Mapping of Difficult Mathematics Topics in Vocational High Schools Based on National Examination Data

Heri Retnawati, Elly Arliani, Ezi Apino, Hasan Djidu, Kartianom, Agus Santoso & Rasmuin

1,2,3 Universitas Negeri Yogyakarta
4 Universitas Semenanjung November Kolaka
5 Institut Agama Islam Negeri Bone
Watampone, Tanete Riantang, Kabupaten Bone, Sulawesi Selatan, Indonesia
6 Universitas Terbuka
Jalan Cabe Raya, Pondok Cabe, Tangerang Selatan, Banten, Indonesia
7 Universitas Dayanu Ikhsanuddin
Jl. Yos Sudarso No.43 Wolio, Kota Bau-Bau, Indonesia
E-mail: heri_retnawati@uny.ac.id

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Abstract. The educational achievement in Indonesia is measured by implementing the National Examination or Ujian Nasional (UN). Throughout its implementation, the UN results have shown unsatisfactory, including in mathematics subjects. This fact indicated that there are mathematics topics that are considered to be difficult for students. This study aimed to investigate the difficult topics of mathematics in Vocational High School (VHS) based on UN data. This study was a descriptive research with the quantitative approach by using the UN report results in the level of VHS from Center for Educational Assessment of the Ministry of Education and Culture in the period of 2008 to 2017 (ten years) as a research data source. Data analysis was carried out in a quantitative descriptive by mapping the mathematics topics based on proportion correct answers or “daya serap”. A topic was considered difficult if the proportion correct answer was less than 50%. The results showed that there were 14 difficult mathematics topics in the UN implementation at the VHS level from 2008 to 2017. These topics include the comparison of trigonometric functions, solid figure, limit, measure of data dispersion, permutation and combination, differential, area between two curves, a measure of central data tendency, probability, logarithm, integral, sequence and series, linear program, and polar coordinates system. The implications of the research findings for learning practice and future research opportunities are discussed.

Keywords: difficult mathematics topic, national examination, vocational high school

INTRODUCTION

An essential aspect of education is assessment. The educational assessment aims to determine the achievements of the implemented education programs (Retnawati, Hadi, & Nugraha, 2017; Retnawati, Kartowagiran, Arliniwibowo, & Sulistyaningsih, 2017). Besides, it is used to make decisions on the graduation of studies (Johnson, Penny, & Gordon, 2009). Assessments have benefits in providing information for educators to improve educational programs (Reynold, Livingstone, & Wilson, 2010). Thus, in general, the assessment in education has the benefit of knowing the achievement of the education process.

In the Indonesian education system, the educational process manages through formal, informal, and non-formal ways. In formal
education, the education levels divide: elementary school, junior high school, and senior/vocational high school. Aiming to determine the achievements of education outcomes for each level, the UN is implemented in Indonesia. In its history, the UN in Indonesia had several changes in format, such as the State Examination (1965 to 1971), which almost applies to all subjects, all levels, and under the control of the central government; the State Examination was abolished in 1972-1979 and changed into a School Examination, in this case, the schools carried out examinations by referring to the policy issued by the central government; the school examination changed into the Final Stage Learning Evaluation from 1980 to 2000; then, it changed into the National Final Examination (2001-2009); and finally, it changed into the UN (2010-2019) (Azis & Sugiman, 2015). Although there are often changed of the name, principally, the UN’s implementation every year aims to determine each student’s achievements for each level and subject tested and determine the quality of education in Indonesia nationally.

UN results are not limited to find out students’ achievement in mastery of the topic but can also improve Indonesia’s educational programs. One of the objectives of using UN results as regulated in Government Regulation Number 19 of 2005 (President of Republic of Indonesia, 2005), stated that the results of the UN were used as one of the considerations for fostering and providing assistance to education units in efforts to improve the quality of education. Considering that it is the only evaluation tool used to evaluate the success of education in Indonesia nationally through the UN; then, using the UN results might explore the information on the various weaknesses of the current education programs, especially the mastery of the topic content. Thus, without considering the UN’s implementation’s pros and cons, the UN’s results might be used as evaluation topics for future education improvements.

If we read the UN’s results carefully in Indonesia in the last few years, it can be concluded that students’ achievements are far from the determined standard. For senior high school level, especially VHS, the average of national achievement for each subject tested from 2013 to 2017 is presented in Table 1.

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Years</th>
<th>2013*</th>
<th>2014*</th>
<th>2015*</th>
<th>2016*</th>
<th>2017*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesian</td>
<td></td>
<td>7.25</td>
<td>B</td>
<td>7.54</td>
<td>A</td>
<td>65.5</td>
</tr>
<tr>
<td>English</td>
<td></td>
<td>7.15</td>
<td>B</td>
<td>6.88</td>
<td>B</td>
<td>55.3</td>
</tr>
<tr>
<td>Mathematics</td>
<td></td>
<td>6.46</td>
<td>C</td>
<td>6.35</td>
<td>C</td>
<td>48.2</td>
</tr>
<tr>
<td>Competence</td>
<td></td>
<td>8.29</td>
<td>A</td>
<td>8.20</td>
<td>A</td>
<td>79.6</td>
</tr>
</tbody>
</table>

Note: * in the period 2013 to 2014: A = Very good (mean score of UN > 7.50); B = Good (6.50 < mean score of UN ≤ 7.50); C = Moderate (5.50 < mean score of UN ≤ 6.50)  
* in the period 2015 to 2017: A = Very good (mean score of UN > 85); B = Good (70 < mean score of UN ≤ 85); C = Moderate (55 < mean score of UN ≤ 70); D = Poor (mean score of UN ≤ 55)

