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# Developing the Nature of Science (NOS) Test Using Covid-19 Theme

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## Abstract

This study aims to develop Nature of Science (NOS) measurement instrument for high school students in the Mathematics and Natural Sciences program using COVID-19 cases that had occurred since the end of 2019. This study also attempts to validate test items with the Rasch model approach. The participants in this study are 194 high school students from the Mathematics and Natural Sciences program. Test participants consist of 132 female students and 62 male students. Their age range is 18-21 years old. NOS measurement instrument is presented in multiple choice form, which consists of 16 questions with narration or readings about COVID-19. Data analysis is conducted by dividing the validity into three types, those are content aspect validity, psychometric aspect validity, and construct validity using Rasch model. Content validity is conducted with an assessment involving three experts related to the test material and measured scientific literacy achievement. Psychometric aspects validity involves three psychometricians associated with the construction of the test. Meanwhile, for construct validity, which refers to the concept of construct validity of Messick. The results shows that there are 8 of 16 items in the NOS measurement that occupies all aspects of validity. Regarding to content of construct validity, there are two items do not appropriate with the model, while with substantive validity 94.4% of the test are consistent with the used Rasch model. Regarding to external aspect of construct validity shows that the test instrument can differentiate test participants into two categories, each of which has high and low NOS abilities.

**Keywords:** NOS, Test, Rasch Model, Covid-19.

## Introduction

Since the COVID-19 pandemic has taken place in the world, all countries are trying to make their people free from the COVID-19 pandemic with various kinds of efforts. However, the government's efforts are sometimes not supported by its citizens so that the recovery rate of a country free from the COVID-19 pandemic is different. Citizen support for the government programs to resolve the COVID-19 pandemic is highly dependent on the scientific literacy competence of every citizen (Miller, 2020).

The scientific literacy ability of citizens has been proven to have an influence on obedience in using masks, attitudes towards vaccination and even belief in conspiracy theories as the cause of the emergence of the COVID-19 pandemic (Miller, 2020; Motoki et al, 2020). Scientific literacy also affects to the occurrence of disinformation related to COVID-19. The low scientific literacy of citizens causes a lot of misinformation and misperception to spread, making it difficult for the Government to handle covid_19 pandemic (Austin et al, 2021; Bridgman, et al, 2020; Eysenbach, 2020). Scientific literacy then affects to person's health literacy. Health literacy determines a person's healing process after being exposed to COVID-19 greatly. Good health literacy will make it easier for someone to recover from covid_19 infection (Čavojová, 2020; Zlotnick, 2021; Rosário, 2020).

The science of COVID-19 is complex. Every day the public is presented with a series of charts, statistics and suggested therapies. Communication with scientists about the infectivity and virulence of COVID-19, sometimes leads to misperceptions both among scientists and common people. In a study involving 9654 adults in the United States, 48% of those with a high school education or less believed the true of conspiracy theory that COVID-19 was planned. There were 15% of those with postgraduate education who believed this (Miller, 2020). The high attitude of science denial towards COVID-19 worsen the death victim from the COVID-19 pandemic in Brazil, which was approaching 4000 deaths in early April 2021 (Malta et al, 2021). The attitude of science denial towards the COVID-19 phenomenon and skepticism towards vaccines as well as belief in conspiracy theories indicate a decline in trust of science that is being experienced by the world community today (Rutjens et al, 2021).

Many people are more comfortable responding to fake data than scientific information.

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The existence of beliefs based on false information, and eventually unable to differentiate between beliefs and facts. This is one indicator of the weakness knowledge of Nature of science (NOS). NOS is basically one of the three dimensions of scientific literacy, namely the ability in scientific reasoning (Scientific Reasoning Skill), scientific inquiry (Scientific Inquiry Skill) and knowledge of the nature of science (Nature of Science Knowledge) (Hanson, 2016; Wenning & Vierya 2015).

