HOTS problem on function and probability: Does it impact to students’ mathematical literacy in Universitas Terbuka?

T D Prastiti¹, S Tresnaningsih¹, J P Mairing² and A R Azkarahman³

¹Department of Mathematics Education, Faculty of Education and Teacher Training, Universitas Terbuka, Indonesia
²Department of Mathematics Education, Universitas Palangka Raya, Indonesia
³Distance Learning Program Unit (UPBJJ) Surabaya, Universitas Terbuka, Indonesia

E-mail: tridyahprastiti@ecampus.ut.ac.id

Abstract. Mathematical literacy is one of the essential skills for students both during their learning and other daily activities. This study aimed to describe the effectiveness of worksheet consisting of higher order thinking skills (HOTS)-based mathematics problems on function and probability to improve the students’ mathematical literacy in Universitas Terbuka (UT) Surabaya. This research was an experimental research, involving six study groups of UT Surabaya students who took mathematics course as the research subjects. The research subjects were then selected using clustered random sampling technique, and two study groups (Tuban and Jombang) were chosen as the research sample. The instruments used in this study were pre-and post-test of mathematical literacy, HOTS-based worksheet, and tutorial kit. The data were analyzed using Wilcoxon non-parametric test as the research data were not normally distributed. The effectiveness of HOTS-based worksheet was measured by using normalized gain measurement with the medium category was set at 0.3. The results showed a significant positive effect (normalized gain value > 0.3) of the mathematics HOTS-based worksheet. It can be concluded that the application of mathematics HOTS problems were effective to improve mathematical literacy of UT Surabaya students.

1. Introduction

Mathematical literacy is defined as the ability to apply basic and geometric calculation skills in everyday life, to understand basic mathematical ideas, to develop relevant mathematical models, as well as to understand and evaluate other mathematical models [1, 2]. The increased mathematical literacy thus should be taken into consideration as the learning outcomes in mathematics education. However, a research showed that only 65.7% of college students had the ability to understand and provide the problem solving strategies, yet only 46.9% of it gave the correct answer [3]. The condition also showed that students still face difficulties in formulating and solving the science-related problems. Moreover, the unsatisfying mathematical literacy is not only found in college student but also in high school student [2].

Mathematical literacy determines the students’ ability to think critically. The critical thinking is part of the higher order thinking skills (HOTS) [4] and defined as the ability to think focusedly on solving the mathematical problems [5]. Compared to other common problems, mathematical problems challenge the student without clear solution and require several steps prior to finding the correct solution. The problem solving thus demand a conceptual understanding to the mathematical concepts related to other subjects to be able to represent the condition of the problem [6].
Universitas Terbuka (UT) is a public university in Indonesia which provides open-distance learning program. Therefore, the students in UT are encouraged to learn independently using modules and worksheet since the face to face meeting is limited. There are several factors that affect students’ mathematical literacy – their characteristics, perceptions, interests, lecturers’ experiences, and the applied learning method [7]. Various research added that learning activities and worksheets would affect students’ mathematical literacy [8, 9]. In this study, we observed the effectiveness of HOTS-based worksheets to the students’ mathematical literacy in UT. The results would bring benefits to recommend the appropriate strategies to improve the students’ mathematical literacy using the independent learning approach.

2. Method

2.1. Research design
This research is an experimental research with pre- and post-test design. The research was conducted in nine stages. They were: selecting the topics, literature reviews, define the problem, develop hypothesis, determine the participants, develop research instruments, collect and analyze the data, test the hypothesis and make conclusion [10]. The effectiveness of HOTS-based worksheet was measured with normalized gain (G) measurement. A significant increase is indicated when the increased G is more than 0.3 (medium category). The G is measured as follow [11].

\[
G = \frac{\text{final score} - \text{initial score}}{\text{maximum score} - \text{initial score}} \tag{1}
\]

2.2. Research instruments
The research instruments in this study include pre-test, post-test, and tutorial kit. The pre- and post-test were isomorphic and contained mathematical problems which will measure the students’ mathematical literacy [12]. The example of the HOTS problems in this study is presented in Figure 1.

2.3. Research sample
Six study groups of UT Surabaya students who took mathematics course were selected as the research subjects. The research subjects were then selected with clustered random sampling, and two study groups consisted of 25 students (Tuban) and 28 students (Jombang) were chosen as research sample.

2.4. Data collection
There are two data analyzed in this study, which were the initial and final scores. Both scores were collected consecutively by giving students pre- and post-test in the first and eight face to face tutorials, respectively. Each solution in both tests was scored by using rubrics of analysis presented in Table 1 [6].