Based on Table 1, the UN’s results for four subjects tested in the UN at the VHS level tend to decrease yearly. Based on the table, the UN’s results for mathematics subjects in the period of 2012 to 2017 showed the lowest results compared to other subjects. It provides a strong indication that, for the VHS, mathematics is the most challenging subject for students compared to other subjects in the UN.
The unsatisfying UN results, especially for mathematics subjects, need to be evaluated. The low achievement of students in mathematics showed that students have low mastery of the content topic during the school’s learning process. A comprehensive evaluation is undoubtedly needed to solve the problems among planning, implementation, and assessment. A step of the effort is by analyzing the difficult topics based on the proportion correct of the UN. It is undoubtedly using the UN results report every year.

There are several reasons why it is important to investigate difficult topics in mathematics. Charles-Ogan and George (2015) suggest that investigating difficult concepts in mathematics is needed as a starting point to deeper investigation on the types of difficulties students experience in solving problems with these mathematical concepts. Olubukola (2015) argues that investigating difficult mathematics topics is required to improve learning on these difficult topics. Many researchers have reported that improving mathematics learning can be initiated by investigating student difficulties in learning mathematics topics (e.g., Hadi, Retnawati, Munadi, Apino, & wulanndari, 2018; Jupri & Drijvers, 2016; Wijaya, van den Heuvel-Panhuizen, Doorman, & Robitzsch, 2014). In Indonesia, to make improvements focus and adjusted to the characteristics of topics considered difficult, we believe it can be started by mapping difficult mathematics learning topics by utilizing the UN’s results in Indonesia.

Previous studies have used the report data of the UN results. Such a study by Kaniawati and Ramalis (2012) researched the analysis of competency maps of senior high school of the UN results from 2007 to 2010 in West Java Province. This study focuses on mapping students’ competencies in West Java Province by analyzing the achievement of basic competencies in the Graduate Competency Standards. Next, the research by Kartowagiran, Munadi, Retnawati, and Apino (2018), examined the equivalence of UN test kits in the period of 2013 to 2016. This study focuses on investigating whether the UN test kits used have the same difficulty and discriminant indexes. Other studies by Nisa (2014) examined the mapping of UN results of mathematics subjects in 2013 at the High School level in Semarang City. However, the mapping is focused on Madrasah Aliyah (Islamic High School). Then, Isgianto (2012) researched the basis and completeness of items' attributes in the UN’s mathematics questions for the Rasch model. This study focuses on finding the attributes that underlie the junior high school examination items and their completeness. These studies used the UN results data as the main object of study, and the recommendations are used to improve the learning and evaluation process, especially in mathematics subjects.

Previous studies related to the use of UN data on mathematics have not focused on nationally mapping on topics that are considered difficult for students. Several studies that have been conducted (e.g., Kaniawati & Ramalis, 2012; Nisa, 2014) analyzed difficult topics and competencies on a narrower scale (province and city). Thus, the results of the mapping that have been carried out certainly cannot be generalized as national map. While other studies (e.g., Isgianto, 2012; Kartowagiran et al., 2018) the analysis focused on the quality of the test items used. Observing what has been done by previous researchers, we are motivated to investigate mathematics topics that are considered difficult by students through the use of UN data. In this study, we focus on investigating difficult topics in VHS, considering that studies related to the use of UN data on VHS are still rare. To identify difficult topics can be seen from the percentage of topic mastery of the items tested in the UN. In this study, we used the term “proportion correct” to represent the percentage of students who were able to correctly answer the items on the topics tested in the national examination. A high proportion correct describes the test taker's high mastery of the topic being tested.

In contrast, a low proportion correct describes the test taker's low mastery of the topic being tested. Based on the background, the proportion correct analysis was essential to find out the difficult topic for the UN participants.
Thus, this particular study aimed to map and describe the difficult mathematics topics in VHS based on the proportion correct of the UN results from 2008 to 2017. Mathematics teachers might use the mapping results to strengthen the understanding and mastery of the UN’s topics that are considered difficult by the participant.

**METHOD**

The research design used was a descriptive research design with a quantitative approach. The descriptive research design was chosen because there was no manipulation or control of the variables in this study, and there were no independent variables (Dulock, 1993). Descriptive research aimed to systematically and accurately describe a fact or phenomenon and the characteristics of the population or area of interest (Dulock, 1983; Nassaji, 2015). The facts or phenomena described in this study were mathematics topics that were considered difficult by VHS students based on UN data. For this purpose, the data could be analyzed quantitatively (Nassaji, 2015).

This study’s data were secondary data, which is the UN results data in the period of 2008 to 2017 published by the Center for Educational Assessment, Research and Development of the Ministry of Education and Culture. We obtained data through the national examination results report application or PAMER, which was reported annually by the Research and Development Agency of the Ministry of Education and Culture. The initial display of the application could be seen in Figure 1. Through this application, we used the “Daya Serap” menu (after this called proportion correct) to determine the percentage of mastery of the topic on the tested mathematics item. We have chosen “indicators” as the unit of analysis (see Figure 2). Each topic could consist of several units of analysis or indicators. In this case, we determined the proportion correct topic by calculating the mean of proportion correct of indicators on that topic.

