuk setiap konstruk yang diukur. Instrumen pengumpulan data berupa lembar validasi tes kemampuan berpikir kritis dan angket sikap rasa ingin tahu dengan skala Likert. Teknik analisis data menggunakan analisis statistik inferensial, yaitu dengan melakukan uji validitas dan reliabilitas dengan menggunakan uji statistik Q-Cochran Hasil penelitian menunjukkan bahwa untuk validitas konstruk diperoleh nilai Asymp. Sig = 0,144 lebih besar dari α = 0,05, dengan demikian $H_0$ diterima dan $H_1$ ditolak dan untuk validitas isi diperoleh nilai Asymp. Sig = 0,287 lebih besar dari α = 0,05, dengan demikian $H_0$ diterima dan $H_1$ ditolak, maka disimpulkan bahwa instrumen berpikir kritis matematis siswa valid. Untuk reliabilitas soal diperoleh $R_{11}$ = 0,807 dan $r_{kritis}$ = 0,203, berarti $R_{11} \geq r_{kritis}$, kesimpulannya soal tersebut reliabel dan memiliki reliabilitas yang sangat tinggi. Untuk kuesioner rasa ingin tahu, validitas item dengan melihat Corrected Item-Total Correlation. Jika ada item yang nilainya di bawah 0,2 maka dikatakan item tersebut tidak valid. Dari 40 item, dapat dikatakan semua valid karena nilai Corrected Item-Total Correlation di atas 0,2 dan untuk reliabilitas diperoleh Cronbach's Alpha sebesar 0,91 ≥ 0,05 yang menandakan bahwa instrumen kuesioner tersebut reliabel dan memiliki kategori sangat tinggi.Hasil penelitian menunjukkan bahwa instrumen berpikir kritis dan kuesioner curiosity adalah valid dan reliabel dan dapat digunakan dalam mata kuliah teori bilangan. Hasil penelitian ini dapat menjadi dasar untuk penelitian lebih lanjut mengenai hubungan antara berpikir kritis, curiosity, dan hasil belajar matematika atau disiplin ilmu lainnya.*

**Keywords**: *Pengembangan Instrumen, Berpikir Kritis, Curiosity, Teori Bilangan*

**Mathematics Clasification:** 97D10 (Education and instruction in mathematics)

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## INTRODUCTION

In the 21st century, critical thinking skills are needed so that humans are able to cope with changing circumstances or challenges in life to face changing circumstances or challenges in life that are always evolving evolving (Kardoyo et al., 2020; Din, 2020). Likewise in the field of mathematics, this skill is a necessity that must be possessed by students, both at the high school and college levels (Zetriuslita et al., 2016). Also, an attitude of curiosity is needed in learning mathematics. Because with high mathematical curiosity, it will have a positive impact on positive impact in learning (Hunaepi et al., 2024; Zetriuslita & Ariawan, 2021) .

Teachers and lecturers aims to develop students' critical thinking skills and curiosity, especially in complex disciplines, one of which is Number Theory. Number Theory is one of the branches of pure mathematics that demands high-level thinking skills, logic, and in-depth analysis. Therefore, an instrument is needed that can measure students' critical thinking skills and curiosity to determine

the extent to which these objectives are achieved. Developing an instrument that is reliable and feasible to be used as a data collector of students' mathematical critical thinking skills is one of the efforts to obtain a valid and reliable instrument (Firdausi et al., 2023). The development of critical thinking and curiosity instruments is important in the context of mathematics education, especially as these two abilities are positively correlated with problem-solving skills and deeper concept understanding (Hunaepi et al., 2024; Arafah et al. 2023). Critical thinking helps students analyse, evaluate and synthesise information to solve problems (Ennis, 1984), while curiosity encourages students to keep exploring and questioning, which can improve their conceptual understanding. Skills already developed by Zetriuslita et al., (2017) and Chukwuyenum, (2013), but this skills is often ignored by teachers in the learning process in the classroom (Cáceres et al., 2020), (Zetriuslita et al., 2021), (Le et al., 2018) and (Anwar et al., 2012). Research instruments are tools or devices used to collect data in a study.The instruments in question are test instruments for critical thinking skills and questionnaire instruments for curiosity. Markey dan Loewenstein are stated that curiosity is a feeling of dissatisfaction that arises when someone faces incomplete information. This curiosity encourages individuals to fill in the information gaps (Rahaja et al., 2022).

The problem is that there is still a lack of critical thinking tests and curiosity questionnaires used by lecturers, they mostly use questions that already exist in reference books used especially for Number Theory courses. In general, the questions in the reference books emphasize more on understanding, not up to the level of high order thinking skills (HOTS). It is crucial to emphasize the importance of solving Higher Order Thinking Skills (HOTS) problems for students. Engaging with HOTS problems encourages critical thinking, creativity, and problem-solving abilities. These skills are essential not only in academic settings but also in real-world situations. By tackling HOTS problems, students learn to analyze complex situations, evaluate different solutions, and make informed decisions. This process fosters a deeper understanding of the subject matter and prepares them for future challenges. Furthermore, developing these skills enhances their ability to collaborate and communicate effectively, which are vital in today's interconnected world.

There are many studies on critical thinking and curiosity, including (Zetriuslita et al., 2017, Raida & Jamaludin, 2020, Iqoh, Rinaldi, & Putra, 2021, Hanifah Ameliah & Munawaroh, 2016; Changwong, 2018; Siti et al., 2021; Sunarti et al., 2021 ; Collins et al., 2004; Hunaepi et al., 2024; Rahaja et al., 2022; (Murphy et al., 2021); (Cohanpou et al., 2022). The results of the research conducted have not fully focused on developing critical thinking and curiosity instruments, as research conducted by Susanti et.al., 2021 entitled Analysis of the Development of Critical Thinking Instruments Test in Physics. It is also necessary to develop critical thinking instruments and curiosity questionnaires in this study as a tool to measure critical thinking skills and curiosity attitudes of students, especially in Number Theory courses. So that lecturers can use learning models to improve students' critical thinking skills and curiosity attitudes.