Based on more than 15 studies about NOS, McComas & Nouri (2016) had succeeded in formulating indicators of how understanding the nature of science, history, values and assumptions about science. These indicators include: (1) Scientific knowledge is not completely objective, (2) Scientists use creativity, (3) Scientific knowledge is tentative but long lasting, (4) Scientific knowledge is socially and culturally embedded, (5) Law and theory are different types of knowledge, (6) Scientific knowledge is based on empirical, (7) There is no universal stepwise scientific method, (8) There is a difference between observation and conclusion, (9) Science can't answer all questions, (10) Cooperation and collaboration are part of developing science, (11) There is a difference between science and technology, (12) Experiments have a role in science.

Some of the other experts (Lederman et al, 2013; Jiang & McComas, 2014; Sumranwanich & Yuenyong, 2014; Settlage & Southerland, 2012; Temel, en, & zcan, 2017; Giancoli, 2014) defined a simpler NOS indicator that included several aspects, those are : (1) Empirical based, scientific knowledge is based on data or evidence obtained from observations with the five senses and or experiments; (2) Tentative, scientific knowledge is not something that is absolutely true and without error, but it can be changed (improved) by new observational evidence and by reinterpretation of existing observations; (3) Theories and law, law describes the relationship, observation, perception of natural phenomena which are usually accompanied by mathematical formulas, while theory is an explanation for natural phenomena and the mechanism of the relationship between natural phenomena, (4) Socio cultural embeddedness, Science is the result of human effort, so the process of obtaining it can be influenced by the society and culture in where it is practiced, then the value system and culture will influence what and how science is conducted, interpreted, and accepted; (5) Creativity, scientific knowledge is created from human imagination, creativity and logical reasoning so that it will continue to evolve, the creation of scientific knowledge is based on creative planning, observation, and conclusions; (6) Scientific method, there is no definite and universally applicable scientific method, scientists are free to use any method as long as it can be justified; and (7) Subjective; Personal subjectivity is unavoidable in science, factors such as personal values, beliefs, self-agenda, and previous experiences will influence what and how scientists do their works.

Behavioral indicators that match the level of NOS knowledge are very appropriate when used to measure NOS knowledge for both students and the community. Due to as part of scientific literacy, NOS knowledge of students and the community is very important to be improved so that the public can respond appropriately to science news, especially those related to the COVID-19 pandemic. To increase community NOS knowledge, starting from enhancing NOS in schools. Improving NOS knowledge in schools is conducted with various approaches, both in the preparation of science education curriculum, science learning models and in science education assessments. Some studies have attempted to develop curriculum and learning models to improve students' NOS knowledge in schools (Brunner, & Abd-El-Khalick, 2020; Cofre et al., 2014; Retnawati et al., 2016; Lestari, & Widodo, 2021). Likewise, the development of an instrument to measure students' NOS knowledge by some researchers (El Islami et al, 2019; Kwon & Nam, 2020; Erduran, & Dagher, 2014). Efforts to increase NOS knowledge are also conducted by science teachers in schools (Abd-El-Khalick, 2013; Moutinho et al, 2015; Akerson et al, 2017).

The COVID-19 pandemic basically is the tests of the NOS knowledge of students and the community in responding to the pandemic phenomenon. The pandemic phenomenon has become very interesting issues to be used as material in measuring students' NOS knowledge. Measuring NOS knowledge with certain themes has not been done by many researchers until now. The phenomenon of the COVID-19 pandemic is currently taking place so that if the COVID-19 theme is used as a theme in the NOS knowledge assessment, it is basically an authentic assessment.

Authentic assessment needs to made because it provides more benefits. The characteristics of authentic assessment are: (1) having relevance to the real world; (2) encouraging students to develop connection that are relevant to real-world assignments; (3) providing complex continuous tasks; (4) observing the task of different perspectives; (5) showing self-reflection; (6) showing teamwork; (7) chasing meaningful works of art; and (8) producing competitive problem solving. Authentic assessment will create active, innovative, socialist and scientific students paradigm (Basuki & Hariyanto, 2014; Hanifah & Irambona, 2019). Another character of authentic assessment is an assessment that occupy various conditions, namely: (1) demonstrating skills that will be used in the future workplace, (2) testing scientific concepts (not memorizing), (3) involving the use of critical thinking or solving problem skills, and (4) incorporating student's choices and input into the assessment (Schultz et al, 2021). Of all these characters, using the COVID-19 theme in the NOS knowledge assessment can be categorized as a form of authentic assessment.