![Figure 1. Example of initial display of the application for the national exam results report for the 2014/2015 academic year](image-url)
Furthermore, the data of proportion correct the UN in the mathematics subject at the level of VHS played as the object of analysis. The data analysis procedure was carried out in several stages. First, we identified mathematics topics tested in the UN on VHS from 2008 to 2017. The topics tested were justified based on the indicators or abilities tested. As a consequence, a topic could consist of one or more indicators or abilities being tested. Secondly, we determined the proportion correct for each topic in each year. We did not calculate proportion correct manually because information regarding the proportion correct for each indicator or ability tested, both at the district/city, province and national levels, was automatically available on the application. In this case, we chose the proportion correct data at the national level, with the aim that the mapping results drawing the overall ability of the UN participants in Indonesia. If a topic consisted of some indicators, we determined the proportion correct of the topic by calculating the mean score of each indicator's proportion correct. Third, we identified difficult topics for every year. We consider that a topic was considered difficult if the percentage of mastery of the topic on the items tested was less than 50%. It means that if the percentage of VHS students who were able to answer items on the topic correctly was less than 50%, then this topic was considered difficult. Fourth, we map the difficult mathematics topic based on the proportion correct of UN presented in the table. The table contained information on difficult topics and their annual proportion correct achievement. The data in the table were interpreted narrative. Data interpretation was also complemented with a graphical presentation of the trend proportion correct achievement for each topic. Presentation of trends through graphs effectively described when the proportion correct on each topic increased or decreased during the period 2008 to 2017.

**RESULT**

**The Trend of Difficult Topics on Mathematics Subject for VHS in the Period of 2008 - 2017**

Analysis of proportion correct carried out to map the difficult topic on mathematics subjects during the UN's implementation at VHS's level for the last ten years, which is from the period of 2008 to 2017. The analysis of the proportion correct of the UN at the level of VHS only focused on the competency of technology, health, and agriculture expertise. In this case, the UN’s topic for mathematics subjects is considered difficult when it has a national proportion correct of less than 50%. Considering the proportion correct from 2008 to 2017 on the most frequent topic tested in the UN were selected, the topic indicated having a low proportion correct (< 50%) for several years of the implementation of the UN (see Table 2). Although the analysis results showed that not all topics consistently indicated as difficult for each

### Table 2: Example of output proportion correct using indicators as the unit of analysis

<table>
<thead>
<tr>
<th>No. Urut</th>
<th>Kemampuan Yang Diuji</th>
<th>Prop</th>
<th>Nas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Menyelesaikan masalah yang berkaitan dengan barisan bilangan dan deret.</td>
<td>74.27</td>
<td>50.31</td>
</tr>
<tr>
<td>2</td>
<td>Menyelesaikan masalah yang berkaitan dengan operasi bilangan berpangkat atau bentuk alkar.</td>
<td>72.43</td>
<td>61.17</td>
</tr>
<tr>
<td>3</td>
<td>Menyelesaikan masalah yang berkaitan dengan operasi tambah, kurang, kali, atau bagi pada bilangan.</td>
<td>22.28</td>
<td>62.00</td>
</tr>
<tr>
<td>4</td>
<td>Menyelesaikan masalah yang berkaitan dengan perbandingan.</td>
<td>67.79</td>
<td>64.24</td>
</tr>
<tr>
<td>5</td>
<td>Menyelesaikan masalah yang berkaitan dengan fungsi.</td>
<td>73.06</td>
<td>54.15</td>
</tr>
<tr>
<td>6</td>
<td>Menyelesaikan masalah yang berkaitan dengan himpunan.</td>
<td>76.74</td>
<td>66.55</td>
</tr>
<tr>
<td>7</td>
<td>Menyelesaikan masalah yang berkaitan dengan fungsi.</td>
<td>67.97</td>
<td>56.85</td>
</tr>
<tr>
<td>8</td>
<td>Menyelesaikan masalah yang berkaitan dengan himpunan.</td>
<td>78.63</td>
<td>61.09</td>
</tr>
<tr>
<td>9</td>
<td>Menyelesaikan masalah yang berkaitan dengan fungsi.</td>
<td>67.01</td>
<td>52.54</td>
</tr>
</tbody>
</table>

Figure 2. Example of output proportion correct using indicators as the unit of analysis
year, if the topic indicated having a low proportion correct at least four years, it is considered a difficult topic for participants in the UN. From the results of the mapping, during the implementation of the UN at VHS in the period of 2008 to 2007 for mathematics subjects in technology, health, and agricultural expertise competencies, obtained the difficult and most frequent topics which are: 1) ratio of trigonometric functions, 2) measure of data dispersion, 3) permutation and combination, 4) differential, 5) solid figure, 6) area between two curves, 7) limit function, 8) central tendency, 9) probability, 10) logarithm, 11) definite and indefinite integral, and 12) trigonometry for polar and cartesian coordinates system. The proportion correct for these topics we present in Table 2.