Based on the above problems, it is necessary to develop critical thinking and curiosity instruments, especially in number theory courses. This study aims to develop a valid and reliable instrument to measure critical thinking skills and curiosity in students who take Number Theory courses. Critical thinking is the skills to analyse, evaluate, and make informed decisions. In Number Theory, this ability emerges when students are faced with various mathematical problems, such as theorem proving, solving congruence problems, and analysing the properties of prime numbers. The critical thinking process allows students to construct logical arguments, analyse patterns, and evaluate the results of their own calculations. (Ennis, 1984; Facione, 1990).

Curiosity refers to a person's drive to dig deeper into a concept or phenomenon. In the context

of Number Theory, curiosity is reflected in students' desire to understand practical applications of abstract concepts, search for unique number patterns, or explore unanswered open questions in mathematics. This attitude not only encourages intellectual exploration, but also increases student engagement and motivation to learn. (Loewenstein, 2023).

## METHOD

This study used the Research and Development (R&D) method which involved several stages, namely: (1) literature study and development of the initial concept of the instrument, (2) validation of the instrument by experts, (3) field trials, and (4) data analysis to determine the validity and reliability of the instrument. The subject of this research is students who have been studied Numbers Theory that consist of 40 peoples and 5 lecturers as expert validators, The research instruments used were critical thinking ability test and curiosity questionnaire.

Data collection used validation sheets, questionnaires, and data analysis using inferential statistical tests, namely the Q-Cochran test.(Sugiyono, 2017a). The Grid of mathematical critical thinking skill test validation sheet and curiosity questionnaire can be seen in table 1 and table 2 below.

Table 1. The Grid of Mathematical Critical Thinking Ability Test Validation Sheet

| Validity | | Question No. | Consideration Result | | Comments and Suggestions for Improvement |
|---|---|---|---|---|---|
| | | | Valid | Invalid | |
| Advance | Language/ redactional clarity | 1 | | | |
| | | 2 | | | |
| | | 3 | | | |
| | | 4 | | | |
| | | 5 | | | |
| | Clarity of problem presentation | 1 | | | |
| | | 2 | | | |
| | | 3 | | | |
| | | 4 | | | |
| | | 5 | | | |
| Contents | Conformity with Indicators | 1 | | | |
| | | 2 | | | |
| | | 3 | | | |
| | | 4 | | | |
| | | 5 | | | |
| | Suitability to the aspect of ability to be measured | 1 | | | |
| | | 2 | | | |
| | | 3 | | | |
| | | 4 | | | - |
| | | 5 | | | |
| | Level of difficulty of questions with student abilities | 1 | | | |
| | | 2 | | | |
| | | 3 | | | |
| | | 4 | | | |
| | | 5 | | | |

Table 2. The Grid of Mathematical *Curiosity* Instrument

| No | Indicator | Sub-indicator | Question Number | |
|---|---|---|---|---|
| | | | Positive | Negative |
| 1 | Asking information regarding issues that have been provided | 1. Asking and response towards problem that have been given.<br>2. Response towards question that have been asked.<br>3. Try to attempt and ask a question. | 1,10,<br>12,27,38 | 15,29,31 |
| 2 | Ambition to know everything in detail | 1. Try to identify the solution.<br>2. Not giving up finding the solution toward the problem that has been given.<br>3. Give attention toward issue that have been given<br>4. Evaluate the results that have been gain.<br>5. Focus towards problem that has been given. | 4,9,11,16, 17, 25, 31, | 13,23,24,32 |
| 3 | Enthusiastic for learning | 1. Enthusiastic in discussion.<br>2. Interested towards the material that has been provided.<br>3. Enthusiast in solving issue that has been given. | 3,6,8,15,35,40 | 18,20,22, 28,30 |
| 4 | Try to discover information from any sources | 1. Reading the related material regarding the problem that has provided.<br>2. Search for references related to the given problem<br>3. Try to find related references towards the issue that has been provided. | 2,26,33,36 | 19,21 |
| 5 | Try to find and execute the alternative solution | 1. Try to find solution regarding problem that has been given.<br>2. Enthusiast to find alternative problem solution. | 7,14,34, 37 | 39,40 |

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The development model used was ADDIE (Alhamuddin et al., 2018). ADDIE model consists of five steps which are: (1) analyze, (2) design, (3) development, (4) implementation, and (5) evaluation (Firdaus & Nisa, 2019). In visual steps ADDIE Model can be look at the figure below:

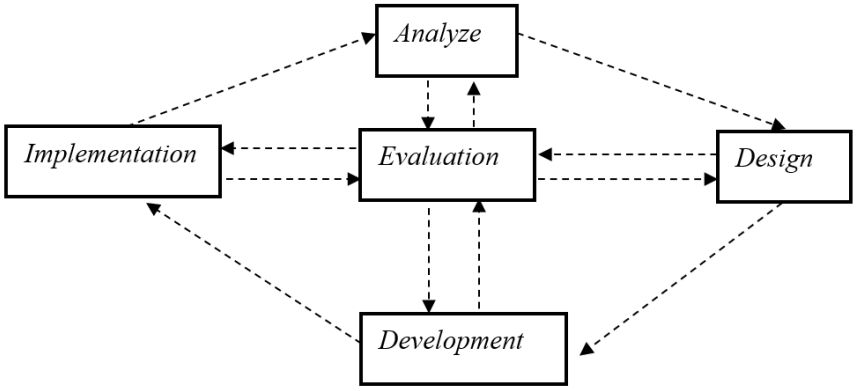



Figure 1. ADDIE Model Research and Development

We can conclude the steps of the research based on the figure above which are : 1) Analyze step, there are no instruments especially in Numbers study to find out critical thinking test and curiosity questionnaire; 2) Design step is a step to design the test that will be developed by creating test grid based on indicator and assessment tool to determine the validity of the critical thinking test and mathematical attitude curiosity questionnaire in the form of validation paper based on Likert scale; 3) Development step, by validate and reliable of the instruments. Validation test are conducted by several mathematical or mathematical education experts, on this study researcher is derived from two mathematic education doctors, one person specialized in number theory study, one doctor who has been teaching in the study for a long time and one other is a doctoral candidate in mathematics education; 4) In Implementation step, instruments that have been validated are being tested for students to identify the validity and reliability by using inferential statistic test which is Q-Cochran test (Sugiyono, 2017b); 5) The final step which is Evaluation step the test result or instruments implementation is being evaluated with statistic test to find out the validity and also the reliability of the instruments which are the critical thinking test and mathematical curiosity questionnaire. The category reliability can be seen at Table 3.

Table 3. Category Reliability Critical Thinking Test and Mathematical Curiosity Questionnaire

| No | Reliability | Category |
|---|---|---|
| 1 | 0,80 --- 1,00 | Very High |
| 2 | 0,60 --- 0,80 | Tall |
| 3 | 0,40 --- 0,60 | Enough |
| 4 | 0,20 --- 0,80 | Low |
| 5 | < 0.20 | Very Low |

The data analysis technique uses the validity of the instrument with the Q-Cohran test to test the hypothesis of expert validation. The hypotheses used are:

$H_0$ : Validators give the same consideration.

$H_1$ : Validators do not give the same consideration.

The test criteria: $H_0$ is accepted if Asymp.Sig score is bigger than $\alpha$ =0,05

For the validity of each question, the criteria used are if $r_{xy} \geq r_{critical}$ then the question is valid, and for the reliability of the question, if $R_{11} \geq r_{critical}$, then the question is said to be reliable.

## RESULTS AND DISCUSSION

### Result

The ADDIE development model was used for product research and development, and the following is a description of the results of each stage of development:

1. Analyse Stage

Analysis activities include needs analysis, curriculum analysis, and analysis of teaching materials used. Based on the results of the analysis, that so far the critical thinking ability test instruments and curiosity questionnaires used so far have not been guaranteed validity and reliability, specifically for test instruments for Number Theory courses. (Zetriuslita et al., 2017).

The results of the curriculum analysis can be seen in the Learning Outcomes (LO) of the Number Theory Course (taken from the semester learning plan) which do not refer to critical thinking skills, namely:

After completing this course in one semester, students are expected to:

1. Students are able to use mathematical induction in mathematical proofs
2. Students are able to solve the Binom theorem
3. Students are able to solve the division algorithm
4. Students are able to solve the Euclide algorithm
5. Students are able to solve Linear Diophantine Equation
6. Students are able to explain the principle of congruence and prove its properties
7. Students are able to solve applications of congruence

From the LO above, the indicators of critical thinking skills have not been seen, still at the application stage.

The analysis of teaching materials used likes test obtained information that the questions are still in the application category such as one of the questions given in the final semester exam in the number theory course "Determine the remainder of the division of $2^{117}$ by 117", this question still understanding concepts, not up to the level of critical thinking. So the need to develop critical thinking instruments and curiosity questionnaires in number theory courses is very important.

For the curiosity, there were exist discuss qualitatively about what curiosity is and there were experimental research raises curiosity through learning like as (Chen et al., 2025; Lapum & Hume, 2015; Ulum, 2022;Jackson & Ward, 2012; Mulyati et al., 2021). Ulum (2022) in his research , "Mathematical Curiosity Scale for Classroom Teachers and Teacher Candidates", used "Personal Information Form" as data collection tools. The scale used was developed by Usluoğlu and Toptaş (2021). It is in a five-point Likert type and consists of 22 items. There were no adverse items on the scale. The ranges for the items in the scale were formed on the basis of five ranges: "I strongly disagree, I disagree, I am undecided, I agree, and I strongly agree." The scale consists of 3 sub-dimensions called "Desire to Know the Unknown," "Seeking for Innovation" and "Desire for Success." There are 11 items in the first dimension, 7 items in the second dimension and 4 in the third dimension. The Cronbach's alpha reliability coefficient for the total scale was calculated as 0.85. Cronbach's alpha reliability coefficient was calculated as 0.81 for the sub-dimensions "Desire to Know the Unknown," 0.79 for "Seeking Innovation" and 0.71 for "Desire for Success." The Cronbach alpha reliability coefficients reached for this study were calculated as 0.93 for the total scale, 0.92 for the "Desire to Know the Unknown," 0.86 for the "Novelty Seeking" and 0.76 for the "Desire for Success."

From the results obtained at this analysis stage, it is necessary to develop critical thinking instruments and curiosity questionnaires, especially in number theory courses.

Based on the result of analysis stage, it was found that it is necessary to develop critical

thinking skills instruments and curiosity questionnaires in number theory courses.

2. Design Stage

At the design stage, a critical thinking skills test grid and a curiosity questionnaire grid were made, the grids were related to the indicators of critical thinking skills and curiosity questionnaire indicators. For critical thinking, this can be seen from the following indicators:

a. Able to identify, i.e. the ability to provide reasons for the problems faced
b. The ability to connect, namely the ability to connect between the events at hand.
c. The ability to analyse, namely the ability to select and determine important information from existing symptoms
d. Evaluating ability, which is the ability to find and detect important things from a given phenomenon.
e. Problem solving ability, which is the ability to understand the problem, choose a strategy and carry out the solution of the given problem.