In the implementation of education in Indonesia, the 2013 curriculum emphasizes that teachers must apply authentic assessment in the learning process. Authentic assessment in the 2013 Curriculum refers to the Minister of Education and Culture Regulation Number 104 of 2014 concerning Educational Assessment Standards. According to (Kunandar, 2013; Ani, 2013), to fulfill these provisions, efforts were made to implement it through the development of an assessment of each lesson based on authentic assessment.

This study aims to develop NOS measurement instrument for high school students in the Mathematics and Natural Sciences program using COVID-19 cases that have occurred since the end of 2019. This study also attempts to validate test items using the Rasch model approach.

# METHOD

## Research Design

This research is a Research and Development with an Analysis, Design, Development, Implementation, Evaluation (ADDIE) design (Molenda, 2003; Wahyuni, 2015). First step was need analysis for developing the intrumen, researchers determine the needs and objectives of the product to be developed by gathering information from the science teachers in focus group disscussion (FGD) session. Second step, reseachers designing the intrumen based on the indicators that have been found from FGD. Third step, The development of research product is an instrument that measures scientific literacy competence in the NOS aspect. An implementation step and Evaluation was going through the high school students from the MIPA program through the thematic study of COVID-19 using field testing to construct objectivity, this instrument is validated with Rasch model.

The concept of objective measurement in the social sciences and educational assessment according to Mok and Wright must have five criteria, namely: (1) Generating linear measures with equal intervals, (2) precise estimation processing, (3) Identify items that are inappropriate (misfits) or uncommon (outliers), (4) being able to handle the lost data, (5) Producing measurements that are independent from the parameters studied (Mok, and Wright, 2004). From the previous five conditions, so far only the Rasch model has occupied these five requirements. The quality of measurements in educational assessments conducted with the Rasch model would have the same quality as measurements made in the physical dimension in the field of physics (Sumintono, & Widhiarso, 2014). In modern test theory measurement, the Rasch model is observed as the most objective measurement model. The use of the Rasch model in educational measurement has advantages in specific objectivity and high stability of item parameter estimates (Wu, & Adams, R, 2007). The Rasch model relates the probability of correct answering each item (P(θ)) as a function of ability (θ) with item difficulty constant (b) through the relation in equation 1.

$$P_i(\theta) = \frac{e^{(\theta - b_i)}}{1 + e^{(\theta - b_i)}} \qquad (1)$$

$P_i(\theta)$ : probability someone ability θ to answer the i-th question items correctly.

$b_i$ : parameter of the difficulty level of the i-th question

i : 1, 2, 3,... 42

e : natural logarithm base number

θ : participant ability parameters

Analysing Rasch model uses the R program software version 3.5.0 via package version 0.15-6 (Mair et al, 2019).

At the design step, researchers begin to collect, to arrange and to design the product that will be developed. At the development step, researchers began to validate the instruments they developed. At the implementation step, the researchers conduct observations by giving an integrated science-based scientific literacy skill instrument. At the evaluation step, external validity tests are constructed using external criteria such as intelligence tests or tests of National Examination results. This study is limited to the analysis, design and development steps.

## Population and Sample/ Study Group/Participants

The participants in this study are 194 high school students from the Mathematics and Natural Sciences program consisting of students from Senior High Schoon in Tegal City at Central Java Provinces. The test participants consist of 132 female students and 62 male students. Their age range is 18-21 years old and sit at 11st grades. They mostly get the science course in class as term an condition for involving as respondents of field testing step.