Table 2. Map of the difficult topic in the mathematics subject at the vocational senior high schools in the period of 2008 to 2017

<table>
<thead>
<tr>
<th>Difficult Topics</th>
<th>Proportion Correct (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio of trigonometric</td>
<td>64.99</td>
</tr>
<tr>
<td>Statistics: Measure of data dispersion¹</td>
<td>64.09</td>
</tr>
<tr>
<td>Permutation and Combination</td>
<td>69.99</td>
</tr>
<tr>
<td>Differential²</td>
<td>57.00</td>
</tr>
<tr>
<td>Solid Figure³</td>
<td>41.13</td>
</tr>
<tr>
<td>Integral: An Area¹</td>
<td>45.29</td>
</tr>
<tr>
<td>Limit⁵</td>
<td>49.62</td>
</tr>
<tr>
<td>Statistics: Measure of data dispersion⁶</td>
<td>73.99</td>
</tr>
<tr>
<td>Probability</td>
<td>57.25</td>
</tr>
<tr>
<td>Logarithm</td>
<td>68.55</td>
</tr>
<tr>
<td>Integral: definite and indefinite</td>
<td>69.44</td>
</tr>
<tr>
<td>Trigonometry: Coordinate⁷</td>
<td>69.69</td>
</tr>
<tr>
<td>Sequence and Series⁸</td>
<td>**</td>
</tr>
<tr>
<td>Linear Program⁹</td>
<td>56.84</td>
</tr>
</tbody>
</table>

Note:
* Topic consider as easy for the UN on the particular year, but it considers as difficult for other years
** The topic was not tested on a particular year
¹ Determine the standard deviation, quartile
² Differential of algebraic and trigonometric function
³ Volume, surface area, combination of several solid figure
⁴ The area between two curves (linear and squared)
⁵ Limit at infinity and infinite limit
⁶ Mean, Mode and Median
⁷ Conversion of polar coordinates to Cartesian coordinates and vice versa
⁸ Geometry Series (for arithmetic sequence and series proportion correct > 50%)
⁹ Determine the optimum value

Based on Table 2, the proportion correct for difficult topics tends to be low, starting at the UN from 2013 to 2017. Meanwhile, in the UN from 2008 to 2012, the proportion correct for these topics tends to be high, except in some topics such as solid figure, area between two curves, and limit functions in the UN on 2008 and trigonometric comparison topic in the UN.
on 2011. This finding is undoubtedly exciting and shows a tendency that most of the difficult topic is experienced by participants during the UN in 2013 until 2018. These difficult topics might map the frequency topics of proportion correct < 50% during the UN in the period of 2008 to 2017, as presented in Figure 3.

Based on Figure 3, in the last ten years, there were three mathematics topics of the most difficult topic, such ratio of trigonometry, solid figure, and limits, where there was six times less than 50% proportion correct for the three topics during the UN in the period of 2008 to 2017. Whereas, considering the mean of proportion correct for each topic in the last ten years, the topic of sequence and series is the topic with the lowest proportion correct. Overall, these difficult topics, the score of proportion correct in the last ten years, is still below 60. Furthermore, it will describe the results of the proportion correct analysis for each difficult topic.

Analysis of Proportion Correct of Trigonometry Topic

Trigonometry is one of the most difficult topics faced by participants in the UN based on the proportion correct analysis in the last ten years. Considering the proportion correct every year, the proportion correct for this topic tends to be fluctuates (see Figure 4). However, the proportion correct of the particular topic tends to decrease continuously after the UN in 2013.

![Figure 3. Frequency proportion correct of difficult topics < 50% and mean of proportion correct for the last ten years](image)

![Figure 4. The graph of proportion correct on the topic of trigonometry on 2008 - 2017](image)
Based on Figure 4, the UN in the period of 2008 to 2012, the lowest proportion correct occurred in the UN in 2011, where, in that year, the topic proportion correct dropped dramatically compared to previous years. It showed that the UN’s trigonometric topic in 2011 was in the difficult category compared to 2008, 2009, 2010, and 2012. Furthermore, the proportion correct for this topic was increased dramatically in 2012, but it was declined in 2013. The result in 2013 showed that this topic was difficult. Although it was increased in 2014 with a not too significant increase, the proportion correct for this topic declined in the following years. Moreover, it was the lowest score of trigonometry topic in 2017.

Analysis of Proportion Correct of Solid Figure Topic

The questions tested in the topic of building space, such as determining the surface area and volume of the solid figure, both a plane-side solid figure and a curved side solid figure. Also, the questions were about determining the surface area or the combined volume of the solid figure. Considering the proportion correct results for the last ten years, the solid figure in the VHS was the most difficult topic. There were six times in the UN’s implementation, which have the proportion correct < 50% (see Figure 3). The tendency of proportion correct for solid figure topic in the UN at the VHS for the last ten years is presented in Figure 5.

![Figure 3. Graph of proportion correct on solid figure topic on 2008 - 2017](image)

Based on Figure 5, the proportion correct on the solid figure topic was lower than 50% in the UN in 2008, 2013, 2014, 2015, 2016, and 2017. However, the score of proportion correct was high in 2009, 2010, 2011, and 2012. In this case, it was found an interesting fact that there is a very significant increase in proportion correct from 2008 to 2009. The proportion correct for the particular topic was increased until 2012. On the other hand, the score was declined significantly in the UN in 2013. If in the previous year (2012) the proportion correct reached above 80%, it was drop to around 40% in 2013. And, after 2013, there was an increase on the proportion correct, but it had not reached 50%. It means that from 2013 to 2017, the solid figure topic was a difficult topic for the UN participants. It certainly provided inversely proportional to the score of the previous four years (2009, 2010, 2011, and 2012).