These critical thinking indicators are inferred from the opinions of several experts such as (Ennis, 1984), Gokhale (1995), O'Daffer and Thornquist (1993) (in Zetriuslita & Ariawan, 2016)

For the attitude of curiosity, this can be seen from the following indicators:

a. Enquire about the information or problem provided
b. Desire to know things in detail
c. Enthusiastic/excited in learning
d. Seeks information from various sources
e. Trying alternative solutions to the problem

(Iqoh et al., 2021; Zetriuslita, Wahyudin, & Dahlan, 2020)

This indicator is used because in previous studies it has not been used and it is also suitable for Number Theory courses.

3. Development Stage

The instruments in this study are tests and non-tests, test instruments are used to measure critical thinking skills and non-test instruments in the form of questionnaires prepared based on a Likert scale to measure students' curiosity attitudes. Instruments for quantitative data in the form of tests to measure students' critical thinking skills were developed by making a test grid with steps, a) designing a test grid, b) compiling test items, c) validating experts, d) testing tests, e) validity and reliability tests, f) making revisions, if needed. After that, the development of student curiosity questionnaires in the form of non-test instruments, compiled based on indicators, then made a grid of statements in the form of positive and negative statements and tested and revised if needed. While the non-test instrument in the form of a questionnaire used to see the increase in students' mathematical curiosity was developed based on curiosity indicators and made positive statements and negative statements and observation sheets used to describe the implementation of learning.

At this stage, critical thinking skills questions and curiosity questionnaires were made based on predetermined indicators. There are 5 critical thinking skills questions made and 40 curiosity questionnaire statements.

a. Critical Thinking Test

In development stage have done content outline for the mathematical thinking ability test and critical thinking abilities guideline. It can be seen in Table 4 and Table 5 at the link https://drive.google.com/drive/folders/1iNnAcVQf5Z-AGuwo4k64lJZ4oopAncAw .

In table 4 at link above , there are 5 questions given where each question is one indicator, this right is done to make it easier to measure the validity of each indicator of each question given,

whether the questions given have been made in accordance with the given indicators.

b. Mathematics Curiosity Questionnaire

The instrument for identify students' curiosity towards mathematics study is a questionnaire that consist positive and negative statement. The scale that researcher uses is Likert scale which is the alternative answer for each statement that can be stated Always (A), Often (O), Rarely (R), and Never (N). Score Categories in Likert Scale can be seen in Table 6.

Tabel 6. Score Categories in Likert Scale

| No | Description | Statement (+) | Statement (-) |
|---|---|---|---|
| 1 | Always | 5 | 1 |
| 2 | Often | 4 | 2 |
| 4 | Rarely | 2 | 4 |
| 5 | Never | 1 | 5 |

(Sugiyono, 2017a)

This questionnaire consists of 40 statements and constructed based on the curiosity indicator that can be in table 7.

Table 7. Mathematical Curiosity Questionnaire

| No | STATEMENT | Always (A) | Often (O) | Rarely (R) | Never (N) |
|---|---|---|---|---|---|
| 1 | I will ask directly if I don't understand the lecturer's explanation and instructions about the assignment to be done. | | | | |
| 2 | I look for information about the material being studied from reference books/other sources such as the internet, learning CDs. | | | | |
| 3 | I study with friends, if there is an assignment that needs to be discussed | | | | |
| 4 | I read the lecture material before it is taught. | | | | |
| 5 | I will ask the lecturer if there is a problem/question given in the lesson that I don't understand | | | | |
| 6 | In group discussions, I try to discuss the given problems with enthusiasm. | | | | |
| 7 | I am challenged in solving the problems given | | | | |
| 8 | I try to find solutions to problems by never giving up | | | | |
| 9 | I will not give up if I experience obstacles in solving problems | | | | |
| 10 | I will answer the lecturer's questions if I know the answer. | | | | |
| 11 | I pay attention to the lecturer's instructions regarding the problems given in the lecture. | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **12** | I try to find out the lecture material by asking friends or lecturers. | | | | |
| **13** | I am indifferent to the problems given by the lecturer in the lecture | | | | |
| **14** | I will present the results of the group discussion, if our group is selected for the presentation. | | | | |
| **15** | I will answer questions from other groups, if anyone disputes the results of our group's presentation. | | | | |
| **16** | I don't want to ask the lecturer or friends even though I don't understand the material being presented. | | | | |
| **17** | I don't have the courage to ask lecturers or friends about the material being studied. | | | | |
| **18** | I feel uninterested in the mathematics materials being taught. | | | | |
| **19** | I am not interested in looking for math materials from various sources. | | | | |
| **20** | I'm afraid when the lecturer asks me to do questions on the blackboard. | | | | |
| **21** | Difficult questions make me lazy to do them. | | | | |
| **22** | This lecture material is too difficult for me. | | | | |
| **23** | If I can't do my homework I'd rather do another job | | | | |
| **24** | When the lecturer was explaining, I didn't listen attentively. | | | | |
| **25** | I evaluate the results of individual or group work. | | | | |
| **26** | I searched for the answers to the problems given by the lecturer myself. | | | | |
| **27** | I asked the presentation group if there was anything that contradicted the results of our group discussion. | | | | |
| **28** | I'm lazy to note down the important points in the worksheet | | | | |
| **29** | When I was tired and sleepy, I couldn't focus and didn't pay attention to the lecturer's explanation. | | | | |
| **30** | This learning is less interesting for me. | | | | |
| **31** | If there is a question from the lecturer, I don't try to answer it and pretend not to know. | | | | |
| **32** | At home I don't study the material that has been delivered on campus | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **33** | I immediately solve the problem, if I understand what I read from the existing references. | | | | |
| **34** | I'm curious, if I haven't found a definite answer to the problem given | | | | |
| **35** | I will not stop solving the problem until I get the answer. | | | | |
| **36** | I read notes, source books related to the courses taught. | | | | |
| **37** | I worked on the questions in the source book even though the lecturer didn't assign them. | | | | |
| **38** | When I made a mistake with my assignment, I asked the lecturer where the mistake was. | | | | |
| **40** | When I work on a difficult math problem, I stop working on it. | | | | |