## Data Collection Tools

The NOS measurement instrument is presented in the form of multiple choices, which consists of 16 questions with narration or readings about COVID-19 and its causes. The NOS test blueprint used can be seen in Table 1 below:

**Table 1**: NOS Test Competencies and Indicators

| No | competencies | Indicators | question code |
|---|---|---|---|
| 1 | Differentiating between facts and explanations | Given a scientific reading, students can differentiate facts and explanations correctly | 1A, 1B |
| 2 | Theoretical Requirements or Partial Subjectivity of the Data | Given a scientific reading, students understand that observations are influenced and guided not only by scientific theory, but also by the beliefs, values, attitudes, commitments, training, prior knowledge, past experiences, and expectations of a scientist. | 2A, 2B |
| 3 | The Role of Creativity | Given a scientific reading, students understand that giving an explanation is not only a matter of collecting data and doing it logically to get it, but also intuition, imagination, and creativity are needed. | 3A, 3B |
| 4 | Nature of the Scientific method | Given a scientific reading, students understand that the scientific method is a strategy for inferring explanations of phenomena and then evaluate the comparison of specific predictions from observational data with data in the real world. | 4A, 4B |

| | | | |
|---|---|---|---|
| 5 | Determining explanation based on data | Given scientific reading, students understand that an explanation is not determined by a single data but some different explanations can explain a particular data set. | 5A, 5B |
| 6 | Reason to accept explanation | Given scientific reading, students understand that scientific explanations must occupy some criteria, one of which is confirmation of observations from predictions that have been made | 6A, 6B |
| 7 | Tentativeness of scientific explanation | Given scientific reading, students understand that a scientific explanation can be abandoned or even rejected in favor of a new, better explanation. | 7A, 7B |
| 8 | Differentiating fact and belief | Given scientific reading, students can differentiate between facts and beliefs | 8A, 8B |

## Data Collection

Trial the test was conducted on July 29, 2022 and August 4, 2022 using assesment website https://www.lisatest.id/. Each respondents was registered and login using this link by entering their username and password. The data of trial test was collecting from the students after they fulfill the test for 120 minutes.

## Data Analysis

Data analysis is conducted by dividing the validity into three types, namely content aspect validity, psychometric aspect validity, and construct validity using Rasch model. Content validity is conducted with an assessment involving three experts related to the test material and measured scientific literacy achievement. The assessors are asked to answer whether the test items have occupied some criteria such as: (1) the truth of the scientific narrative presented, (2) the validity of the data presented, (3) the suitability of the questions with scientific literacy indicators, (4) the truth of the answer keys. and (5) integrated science capability involvement.

Psychometric aspects validity involves three psychometricians associated with the construction of the test. Aspects of the construction of the test that are assessed included aspects of the material, construction, language and narrative of the test-let.

Meanwhile, for construct validity, which refers to the concept of construct validity of Messick (1996), where construct validity is divided into six aspects, those are content, substantive, structural, external, consequential and generalization (Baghaei, & Amrahi, 2011). Susongko (2016) provided quantitative criteria relating to indicators of construct validity based on Rasch model as described in Table 2 below.

**Table 2:** Valid test criteria observed from various aspects of validity and criteria by applying the Rasch Model

| **Aspects of Construct Validity** | **Indicators** | **Criteria** |
|---|---|---|
| Content | Item fit test (itemfit) | P > 0.05<br>0,5 <MNSQ<1,5<br>-2,0 < ZSTD<2,0 |
| Substantive | Person fit statistic | P > 0.05<br>0,5 <MNSQ<1,5<br>-2,0 < ZSTD<2,0 |
| | accuracy, sensitivity, dan specificity | close to 1.0 |
| | Invariance Test (LRtest) | P< 0,05 Consequential |
| External | value of separation Person strata | close to 1.0 |
| | DIF | there is no significant DIF |

The used software to analyze Rasch model in this study is the R version 3.5.0 program with the e-Rm package version 0.16-2. This software is used because it is open source so it is easy to access and develop for educational assessment research observers.

## Findings

The validation result of the content aspects validity can be seen in Table 3 while of the validation result of the psychometric validity can be seen in Table 4.