Analysis of Proportion Correct of Limit Topic

The questions tested on the limit topic in the UN, such as finite and infinite limits for algebraic functions and trigonometric functions. From 2008 to 2017 of the UN, this topic was tested nine times, but this topic was not tested in 2010. Like trigonometry and solid figure topic, the limit topic is also the most difficult topic compared to other UN topics over the past ten years. The limit topic during the UN’s implementation from 2008 to 2017, there were six times in which the results of the proportion correct was < 50%. The tendency of proportion correct of the UN’s limit topic at VHS from 2008 to 2017 we presented in Figure 6.
Based on Figure 6, the proportion correct on the limit topic is good for the UN in 2009, 2011, and 2012, while the proportion correct is < 50% in 2008, 2013, 2014, 2015, 2016, and 2017. Based on the graph in Figure 6, the UN participants in 2008 have difficulties with the limit topic, but there was a very significant increase in proportion correct in 2009. From 2009 to 2012, the proportion correct for the limit topic is stable. It showed that in this period, the limit topic is not a difficult topic for participants. After that period, a very significant decrease in proportion correct occurred in the UN in 2013. Moreover, the topic’s proportion correct reached the lowest point, which was only 34.70% in 2013. Then, the proportion correct of the topic in the UN was stable at < 50%. It means that, in the period from 2013 to 2017, the limit topic was one of the difficult topics for participants.

Analysis of Proportion Correct of Data Dispersion (Statistics) Topic

A measure of data dispersion of statistics topic indicated as a difficult topic for participants in the UN. In this topic, the questions tested are related to the standard deviation and quartile of data. During the UN’s period over the last ten years, there have been five times the proportion correct, which is less than 50%, starting from 2013 to 2017. It showed that the participants found difficulties in the UN’s topic from 2013 to 2017. The tendency of proportion correct of measure of data dispersion topic in the UN at the VHS from 2008 to 2017 we presented in Figure 7.

Figure 7 showed that, over the last ten years, the highest topic proportion correct of the data dispersion occurred in 2012, while the lowest of topic proportion correct occurred in 2016. By having the same result of the difficult topic, the UN from 2008 to 2012, the topic proportion correct showed good and tended to increase. However, a very significant decrease in proportion correct occurred in 2013, which decreased by 39.32 points compared to the previous year. This fact indicated that the UN participants had found difficulties on this topic over the past ten years, starting in 2013. After 2013, the topic proportion correct has decreased. In 2017, however, the topic was increasing. In
This topic was indicated as difficult from 2013 to 2017.

**Analysis of Proportion Correct of Permutation and Combination Topic**

Permutation and combination are a sub-section in the counting rules topic. In the UN, one or both of them tested in the question task. Based on the proportion correct analysis in the past ten years, permutation and combination topic are a difficult topic assumed by participants. During the UN’s implementation from 2008 to 2017, there was five times proportion correct the topic with a percentage below 50%, which occurred in 2013, 2014, 2015, 2016, and 2017. The mean proportion correct for the topic over ten years was categorized low, at 52.95%. The tendency of proportion correct permutation and combination topic in the UN at VHS from 2008 to 2017 is presented in Figure 8.

![Figure 8. Graph of proportion correct on permutation and combination topic on 2008 – 2017](image)

Based on Figure 8, the proportion correct of permutation and combination topic fluctuated graph in the UN’s implementation in 2008 to 2017. For ten years, the highest proportion correct for the topic occurred in 2009, which reached 86.16%. Meanwhile, the lowest proportion correct for the topic occurred in 2014, with only 38.42%. In the UN from 2008 to 2012, the proportion correct showed satisfaction because of the proportion correct on the period above 50%. It showed that permutation and combination might not be too difficult for participants in the UN. The different results occurred from 2013 to 2017, where the topic proportion correct was < 50%. Moreover, in 2014, it was the lowest score. It showed that permutation and combinations are difficult topics in the UN from 2013 to 2017.

**Analysis of Proportion Correct of Differential Topic**

In the differential topic, the questions tested include algebraic and trigonometric functions differential and their applications. In the UN’s implementation in the last ten years, there were five times the proportion correct < 50%, which occurred in 2013, 2014, 2015, 2016, and 2017. When calculated on mean, during the UN at VHS from 2008 to 2017, the proportion correct for the differential topic is only 51.88%. The score is certainly not much different from the other difficult topics. The tendency of proportion correct of the differential topic in the UN at VHS from 2008 to 2017 we presented in Figure 9.
Based on Figure 9, the highest proportion correct for differential topics occurred in 2012 with the proportion correct of 80.18%, and the lowest proportion correct occurred in 2017 with the proportion correct of only 28.91%. In the UN’s implementation from 2008 to 2012, the topic proportion correct has reached above 50% and tends to increase. It showed that differential topic was not included in a difficult topic in 2008 - 2012. However, a very significant decrease in proportion correct occurred in 2013 that in the previous year (2012), the proportion correct reached 80.18%, dropped to 38.67% in 2013. Figure 9 shows that the proportion correct of differential topics from 2013 to 2017 was still below 50%. Moreover, the lowest proportion correct for this particular topic occurred in in 2017. It showed that in the UN from 2013 to 2017, the differential topic was difficult.

### Analysis of Proportion Correct of Area between Two Curves (Integral) Topic

In the integral topic, a subtopic that is often tested in the UN determines the area between two curves. Based on the proportion correct analysis, the questions of this topic were tested at the UN in the period of 2008 to 2016 and were not tested in 2017. From 2008 to 2016, there was five times the topic proportion correct of < 50%, which occurred in 2008, 2013, 2014, 2015, and 2016. The mean proportion correct over the last nine years period is categorized as low, which is only 51.17%. The tendency of proportion correct of the area between two curves topic in the UN at the VHS from 2008 to 2017 is presented in Figure 10.