4. Implementation Stage

The questions of critical thinking skills and curiosity questionnaire were given to the research subjects, to determine the validity and reliability of the tests and questionnaires that had been made. And also given to the validator to assess the test and questionnaire. Validation test are conducted by several mathematical or mathematical education experts, on this study researcher is derived from two mathematics education doctors, one person specialized in number theory study, one doctor who has been teaching in the study for a long time and one other is a doctoral candidate in mathematics education. In total there are five expertise who conduct the validation test.

In general, the result of validator consideration is stated that the question item in the test can be used as a research instrument although some changes and improvement need to do especially in the narration or language and the correlation between questions and the indicators. The consideration result from validator which are face validation and content can be seen next.

a. Face Validity

Here is the validators'consideration result of face validation ($V_1$ until $V_5$) can be seen in table 8:

Tabel 8. Validators' Consideration Result of Face Validation for Critical Thinking Test

| QN | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_5$ |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 0 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 |
| 5 | 0 | 1 | 1 | 0 | 1 |

QN : Question Number

Vi : Validator , i =1,2,3,4,5

To test the consideration of face validity from critical thinking from five experts, then formulation of statistical hypothesis is needed.

The hypotheses are:

$H_0$ : Validators give the same consideration.

$H_1$ : Validators do not give the same consideration.

To test the same consideration result of this face validation then researcher use Q-Cochran statistical test. The test criteria: $H_0$ is accepted if Asymp.Sig score is bigger than α =0,05. The result of Q-Cochran statistical test can be seen in Table 9.

Table 9. Uniformity Test Result of Instrument Face Validity

| | |
|---|---|
| N | 5 |
| Cochran's Q | 6.857[a] |
| Df | 4 |
| Asymp. Sig. | 0.144 |

a. 1 is treated as a success.

In table 9 can be seen that Asymp.Sig score is 0,144 more than α =0,05. With that $H_0$ can be accepted and $H_1$ is rejected, it can be conclude that five validator have been given uniformity consideration towards face validity for critical thinking instrument. It means the language feature in the instrument that have been given to the validator proven to be effective and can be used for the participants.

b. Content Validity

The result of validators consideration for content validity can be seen in table 10:

Table 10. Validators' Consideration Result for Content Validity

| No Soal | V1 | V2 | V3 | V4 | V5 |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 0 | 0 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 |
| 5 | 0 | 1 | 1 | 0 | 1 |

To test the same consideration result of this face validation then researcher use Q-Cochran statistical test. The test criteria: Ho is accepted if Asymp.Sig score is bigger than α =0,05. The result of Q-Cochran statistical test can be seen in Table 11 :

Table 11. Uniformity Test Result of Instrument Content Validity

| | |
|---|---|
| N | 5 |
| Cochran's Q | 5,000[a] |
| Df | 4 |
| Asymp. Sig. | ,287 |

a. 1 is treated as a success.

It can be seen in table 11 that Asymp.Sig score is 0,287 more than =0,05. Because of it $H_0$ can be accepted and $H_1$ is denied and it can be summarize that all of five validators is given uniformity of consideration regarding the content validity of critical thinking skill. From the results of expert validation, it was found that the critical thinking skills test was valid and reliable.

The validators' comments on the critical thinking instrument are as follows:

1. For question no.1 indicator 1, only words such as "solve it", according to the validator "solve the problem:
2. For question no.5 indicator 5, it says a dozen fruits, according to the validator the sentence is not correct.

The validators' comments can be seen on figure 2.

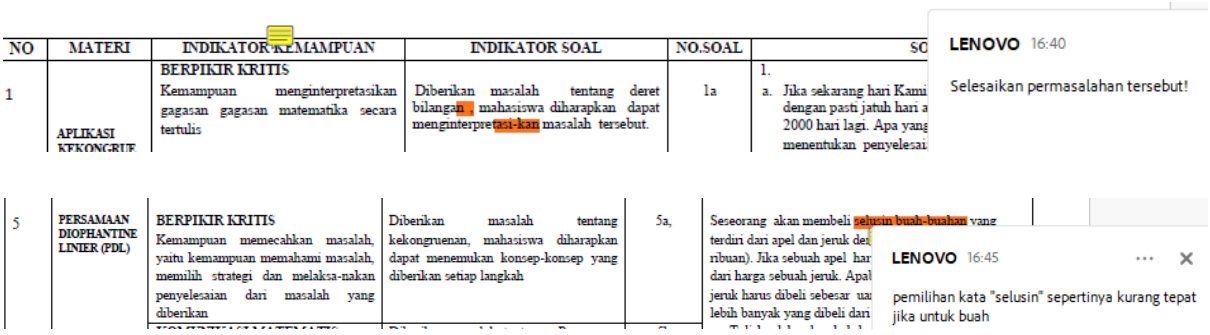
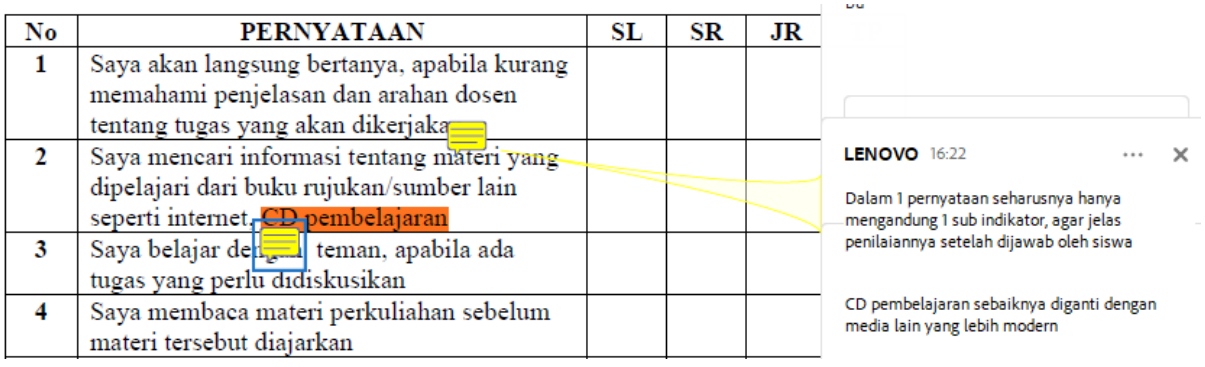