**Table 3:** Content Validity Analysis Result of NOS Measurement Instruments for MIPA Program High School Students.

| **No** | **Criteria** | **Match Test Items with Criteria** | | |
|---|---|---|---|---|
| | | **Validator 1** | **Validator 2** | **Validator 3** |
| 1 | The scientific truth presented | Match | Match | Match |
| 2 | The validity of data being presented | Match | Match | Match |
| 3 | The compatibility of problems to the scientific literacy indicator | Match | Match | Match |
| 4 | The truth of key answers | Match | Match | Match |
| 5 | Integrated science ability involvement | Match | Match | Match |

**Table 4:** Psychometric Validity Analysis Result of NOS Measurement Instruments for MIPA Program High School Students.

| **Rubric** | **Match Test Items with Criteria** | | |
|---|---|---|---|
| **Materials** | Validator 1 | Validator 2 | Validator 3 |
| 1. Questions must match the indicators | Match | Match | Match |
| 2. Answer choices must be homogeneous and logical in terms of material | Match | Match | Match |
| 3. Each question must have one correct or most correct answer | Match | Match | Match |
| **Construction** | Match | Match | Match |
| 4. The subject matter must be formulated clearly and firmly | Match | Match | Match |
| 5. The formulation of the main questions and the answer choices must be only required statements. | Match | Match | Match |
| **6.** The point of the question does not give clues to the correct answer | Match | Match | Match |
| 7. The subject matter should not contain statements that are double negative. | Match | Match | Match |
| 8. The length of the answer choice formulations must be relatively the same | Match | Match | Match |
| 9. The answer choices should not contain the statement, "All of the answer choices above are wrong", or "All of the answer choices above are correct" | Match | Match | Match |
| 10. The answer choices in numbers or time form must be arranged in order of the size of the value of the number, or chronologically | Match | Match | Match |
| 11. Pictures, graphs, tables, diagrams, and its kind in the questions must be clear and functional | Match | Match | Match |
| 12. Item questions do not depend on the answers to the previous questions | Match | Match | Match |
| **Language** | Match | Match | Match |
| 13. Each question must use language that is in accordance with the rules of the Indonesian language | Match | Match | Match |
| 14. Do not use local language, if questions will be used for other regions or nationally | Match | Match | Match |
| 15. Each question must use communicative language | Match | Match | Match |
| 16. Answer choices do not repeat words or phrases that are not a unified meaning. | Match | Match | Match |
| **Testlet Narrative** | Match | Match | Match |
| 17. Appropriate with the field of science that is multidisciplinary | Match | Match | Match |
| 18. Easy to reach for MIPA program high school students (Class XI) | Match | Match | Match |
| 19. Clear and inferred description | Match | Match | Match |

The construct validity analyzed in this study includes four aspects, namely content aspects, substantive aspects, structural aspects and external aspects. For this description can be seen in Table 5, Table 6 and Table 7 below.

**Table 5:** Responses Appropriateness Test of Each NOS Item with the Model Used

| **Item number** | **Chi Square Value** | **P Value** | **noted** | **Item number** | **Chi Square Value** | **P Value** | **noted** |
|---|---|---|---|---|---|---|---|
| 1 | 165.772 | 0.923 | appropriate | 9 | 220.590 | 0.084 | appropriate |
| 2 | 232.133 | 0.028 | inappropriate | 10 | 234.903 | 0.021 | inappropriate |
| 3 | 195.161 | 0.443 | appropriate | 11 | 179.413 | 0.750 | appropriate |
| 4 | 193.921 | 0.468 | appropriate | 12 | 156.505 | 0.975 | appropriate |
| 5 | 144.158 | 0.997 | appropriate | 13 | 210.265 | 0.187 | appropriate |
| 6 | 176.436 | 0.798 | appropriate | 14 | 204.325 | 0.274 | appropriate |
| 7 | 129.235 | 1.000 | appropriate | 15 | 180.731 | 0.727 | appropriate |
| 8 | 173.586 | 0.839 | appropriate | 16 | 186.083 | 0.626 | appropriate |

**Table 6:** Difficulty level of NOS items by Applying Rasch Model

| **Item number** | **Difficulty Level** | **Standard Error** | **Item number** | **Difficulty Level** | **Standard Error** |
|---|---|---|---|---|---|
| 1 | 0.099 | 0.147 | 9 | -0.202 | 0.151 |
| 2 | 2.685 | 0.228 | 10 | 0.937 | 0.148 |
| 3 | 0.648 | 0.145 | 11 | 0.277 | 0.145 |
| 4 | 0.054 | 0.147 | 12 | -1.265 | 0.191 |
| 5 | 1.115 | 0.183 | 13 | -0.300 | 0.153 |
| 6 | 0.517 | 0.145 | 14 | 0.914 | 0.148 |
| 7 | 1.431 | 0.201 | 15 | 0.364 | 0.145 |

| | | | | | |
|---|---|---|---|---|---|
| 8 | 0.614 | 0.162 | 16 | -1.568 | 0.210 |