The pre-test was done during the first tutorials, and the HOTS-based worksheet was applied from second to seventh tutorials, and the post-test was done in the final tutorial or during the eight tutorials. A more detailed learning stages of the student were as follows.

2.4.1. Preliminary stage (First tutorial). In this stage, (1) the tutors correlate the learning material to the context in everyday life, (2) tutors ask questions to explore students’ understanding of prerequisite material, and (3) the tutors convey the aim and goal of the tutorial.
According to both functions’ properties, what is the definition of function?

Function is a special relation matching every element of domain $x$ to exactly one element of codomain $f(x)$.

Could any two functions be composed? Why? If not, provide 2 examples of the function which could not be composed.

Not always, because the requirement of composition of two functions $f \circ g$ is that the intersection of range $f$ and domain $g$ is not empty.

How do you solve the probability problems? Explain your steps in solving them.
- Find the number of events $n(A)$
- Find the number of sample space $n(S)$
- $P(A) = \frac{n(A)}{n(S)}$

Figure 1. Example of the problems in the HOTS-based worksheet
Table 1. Rubrics of analysis

| Variables          | Score                                                                 |
|--------------------|----------------------------------------------------------------------|
| Problem understanding | 0: Misunderstood the problem                                      |
|                     | 1: Misunderstood or misinterpret some parts of the problem         |
|                     | 2: Correctly understood the problem                                |
| Plan conducting     | 0: No plan, or the conducted plan is not suitable                   |
|                     | 1: Some parts of the plan are conducted correctly by following correct problem understanding |
|                     | 2: Correct plan and properly implemented which lead to correct answers |
| Problem solving     | 0: No answer, or wrong answer because the plan is not appropriate   |
|                     | 1: Incorrect writing, miscalculation, or only part of the answer is correct |
|                     | 2: Correct answer                                                  |

2.4.2. Core stage (Second to seventh tutorial). In this stage, (1) students learn and answer questions or problems in student worksheet independently prior to face-to-face tutorials, (2) during the tutorial, students share answers or solutions of the problem in group. Tutors guide students to answer questions or solve problems in the HOTS-based worksheet by asking questions,, and (3) the student groups take turn in presenting their work in front of the class. Tutors facilitate class discussion by asking metacognitive questions.

2.4.3. Closing stage. In this stage, (1) students reflect on the learning material and acquired solution of the problem, and (2) the tutors convey learning activities and HOTS-based worksheet.

2.5. Data analysis
Initial and final scores were analyzed by using two paired samples comparison test. The hypothesis is as follows.

\[ H_0 : \mu_G \leq 0.3 \]  \hspace{1cm} (2)
\[ H_1 : \mu_G > 0.3 \]  \hspace{1cm} (3)

with \( \mu_G \) is the average normalized gain (G). The obtained data were tested with Kolmogorov-Smirnov test to measure the data normality and followed with Wilcoxon nonparametric test to determine differences.

3. Results and discussion
Students’ mathematical literacy were initially observed with pre-test on the first tutorial. The HOTS-based worksheet was then given during the second to the seventh tutorials, and the results were measured on the eight tutorials with post-test. Both pre- and post-test consisted of four problems with each maximum score is six, thus the total of maximum score is 24. The result of both pre- and post-test in Tuban and Jombang study groups are presented in Table 2.

Table 2. Statistical analysis of the pre- and post-test

| Scoring | Minimum | Maximum | Average | Median | SD | Variance |
|---------|---------|---------|---------|--------|----|----------|
| Pre-test| 8.00    | 23.00   | 18.19   | 19.00  | 2.91| 8.46     |
| Post-test| 16.00  | 24.00   | 21.68   | 22.00  | 2.23| 4.99     |
| G       | -1.00   | 1.00    | 0.48    | 0.60   | 0.52| 0.27     |

The results showed that the students had higher average score on their post-test compared to the pre-test. This showed that the application of HOTS-based worksheet could increase students’ mathematical
literacy reflected from their improved ability to solve the provided mathematical problems. The boxplot of pre- and post-test scores is presented in Figure 2. It can be seen that the achieved score was increased from the pre-test to the post-test. In addition, it can also be seen that in the pre-test, there were three students (5.7%) whose score were way below the average, or known as outliers, indicated with asterisks (*). However, the outliers were not found in the post-test, which indicates that the HOTS-based worksheet could help them to better understand and solve mathematical problems as well.

![Boxplot of PRE; POST](image)

**Figure 2.** Boxplots of pre- and post-scores

In this research, we measure the distribution normality of the data with Kolmogorov-Smirnov test before measuring the significant differences. The results can be seen in Figure 3, and showed abnormal distribution of normal gain data. The Wilcoxon nonparametric test was then used to measure differences.