Figure 2. The validators' comments on the critical thinking instrument

The validators' comments for curiosity questionnaire are as follows:

1. Statement 1 should contain only 1 sub-indicator and statement 2, the word learning CD should be replaced with more modern media.
2. For the other statements, there are only incomplete sentences and some have repeated writing.

The validators' comments can be seen on figure 3.



| | | | | | |
|---|---|---|---|---|---|
| 30 | Pembelajaran ini kurang menarik bagi saya. | | | | |
| 31 | Apabila ada pertanyaan dari dosen, saya tidak berusaha menjawabnya dan berpura-pura tidak tahu | | | | |
| 32 | Di rumah saya tidak mempelajari materi yang telah disampaikan di kampus | | | | |
| 33 | Saya langsung menyelesaikan masalah, apabila sudah memahami apa yang dibaca dari referensi yang ada | | | | |
| 34 | Saya penasaran, apabila belum menemukan jawaban yang pasti dari masalah yang diberikan | | | | |
| 35 | Saya akan belum berhenti menyelesaikan masalah, apabila belum mendapatkan jawabannya | | | | |
| 36 | Saya membaca catatan, buku sumber yang berhubungan dengan mata kuliah yang diajarkan | | | | |
| 37 | Saya mengerjakan soal-soal yang yang ada di buku sumber walaupun tidak ditugaskan dosen | | | | |
| 38 | Ketika ada tugas saya yang salah, maka saya bertanya kepada dosen letak kesalahannya | | | | |
| 39 | Ketika mengerjakan soal matematika yang sulit, saya berhenti mengerjakannya | | | | |
| 40 | Jika diberikan tugas oleh dosen, saya langsung mengerjakannya | | | | |

LENOVO 16:30
sebaiknya hanya satu kalimat dalam 1 pernyataan

LENOVO 16:31
saya tidak akan berhenti...

LENOVO 16:31
di mana letak kesalahannya

**Komentar dan Saran Perbaikan Secara Keseluruhan**

Perbaiki angket sesuai saran terlampir.

**D. KESIMPULAN**

Berdasarkan penilaian yang telah dilakukan, lembar wawancara untuk guru ini dinyatakan:

1. Layak digunakan untuk uji coba tanpa revisi.
2. **Layak digunakan untuk uji coba setelah revisi.**
3. Tidak layak untuk digunakan untuk uji coba.

Figure 3. The validators' comments and suggestions for curiosity questionnaire

5. Evaluation Stage

The results of the critical thinking test and curiosity questionnaire validation analysis can be described below.

a. Critical Thinking Test

The instrument was tested on students who had taken the Number Theory course so that the validity and reliability of the test were obtained according to the desired standard. For the validity of each question, the criteria used are if $r_{xy} \geq r_{critical}$ then the question is valid, and for the reliability of the question, if $R_{11} \geq r_{critical}$, then the question is said to be reliable.

From the test results obtained data on the validity and reliability of the critical thinking ability test can be seen in Table 12 as follows:

Table 12. Critical Thinking Test Validity and Reliability Results

| Question Number | Validity | | Reliability | |
|---|---|---|---|---|
| | $r_{xy}$ | Description | $R_{11}$ | Category |
| 1 | 0,535 | Valid | 0,807 | Very High |
| 2 | 0,432 | Valid | | |
| 3 | 0,705 | Valid | | |
| 4 | 0,518 | Valid | | |
| 5 | 0,279 | Valid | | |

Note: $r_{critical}$ = 0.273 and dk = 50 for α = 0.05

Table 12 shows that the critical thinking test questions can be used in this study because all the questions given are valid and have very high reliability.

In this study, the Q-Cochran statistical test was used to test the uniformity of the results of face validity and content validity of the instruments developed, especially the critical thinking ability instrument. The Q-Cochran test is a non-parametric test used to test whether there is uniformity or significant differences among groups of respondents (in this case the validators) in assessing a criterion.

Face validity relates to whether an instrument appears subjectively valid, especially in terms of language use and overall appearance. In the face validity test results, the test criteria is to accept $H_0$ (null hypothesis) if the Asymp. Sig value is greater than the significance level α = 0.05. Conversely, if the Asymp. Sig value is smaller than α, then $H_0$ is rejected. In this study, the Q-Cochran test results for face validity showed an Asymp. Sig = 0.144, which is greater than α = 0.05. Therefore, $H_0$ is accepted and $H_1$ is rejected. This means that the conclusion can be drawn that the validators gave uniform judgements regarding the face validity of the instrument. This indicates that the language and appearance of the instrument have been considered effective by the validators.