The graph in Figure 10 showed that the proportion correct in the area between two curves tends to have fluctuation. In 2008, the topic’s proportion correct was 45.25%, which showed a difficult topic this year. However, in 2009, there was a significant increase in the proportion correct. And the proportion correct from 2009 to 2012 was consistently above 50%. This fact showed that the topic was not difficult for participants in the period of 2009 to 2012. The proportion correct dropped dramatically in the UN in 2013. Moreover, from 2013 to 2016,
the proportion correct score was consistently below 50%. And it showed that this topic is a difficult topic for participants in the period of 2013 to 2017. The proportion correct score in the UN in 2016 is the lowest for this topic for the past nine years.

**Analysis of Proportion Correct of Central Tendency (Statistics) Topic**

Data dispersion and central tendency of the statistics topic were also considered to be difficult by the participant over the past ten years. The question tested topics were determining the mean, mode, and median of a data set, both single and group data. During the UN’s implementation from 2008 to 2017, the topic proportion correct below 50% occurred five times, from 2013 to 2017. The mean proportion correct on the period was only 55.80%. The mean proportion correct is certainly not a satisfactory result. It indicated that this topic is a difficult topic for general participants, especially at the level of VHS. The tendency of the proportion correct of the central tendency topic in the UN at the VHS in the period of 2008 to 2017 is presented in Figure 11.

Based on the graph in Figure 11, the proportion correct score in the central tendency topic in the UN from 2008 to 2009 has shown well. It showed that most participants in that period did not experience significant difficulties. The finding is certainly inversely proportional to the results in the period of 2013 to 2017, where the topic proportion correct was consistently below 50%. The decrease in proportion correct in the UN from 2012 to 2013 was very drastic, which is a decrease of 36.79 points from the previous year's proportion correct score. Even though, in the UN from 2013 to 2017, the topic proportion correct increased and decreased. The increase has not reached 50%. And, the lowest proportion correct for this topic occurred in 2016. In sum, the central tendency topic in the UN at VHS in the period of 2013 to 2017 is a difficult topic for participants.

**Analysis of Proportion Correct of Probability Topic**

The probability topic is almost tested in the UN every year. From 2008 to 2017, this topic was always tested in the question. Based on the proportion correct analysis, this topic also included a difficult topic for participants. For example, in the UN from 2008 to 2017, there was five times the proportion correct with < 50%, which occurred from 2013 to 2017. And, in the period of the last ten years, the mean proportion correct for the probability topic was only 52.90%. Surely, the results are not a proud result due to place in the range of 50%. The tendency of proportion correct of the probability topic in the UN at the VHS from 2008 to 2017 is presented in Figure 12.
Based on Figure 1, the probability topic was not categorized as a difficult topic in the UN’s implementation from 2008 to 2012. During this period, the topic proportion correct was above 50%. And the lowest proportion correct occurred in 2010 with 56.96%. Similar to the previous difficult topic, for this opportunity topic, a very significant decrease in proportion correct began from 2013 to 2017. In 2013, there was a decrease in proportion correct of 32.82 points from the previous year. After that, the score of the topic proportion correct decrease and becomes the lowest score in 2017. This finding showed that the difficulty of participants for this topic occurred from 2013 to 2017.

Analysis of Proportion Correct of Logarithm Topic

Logarithm indicated a difficult topic during the implementation of the UN at VHS from 2008 to 2017. Over the last ten years, the logarithm topic proportion correct, which was less than 50%, occurred five times, namely in the UN’s implementation from 2013 to 2017. Meanwhile, the mean topic proportion correct of the logarithm only obtained an average score of 60.26%. Compared to the mean proportion correct of other difficult topics; the mean proportion correct of logarithm topic is the highest. The tendency of proportion correct of the logarithm topic in the UN at the VHS from 2008 to 2017 is presented in Figure 1.

Analysis of Proportion Correct of Definite and Indefinite Integral Topic

The integral topic often tested in the UN is determining the definite and indefinite integral of a function. Based on the UN’s proportion correct from 2013 to 2017 is still below 50%. It certainly gives a strong indication that the logarithm topic was difficult in 2013-2017.
In the period 2008 to 2017, both topics were indicated as difficult topics. During the UN’s implementation at VHS in the last ten years, there were only five times the topic proportion correct above 50%, which occurred from 2008 to 2012. Meanwhile, in the next five years, the topic proportion correct was consistently below 50%. Also, during this period, the mean proportion correct of the definite and indefinite integral topic was 57.09%. The mean proportion correct is certainly still low. The tendency of proportion correct of the definite and indefinite integral topic in the UN at the VHS from 2008 to 2017 is presented in Figure 14.

Figure 14. Graph of proportion correct on the definite and indefinite integral topic on 2008 - 2017

Figure 12 showed that the highest proportion correct of the integral topic occurred in the UN in 2012. Meanwhile, the lowest proportion correct of the integral topic occurred in the UN in 2017. Considering the UN graph trends from 2008 to 2012, the proportion correct has fluctuated, but it is consistently above 50%. It indicates that an integral topic is not indicated as a difficult topic from 2008 to 2012. Meanwhile, a very significant decrease in proportion correct occurred in the UN in 2013. Considering the graph, the UN’s proportion correct score in 2013-2017 is consistently below 50%. It certainly indicates that definite and indefinite integral topics are indicated as difficult topics in the UN from 2013 to 2017.