![Probability Plot of GAIN Normal](image)

**Figure 3.** Kolmogorov-Smirnov test of the normalized gain (G) data
The Wilcoxon test showed that the obtained p-value was $0.006 < 0.05 = \alpha$ (Table 3), and showed an increased $G > 0.3$ (significantly increased) with confidence level at 95%. This showed that the application of HOTS-based worksheet is effective to improve UT students’ mathematical literacy.

**Table 3. Wilcoxon nonparametric test results**

| Null hypothesis | Alternative hypothesis | $H_0$: $\eta = 0.3$ | $H_1$: $\eta > 0.3$ |
|-----------------|------------------------|----------------------|---------------------|
| Sample          | N                      | Wilcoxon test        | $P$ value           |
| G               | 53                     | 1001.00              | 0.006               |

The Wilcoxon test showed that the obtained p-value was $0.006 < 0.05 = \alpha$ (Table 3), and showed an increased $G > 0.3$ (significantly increased) with confidence level at 95%. This showed that the application of HOTS-based worksheet is effective to improve UT students’ mathematical literacy.

Mathematical literacy correlates with the ability to conduct a model of the problem as well as the solution which required interrelationship understanding. Previous research had also shown that the HOTS-based learning approach could help students in improving their mathematical literacy [3, 7, 13, 14]. The improvement in students’ mathematical literacy thus would help them in finding solution to the contextual problems in daily life [2]. The students are then encouraged to think critically to solve the problem [6], which will improve their higher order thinking skills as well. In this research, the subjects were students who were taught to learn independently, as UT promotes an open and distance learning system. The positive outcomes in this research thus elucidate that the improvement on students’ mathematical literacy could also be done in a non-conventional learning system (face-to-face), but in an open learning system as well, such as through HOTS-based worksheet.

4. Conclusions

The research concludes that the application of HOTS-based worksheet is effective to improve the mathematical literacy of UT students, with the increased normal gain ($G$) was more than 0.3. In addition, it showed that the HOTS-based worksheet could be applied to improve students’ mathematical literacy under open and distance learning system.

Acknowledgments

We would like to thank Universitas Terbuka for providing research fund through Penelitian Dasar (PD) UT research scheme with contract number: 2654/UN31.LPPM/PM/2019.

References

[1] Dinni H N 2018 HOTS (Higher order thinking skills) and its relation to mathematical literacy skills PRISMA Prosiding Seminar Nasional Matematika 1 170-6
[2] Mahdiansyah M and Rahmawati R 2014 Literasi matematika siswa pendidikan menengah: Analisis menggunakan desain tes internasional dengan konteks Indonesia Jurnal Pendidikan dan Kebudayaan 20 452-69
[3] Winardi and Dwijanto 2018 Analysis of mathematical literacy skills through the Missouri Mathematics Project model with the open-ended approach UJMER 6 175
[4] Lewis A and Smith D 1993 Defining higher order thinking Journal Theory Into Practice 32 131-7
[5] Krulik S, Rudnick J and Milou E 2003 Teaching Mathematics in Middle School: A Practical Guide (Boston: Pearson Education Inc.)
[6] Mairing J P 2018 Mathematical Problem Solving: The Way Students Obtain Ways to Think Creatively and Positively (Bandung: Alfabeta)
[7] Susanti E and Syam S S 2017 The role of the teacher in improving the mathematical literacy skills of Indonesian students Proceedings of the Mathematics and Mathematics Education Seminar 30-5
[8] Budiono C S and Wardono 2014 PISA-oriented PBM approached by PMRI with LKPD media
improves mathematics literacy of junior high school students. *Unnes Journal of Mathematics Education* 3 210-9

[9] Indah N, Mania S and Nursalam 2016 Improving students' mathematical literacy skills through the application of the problem based learning model in grade VII of SMP Negeri 5 Palangga Gowa district. *Journal of Mathematics and Learning* 4 198-210

[10] Lodico M G, Spaulding D T and Voegtle K H 2006 *Method in Educational Research: From Theory to Practice* (San Francisco, CA: John Willey & Sons, Inc.)

[11] Mairing J P 2016 Educational Statistics: Concepts and Applications Using Minitab and Excel (Yogyakarta: Andi Offset)

[12] Sternberg R J and Sternberg K 2012 *Cognitive Psychology* (Belmont, CA: Wadsworth)

[13] Fajriyah E, Mulyono and Asikin M 2019 Mathematical literacy ability reviewed form cognitive style of students on double loop problem solving models with the RME approach. *Unnes Journal of Mathematics Education Research* 8 57-64

[14] Lailiyah S 2017 Mathematical literacy skills of students’ in term of gender differences. *AIP Conference Proceedings* 1868 050019