After face validity is tested, the next step is to test content validity, which relates to whether the instrument thoroughly covers all aspects of critical thinking skills to be measured. The testing process uses the same criteria, which is to accept $H_0$ if the Asymp. Sig value is greater than α = 0.05. The Q-Cochran test results for content validity showed an Asymp. Sig = 0.287, which is also greater than α = 0.05. Based on this result, $H_0$ was accepted, which means that the validators gave a uniform assessment of the content validity of the instrument. In other words, all five validators agreed that the instrument had appropriately covered all aspects of critical thinking skills.

From these two tests, it can be concluded that the critical thinking skills instruments tested have met the standards of face validity and content validity. The validators have given uniform consideration, both in terms of language use and the content of the instrument developed. Thus, this instrument is considered suitable for use in measuring critical thinking skills. Many studies on the development of critical thinking test instruments, to get a valid and reliable test instrument such as research Rohmatulloh, Nindiasari, & Fatah, (2023) and Firdaus & Nisa, (2019). From the research results obtained, the instrument can be used.

b. Curiosity Questionnaire

The instrument used to measure students' curiosity towards Number Theory course is a questionnaire containing positive and negative statements. The scale used is a Likert scale, with alternative answers for each statement being Always (SL), Often (SR), Rarely (JR) and Never (TP). This questionnaire consists of 40 statements arranged based on curiosity indicators, which can be seen in Table 13 below.

Table 13. Reliability of Mathematical Curiosity Questionnaire Instrument

Reliability Statistics

| Cronbach's Alpha | N of Items |
|---|---|
| .910 | 40 |

Table 13 shows the Cronbach's Alpha coefficient value of 0.910. It is concluded that the reliability of the instrument is categorised as very high. Furthermore, the validity of each item or item can be seen in Table 14 below:

Table 14. Correlation of Items with Total Items

| | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted | Decision |
|---|---|---|---|---|---|
| Item 1 | 114,2459 | 142,155 | ,407 | ,909 | Valid |
| Item 2 | 113,7869 | 144,504 | ,301 | ,910 | Valid |
| Item 3 | 113,4754 | 143,854 | ,441 | ,908 | Valid |
| Item 4 | 114,4754 | 145,687 | ,309 | ,910 | Valid |
| Item 5 | 114,2131 | 139,037 | ,618 | ,906 | Valid |
| Item 6 | 113,8525 | 143,095 | ,473 | ,908 | Valid |
| Item 7 | 113,9672 | 144,166 | ,408 | ,909 | Valid |
| Item 8 | 114,0492 | 145,381 | ,317 | ,910 | Valid |
| Item 9 | 114,0656 | 144,596 | ,350 | ,909 | Valid |
| Item 10 | 113,7541 | 140,655 | ,542 | ,907 | Valid |
| Item 11 | 113,3115 | 144,085 | ,399 | ,909 | Valid |
| Item 12 | 113,4918 | 144,454 | ,363 | ,909 | Valid |
| Item 13 | 113,2623 | 140,163 | ,640 | ,906 | Valid |
| Item 14 | 113,2295 | 142,680 | ,435 | ,908 | Valid |
| Item 15 | 113,6066 | 142,976 | ,393 | ,909 | Valid |
| Item 16 | 113,2951 | 143,945 | ,344 | ,909 | Valid |
| Item 17 | 113,3607 | 139,534 | ,661 | ,905 | Valid |
| Item 18 | 113,3115 | 142,285 | ,523 | ,907 | Valid |
| Item 19 | 113,3279 | 142,491 | ,535 | ,907 | Valid |
| Item 20 | 113,8689 | 143,383 | ,390 | ,909 | Valid |
| Item 21 | 113,9836 | 142,616 | ,466 | ,908 | Valid |
| Item 22 | 113,5902 | 143,513 | ,419 | ,908 | Valid |
| Item 23 | 113,7869 | 141,670 | ,499 | ,907 | Valid |
| Item 24 | 113,3607 | 143,301 | ,417 | ,908 | Valid |
| Item 25 | 114,0492 | 144,981 | ,345 | ,909 | Valid |
| Item 26 | 114,1148 | 145,970 | ,266 | ,910 | Valid |
| Item 27 | 113,9344 | 142,396 | ,412 | ,909 | Valid |
| Item 28 | 113,4262 | 145,282 | ,347 | ,909 | Valid |
| Item 29 | 114,2295 | 141,280 | ,522 | ,907 | Valid |

| | | | | | |
|---|---|---|---|---|---|
| Item 30 | 113,3279 | 142,657 | ,498 | ,907 | Valid |
| Item 31 | 113,5902 | 141,813 | ,532 | ,907 | Valid |
| Item 32 | 113,6393 | 145,034 | ,398 | ,909 | Valid |
| Item 33 | 113,7213 | 139,771 | ,525 | ,907 | Valid |
| Item 34 | 113,6885 | 140,518 | ,599 | ,906 | Valid |
| Item 35 | 114,0820 | 144,510 | ,353 | ,909 | Valid |
| Item 36 | 113,7213 | 140,838 | ,532 | ,907 | Valid |
| Item 37 | 114,6885 | 146,918 | ,326 | ,909 | Valid |
| Item 38 | 114,3770 | 144,572 | ,337 | ,909 | Valid |
| Item 39 | 114,0164 | 145,516 | ,273 | ,910 | Valid |
| Item 40 | 114,2367 | 140,231 | ,223 | ,905 | Valid |

Table 14 can be used to see the validity of items by looking at the Corrected Item-Total Correlation. If there are items (items) whose value is below 0.2, it is said that the item is invalid. Of the 40 items, it can be said that all are valid because the Corrected Item-Total Correlation value is above 0.2. The instrument used in this study aims to measure students' curiosity towards Number Theory course. The instrument is a questionnaire containing 40 statements, consisting of positive and negative statements, which are arranged based on curiosity indicators.