Analysis of Proportion Correct of Sequence and Series Topic

Based on the UN’s proportion correct analysis at VHS in the competency of technological, health, and agricultural expertise, the sequence and series topic was first tested in 2011. After 2011, this topic continued to be tested until 2017. During the seven years (2011 to 2017), this theme topic indicated a difficult topic for UN’s participants, especially on geometric sequences and series. From 2011 to 2017, there is five times the proportion correct score with < 50% from 2013 - 2017. Meanwhile, in the previous two-year (2011 and 2012), the proportion correct score is above 50% and tends to increase. The mean proportion correct of geometric sequence and series topic was only 46.84% in the seven years. The score is certainly very low because the mean proportion correct is still < 50%. The tendency of proportion correct of the geometric sequence and series topic in the UN at VHS from 2008 to 2017 is presented in Figure 15.
The graph in Figure 15 showed that the proportion correct of geometric sequence and series topic in the first two years is good and tends to increase. However, in the UN in 2013, the proportion correct decreased to 40.73% from the previous year at 74.63%. It certainly showed that there are very significant differences in the theme of the topic in terms of level difficulty between the question task in 2013 and the previous year. Considering the proportion correct of the UN from 2013 to 2017 clearly showed that the topic proportion correct was still consistently below 50%. The highest proportion correct from 2013 to 2017 occurred in 2015, which was 38.47%. Meanwhile, the lowest proportion correct occurred in 2014, which was 32.52%. Based on these results, the geometric sequence and series topic indicated as difficult for the UN participants in the period of 2013 to 2017.

Analysis of Proportion Correct of Linear Program Topic

In the linear program topic, one of the most frequently tested in the UN is determining the optimum value of a system of linear inequalities. Based on the proportion correct analysis from 2008 to 2017, the topic also indicated a difficult topic. In the UN’s implementation at VHS for the last ten years, only five times the topic proportion correct was above 50%, which occurred from 2008 to 2012. Meanwhile, in the next five years (2013 to 2017), the proportion correct of the topic was consistently below 50%. During the period, the mean proportion correct was only 55.74%. The tendency of proportion correct of the linear program topic in the UN at VHS from 2008 to 2017 is presented in Figure 16.
The graph in Figure 16 showed that the highest proportion correct of the linear program topic occurred in 2009, namely 84.98%. Meanwhile, the lowest proportion correct occurred in 2017, which was 31.22%. Considering the graph trends, the UN in the period of 2008 to 2012, the proportion correct score tends to show good and consistently above 50%. This finding indicated that the linear program topic is not indicated as a difficult topic from 2008 to 2012 of UN implementation. Meanwhile, a very significant decrease in proportion correct occurred in 2013 of UN implementation. Considering the graph, the proportion correct score in 2013-2017 is below 50% and tends to decrease. It certainly provides a strong indication that the topic indicated as difficult for the UN participants in the period of 2013 to 2017.

Analysis of Proportion Correct of Coordinates (Trigonometry) Topic

Convert the polar coordinates into cartesian coordinates, or vice versa, is a trigonometry topic often tested in the UN at VHS. In the last ten years, the topic tested almost every year, except in 2016. Based on the proportion correct analysis, the topic was one of the difficult topics from 2008 to 2017. During the UN’s implementation at VHS from 2008 to 2017, the topic proportion correct of < 50% occurred four times in 2013, 2014, 2015, and 2017. Considering the mean proportion correct of trigonometry topic in the period, the topic only obtained the mean of 55.81%. The tendency of proportion correct of the UN's topic at the VHS from 2008 to 2017 is presented in Figure 17.

Based on the graph in Figure 17, the proportion correct on the polar coordinate topic has fluctuated. From 2008 to 2012, the topic proportion correct has above 50%. This finding indicated that the topic is not indicated as a difficult topic from 2008 to 2012. In 2013, 2014, 2015, and 2017, the proportion correct score was below 50%. In this period, the highest proportion correct occurred in 2015, which was 42.12%. Meanwhile, the lowest proportion correct occurred in 2017, which was 36.07%.

The trend of proportion correct for each difficult math topic on the UN for VHS shows almost the same pattern. In the period 2008 to 2012, the trend of proportion correct tended to fluctuate but consistently was above 50%. It indicates that during that period, the mathematical topics tested could be mastered by most of the UN participants in VHS. In contrast, from 2013 to 2017, the trend of proportion correct on difficult topics tended to decrease every year. It indicates that the percentage of students who master the topics that are considered difficult continues to decline from year to year. Based on this, it can be understood that there is a very contrasting difference between the national examination achievements of VHS students in the period 2008 to 2012 and the period 2013 to 2017.
DISCUSSION

Analysis results of the national proportion correct on mathematics subjects in the VHS in the period of 2008 to 2017 for the expertise competencies of technological, health, and agricultural showed 14 mathematics topics that have low proportion correct scores. Its topics are trigonometry, solid space, limit functions, the measure of data dissemination, permutation and combinations, differential, the area between two curves, central tendency, probability, logarithms, integrals, sequences and series, linear programs, and polar coordinates system. The low proportion correct of the fourteen mathematics topics indicated that students have difficulties with the topics. The difficult topic findings are in line with Azis and Sugiman (2015) results, which found out the difficult topics such as probability, differential, statistics, trigonometry, linear programs, and limit. Moreover, the findings are also in line with the study conducted by Nisa (2014).