**Table 7:** The List of Test Participants Responses that are Inappropriate with Model at Significance level of 0.05

| Participant number | Chi Square Value | P Value | Participant number | Nilai Chi Square | P Value |
|---|---|---|---|---|---|
| 37 | 26.962 | 0.029 | 134 | 25.776 | 0.04 |
| 50 | 25.989 | 0.038 | 150 | 25.776 | 0.040 |
| 89 | 46.906 | 0.000 | 177 | 27.079 | 0.028 |
| 103 | 26.430 | 0.034 | 182 | 43.470 | 0.000 |
| 114 | 25.235 | 0.047 | 190 | 37.927 | 0.001 |
| 121 | 37.348 | 0.001 | | | |

The test items that measure NOS after validation with Rasch model and the Messick (2006) validity approach can be seen in Table 8.

**Table 8:** Test Items for Scientific Literacy Measurement of NOS Aspects after validation

| No | Item | Difficulty level |
|---|---|---|
| 1 | Based on the reading, which of the following choices is a fact?<br>Humans infected COVID-19 from bats<br>Scientists discovered RaTG13 virus in bat droppings in 2013<br>covid 19 originates from outside Wuhan, China<br>There's no way COVID-19 came from a leaky laboratory<br>There are other animals that are responsible for helping the virus move from bats to humans | 0.099 |
| 2 | International world found out about COVID-19 after a case group of people experiencing symptoms of cough and fever at the Hunan Seafood Market in Wuhan, China., Could it be concluded that COVID-19 originated from the market?<br>a. It could be because in the market there is bat meat that is consumed by people in Wuhan<br>b. According to Erin Garcia de Jesús (March, 2021) to find out the virus source, we must first understand the genetic material of the virus and evidence infection in the past.<br>c. It could be because it is proven that COVID-19 has several features that can only come from viruses circulating in animals,<br>d. It is uncertain because researchers do not fully understand how bats interact with the viruses they carry and thus how they can transmit the virus to other animals.<br>e. Maybe because after visiting China, the WHO team concluded that the virus could not have leaked from the laboratory | 0.648 |
| 3 | In paragraphs 17 and 18 it is explained that the virus may exist somewhere in one season and disappear in the next season. It's not clear why viruses come and go, said. Plough. Below is a possible explanation from scientist regarding the phenomenon:<br>. Stressed bats are more likely to spread the virus into the environment, just like stressed people who get sores from the herpes virus<br>. Constantly infected bats can be contagious under stress such as habitat loss, and then stop spreading virus when the threat is gone<br>. Viruses may be somewhere in one season and disappear the next<br>d. Finding out when bats release virus can help reduce the risk of infection<br>e. Cutting down dense forests for agriculture or building roads can bring people closer to virus-infected animals | 0.517 |
| 4 | In reading paragraph 18 explains about research has shown that stressed bats are more likely to spread the virus to the environment, such as stressed people who are exposed to sores from the herpes virus. From this information, the following policies should be conducted by state official to protect their citizens from virus infections in the future:<br>a. Cutting down forests and turning them into agricultural land<br>b. Cutting down forest and making it into new places to live<br>c. Creating housing area system that maintains social distancing<br>d. Destroying bats<br>**e.** Protecting the forest and increasing the urban forest | -0.614 |
| 5 | Many researchers agreed that the virus most likely originated from nature and most likely came from bats. Nonetheless, conspiracy theories claiming that virus originated from a laboratory appeared shortly after the first genetic blueprint for SARS-CoV-2 was unveiled in January 2020. What do you think of these two different explanations for the appearance of coronavirus?<br>a. Currently the theory that says it came from bats has been proven true<br>b. Currently the theory that says it came from a laboratory leak has been proven true<br>c. Both theories are all correct<br>d. The theory that said virus originated from bats has strong evidence<br>e. Currently, the theory that virus came from a laboratory tends to have more empirical evidence to | 0.937 |