To ensure that this instrument has a high level of consistency in measuring curiosity, reliability testing was carried out using the Cronbach's Alpha coefficient. Reliability indicates the extent to which an instrument provides consistent results when measured repeatedly. In general, the value of Cronbach's Alpha between 0.7 to 0.9 is considered a good indication of reliability, while values above 0.9 indicate very high reliability.

Based on Table 13, the Cronbach's Alpha value obtained is 0.910, which indicates that the instrument has a very high reliability. This means that the questionnaire used is very consistent in measuring students' mathematical curiosity towards the Number Theory course. This high reliability value has several important implications. Firstly, the instrument can be trusted to provide consistent results if used in different measurements or on similar student populations. Secondly, since the Cronbach's Alpha value is above 0.9, the instrument is not only consistent but also highly accurate in capturing the measured dimensions of curiosity. Thus, the measurement results obtained from this questionnaire can be used as valid data in evaluating students' curiosity in the context of learning Number Theory.

Overall, this instrument can be considered as a reliable measurement tool in research on mathematical curiosity, so that it can be used as a basis for decision making related to improving teaching methods or developing course materials in the field of Number Theory. From the results of the consideration of the validators and the validity and reliability tests of the mathematical critical thinking ability instrument and the mathematical curiosity questionnaire, an instrument that meets the criteria of a good instrument is obtained. In the sense that this instrument can be used in the process of collecting the necessary data.

## Discussion

The development of critical thinking and curiosity instruments in the Number Theory course is very important to evaluate the effectiveness of learning and to encourage the development of students' skills in solving mathematical problems. Valid and reliable instruments will help lecturers in designing teaching strategies that are more effective and adaptive to student needs. Some

previous studies that developed critical thinking test instruments include (Siti et al., 2021; Atika & Mz, 2016; Susanti & Adamura, 2020; Uki & Bire, 2021;Rohmatulloh et al., 2023; Firdausi et al., 2023; Rokhis & Mas'ula, 2020; Aini et al., 2023), while for curiosity instruments including (Bayuningrum et al., 2021; Dwidayati, 2017; Facione, 1990; Fauzi et al., 2017; Hanifah Ameliah & Munawaroh, 2016; Hunaepi et al., 2024; Kadek et al., 2020; Kundu & Bej, 2022). Kundu & Bej in their research was focused on comparing the effectiveness of three learning models on student curiosity in primary schools in India, not specifically developing a curiosity instrument. From the above studies, both for critical thinking instruments and for curiosity instruments, not many have developed them, so that from the research that researchers have done, they have provided something new and obtained new findings

From the results of research on the development of valid and reliable critical thinking and curiosity instruments, this instrument was tested on students to see their critical thinking skills and curiosity. The results of data processing using the t test, it was found that there was an increase in students' critical thinking ability and curiosity.

The new instrument developed in this study differs from the previous instrument in several key aspects : 1). Validity and reliability, the new instrument was designed with a stronger focus on validity and reliability. The development process involved pilot testing and statistical analysis to ensure that the instrument could accurately measure what it was intended to measure, whereas previous instruments may not have gone through this process as thoroughly. 2) Focus on number theory context, the new instrument is more specific to the learning context of number theory, with questions and tasks that are relevant to the material being taught. This is different from previous instruments which may have been general and not focused on specific aspects of the subject. 3). Increased student engagement, the new instrument is designed to encourage active student engagement, with questions that challenge them to think critically and explore new ideas. This is different from previous instruments that may not have stimulated students' curiosity enough. 4) More constructive feedback, the new instrument provides more constructive feedback to students, helping them understand areas for improvement and how to improve their critical thinking skills. Previous instruments may not have provided feedback that was in-depth or specific enough. With these differences, the new instrument is expected to provide a more accurate and in-depth evaluation of students' critical thinking skills and curiosity in learning Number Theory. Improved instruments are expected to increase student understanding and engagement in the subject of Number Theory. Valid and reliable instruments allow teachers to get a more accurate picture of students' abilities and identify areas for improvement .

This study recommends that the developed instrument be implemented in the learning process at large. In addition, it is important to conduct training for teachers so that they can use this instrument effectively in curriculum evaluation and development.This study also shows that a problem-based learning approach can positively contribute to the development of students' critical thinking skills and curiosity. This is in line with findings from other studies showing that active learning methods can increase student engagement.

Overall, this study made an important contribution in the development of instruments to measure students' critical thinking skills and curiosity in Number Theory. With more valid and reliable instruments, it is expected that the learning process can be improved, so that students can be better prepared to face challenges in learning mathematics.

The limitations of this research are that it has not reached the stage of testing effectiveness in learning and for critical thinking instruments, namely tests can only be used for number theory

courses, while curiosity questionnaires can be used for all courses.

## CONCLUSION

The results of this study indicate that the instrument developed has good validity and reliability to be used in measuring the level of critical thinking and curiosity of students in the Number Theory course. This instrument is expected to be used by lecturers to evaluate and develop students' critical thinking and curiosity skills, as well as a tool for further research in the field of mathematics education. This instrument can provide information about improving critical thinking skills and curiosity attitudes of students in Number Theory courses and the results can proving critical thinking skills and curiosity attitudes of students in Number Theory courses and the results can provide a basis for further research on the relationship between critical thinking, curiosity, and learning outcomes in mathematics or other disciplines. Therefore, for further research to test the effectiveness of the instrument using N-Gain with conduct experimental research so that significant results are obtained from the effectiveness of the instrument.

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