Considering the trends of the proportion correct of difficult topics, the analysis results showed that most of the difficulties experienced by students occurred in the UN from 2013 to 2017. It indicated that the UN’s difficulty level from 2013 to 2017 is higher than the previous year of UN implementation. The tendency strongly assumed influenced by several factors. First, there is a change in curriculum, where the implementation of Curriculum 2013 began in 2013. Referring to the data on the results of the UN for mathematics in VHS (see Table 1), before the Curriculum 2013 was implemented, the mean score of UN for mathematics in 2011 and 2012 was in the “C” category (moderate). However, after the Curriculum 2013 was implemented, the UN’s mean score for mathematics from 2013 to 2017 was consistently in the “D” category (poor). This fact describes contrasting differences in the UN results before and after the Curriculum 2013 was implemented. A goal of the Curriculum 2013 was to train the students with higher-order thinking skills (Apino & Retnawati, 2017; Jailani, Sugiman, & Apino, 2017), then, UN in 2013 and following years started using HOTS-based questions. The HOTS questions in the UN contributed to the level of difficulty of the items, which impacted decreasing the UN’s proportion correct.

Secondly, the UN consisted of several packages, which aimed to anticipate fraud during the UN (Kartowagiran et al., 2018). The use of questions of several packages expected to reduce the level of fraud or improve integrity during the UN’s implementation. However, the decrease in fraud is also directly proportional to the decrease in proportion correct. Nizam (n.d.) stated that, nationally, the mean score of schools with low integrity was higher than the mean score of schools with high integrity. One of the disadvantages of using questions of several packages is the equality aspect between the package questions. Although each package’s questions developed based on the same guideline, there is a possibility that the package questions have a different level of difficulty. It is allegedly one of the causes of the low proportion correct of the UN.

Third, the UN is no longer used as a determinant indicator of students’ graduation, impacting a decrease in students’ motivation and spirit to face the UN. The study by Retnawati et al. (2019) reported that when the UN was not a graduation requirement in 2015, based on information from teachers and school principals, it could be concluded that students’ preparation for the UN was greatly decreased. Students preferred to focus on preparing for college entrance exams. This study also found that teachers and schools must work hard to motivate students to be more serious in preparing for the UN. Abdullah (2017) discussed the scores in the UN in the middle school, when the UN is no longer used as a standard for graduation, the score is only in the “sufficient” category, and the distribution of scores is only 33.58% or in the sufficient category and 20.89% or the less category. The study clearly showed when the UN is no longer used as a standard for graduation standards, but the UN’s results are still low. Moreover, Alawiyah (2015) also stated a decrease in the UN results at the middle school when the UN was no longer used as students' graduation standard. In short, when the UN is
no longer used as a standard for students' graduation, then the enthusiasm and motivation of student's learning tend to decrease. It is alleged as one of the factors the low proportion correct of the UN.

The use of HOTS questions in the UN needs special attention. Besides the low of HOTS among students in Indonesia (Apino & Retnawati, 2017; Jalani, Sugiman, & Apino, 2017), it needs to improve the teacher's understanding of HOTS (Retnawati, Djidu, Kartianom, Apino, & Anazifa, 2018). Also, it needs to improve teachers' ability to conduct HOTS assessments (Retnawati, Hadi, & Nugraha, 2016). Thus, aiming to improve the results of the UN, the improvement of the education program might not only focus on improving the students' abilities, but also needs to consider an increase in the teacher's competence, such in terms of designing, implementing, and evaluating the learning process in the classroom. When the HOTS is currently one of the capabilities that students must possess, the design of classroom learning, both for mathematics and other subjects, needs to develop following science and technology development continuously. Therefore, the low result of the UN of students in Indonesia should be an evaluation topic for policymakers to improve Indonesia's education policies.

The findings of this study contribute to the improvement of mathematics learning. Referring to the research findings, we suggest that Indonesia's mathematics teachers pay more attention to mathematics topics that are considered difficult. Teachers can initiate learning improvements by selecting suitable learning models or strategies for teaching difficult topics. Also, we suggest that teachers take advantage of various learning media that can make it easier for students to understand mathematical concepts. Paying more attention to difficult topics does not mean neglecting other math topics. In this case, it is hoped that teachers will continue to pay attention to the balance in teaching mathematics topics, according to the curriculum and student needs.

This study has some limitations. Research that only focuses on investigating difficult mathematical topics is one of the limitations of this study. However, these limitations provide opportunities for future research. Our research findings can serve as a basic framework for other researchers to deeply investigate the types of difficulties students experience working on items on difficult topics. Besides, other researchers can also investigate the factors that cause student difficulties on certain topics. The research findings are expected to strengthen this study's findings and contribute to improving the quality of mathematics learning in the future.

**CONCLUSION AND RECOMMENDATION**

The results concluded that during the UN implementation at VHS from 2008 to 2017, 14 mathematics topics were indicated as difficult topics. These topics are trigonometry, solid space, limit functions, the measure of data dissemination, permutation and combinations, differential, the area between two curves, central tendency, probability, logarithms, integrals, sequences and series, linear programs, and polar coordinates system. Based on the analysis of each difficult topic's trends, generally, the student difficulties dominantly occurred in the UN from 2013 to 2017, with the mean of proportion correct was less than 50%. Based on the findings, the research proposed recommendations: 1) mathematics teachers need to consider the topics that are indicated as difficult and provide deep exploration on these topics; 2) mathematics teachers need to train HOTS questions to students, due to the starting the helpful HOTS questions in the UN; and 3) there is a need for further studies to investigate the types of difficulties students experience and the factors that cause its.

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REFERENCES