| | | |
|---|---|---|
| | support it | |
| 6 | At the first time of SARS outbreak in 2003, the virus began to spread widely in people who came into contact with wildlife, a clue that the virus came from animals. In October 2003, after the worst outbreak ended, researchers reported that some wild palm civet sold in live animal markets had been infected.<br>After that it was discovered that wild palm civets did not carry the virus in nature. Only animals sold in the market were infected, meaning they might not be natural hosts of virus. Researchers finally referred to the horseshoe bat (Rhinolophus) as a potential source. Genetic tracing work revealed that wild palm civets most likely infected the virus from bats and then passed it on to people they came into contact with.<br>From this description can be concluded that the wild palm civet is the natural host of the SARS virus. What do you think?<br>The conclusion is accurate<br>That conclusion makes sense<br>The conclusion is scientific<br>The conclusion is based on facts<br>That conclusion is not accurate | 0.277 |
| 7 | A number of vaccinated people have been infected to COVID-19. What do you think?<br>The scientific research results still have an error level<br>The scientific research results are not necessarily true<br>There is an incorrect procedure in the research that produce the vaccine<br>The vaccine is still in the experimental stage<br>There is a genetic influence on the effectiveness of vaccine | 0.914 |
| 8 | Below, the true facts about COVID-19 are:<br>. The Covid-19 pandemic is caused by degenerate human morality<br>. The COVID-19 pandemic is a test from God<br>. The world has experienced several pandemics<br>. The COVID-19 pandemic can be overcome only by praying<br>. The COVID-19 infects people who don't have faith | 0.364 |

## Discussion

The overall validity analysis of the instrument that measures NOS for high school students in the Mathematics and Natural Sciences program includes content aspects validity, psychometric aspects validity, and constructs validity with Rasch model. Using three validators, two professors each and one associate professor in the field of science education, it is stated that all criteria related to the validity of the contents of the NOS test instrument is valid. The psychometric aspect validity involves three psychometric experts consisting of one professor in the field of psychometry, 1 associate professor in the field of educational assessment and one senior teacher at the school. The three analysis results shows that the test items have occupied psychometric validity. The construct validity analyzed in this study includes four aspects, namely content aspects, substantive aspects, structural aspects and external aspects. Content aspect is related to the level of appropriateness of each item's response to the Rasch model used, the level of difficulty of each item, while substantive aspect is related to the level of appropriateness of each student's response to the Rasch model used, as well as accuracy, sensitivity, and specificity. From Table 5, it can be observed that there are two item responses that do not appropriate the Rasch model used at a significance level of 0.05, those are number 2 and number 10 item. It shows that those two items cannot prove to be valid items to measure NOS. From Table 6, it can be observed that there is one test item that has fairly extreme level of difficulty above 2.0, it is number 2 with a difficulty level of 2.685. It also shows that the item is not appropriate to be used as test item because it can only measure the ability of students who are very high outside the range of students' abilities commonly. From Table 7, it can be observed that there are 11 test participants who have responses that is inappropriate with Rasch model used at a significance level of 0.05 and degrees of freedom at 15. This discrepancy can be interpreted as an inconsistent response from test participants. There are some test participants who manage to answer difficult test items correctly but failed to answer relatively easy test items correctly. This aberration can be impendent the test substantive validity. Observing from the ratio, there are only 5.6% of test participants who are inconsistent, on the contrary there are as many as 94.4% of test participants' responses that are consistent. This proves that the compiled NOS test has been occupied the construct validity of substantive aspect. The analysis results also shows that test accuracy is 0.732, sensitivity is 0.829, and specificity is 0.59. The three quantities are relatively close to 1.0 so that they also support the evidence for the construct validity of the substantive aspect.

To prove construct validity of structural aspect, an invariance test using the Likelihood Ratio Test is required. This invariance test aims to observe the consistency in the estimation of the item parameters, in this case the item difficulty level. By dividing the test participants into groups based on the average score of the test participants, then an analysis of the item parameters is conducted. The analysis result shows that there is one item that is inconsistent in both groups, namely item number 7. Thus, item no 7 can't be used as an item in the NOS measurement instrument.

To prove construct validity of the external aspect, Separation Reliability level is required. The analysis result shows the value of Separation Reliability is 0.4663. According to Sumintono & Widhiarso (2015) the value of person separation could be determined as follows:

$$H=\frac{(4 \times \text{Separation}+1)}{3}$$

Hence the person separation value for the test is 0.95. From the person separation value, it can be observed that the classification of the test participants obtained is only 1 (rounding off from 0.955). This means that the made instrument only differentiate test participants in two categories, those are high and low. The consequence is that the results of this test only differentiate the test participants into two groups, namely the test participants who already have a minimum adequacy of scientific literacy in the NOS aspect and those who do not yet have the minimum adequacy of scientific literacy in the NOS aspect. This information can be followed up in determining the passing limit for the NOS aspect of scientific literacy tests for high school students in the Mathematics and Natural Sciences Program.

By concerning to the results of the trial analysis and the distribution of the level of difficulty of the test items, it is determined that eight test items are appropriate for measuring the ability of Scientific Literacy in the NOS aspect. The test items that measure NOS after validation with Rasch model and the Messick (2006) validity approach can be seen in Table 8.

Different from the NOS measurement that had been widely developed before, the developed NOS in this study is based on a particular theme with the COVID-19 theme. The NOS measurements that have been conducted so far are still measuring based on the nature and character of Science and those have not been implemented to respond to scientific issues. Van Griethuijsen et al (2015) measured NOS in accordance with the nature of science based on empiricism and the usefulness of science in daily life. Widowati et al (2017) conducted an assessment of students' NOS abilities that were integrated with inquiry abilities in science learning at school. Edgerly (2022) conducted an assessment of NOS skills on elementary school teachers and found four constructs of NOS measurement, those were Social and Cultural aspects, Collaboration, Creative and Imagination, Scientific Methods and Scientific Epistemological Views (SEV). NOS measurement using Scientific Epistemological Views (SEVs) has also been applied with a construction similar to the developed NOS in this study, especially with the character of science which is tentative, empirical, full of theory, imagination and human creativity, and social and cultural aspects of society. However, the use of SEVs also has not used specific or thematic issues (Lyu, 2019; Kim et al, 2021; Kim et al, 2020). Some studies examine the NOS assessment using themes such as evolution theme and Biology theme (Sumranwanich et al, 2016; Toro, 2018). The results of this study provide an example of how a scientific phenomenon in life also can be used to test students' NOS skills.

## Conclusion

The NOS measurement of senior high school students in the Mathematics and Natural Sciences program that occupies all aspects of validity, both content validity, psychometric and construct validity. Regarding to content of construct validity, 95 % items was appropriate with the model, while with substantive validity 94.4% of the test participants' responses are consistent with the used Rasch model. Regarding to structural aspect of construct validity, 97% of the items can be used, while with external aspect of construct validity shows that the test instrument can differentiate test participants into two categories, each of which has high and low NOS abilities.

## Suggestion

NOS tests should be given to students from the basic level so that students' interest in learning science further increases student motivation in science subjects. Teachers can emphasize to students the importance of studying NOS, especially helping students prepare themselves for changing situations during the COVID-19 period. The NOS test emphasizes students' understanding of the current situation of the COVID-19 pandemic so that students can understand the situation they are facing and can make efforts to prevent the spread COVID-19. In the future research, NOS test can be generated in large field testing outside Tegal City Region to find out the NOS ability of student and giving impact for enhancement of students NOS ability.

## Limitation

The limitation of this study lies in taking samples that are still in the same area, but this sample limitation has helped researchers to get a valid and reliable NOS test using Rasch modeling and Messick validation. Researchers hope that the construction of the tested NOS test can be used on a wider scale through implementation in several testing areas such as in other parts of Indonesia, so that it can help teachers and students to determine the level of NOS ability.

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