Analysis of number sense capabilities of prospective mathematics teachers

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Abstract. A person's sensitivity to numbers and their calculations is called number sense. This study aims to (1) analyze the number sense ability of prospective mathematics teacher students, (2) determine the mathematics learning achievement of prospective mathematics teacher students, and (3) analyze whether there is a relationship between number sense ability and mathematics learning achievement of prospective mathematics teacher students. The method used in this research is a descriptive quantitative method. The population in this study were students of the Mathematics Education Study Program FKIP University of Lambung Mangkurat Banjarmasin in the odd semester of 2019/2020. The sample in this study were students of the Mathematics Education Study Program Class of 2018. Data collection techniques were tests and questionnaires. The data obtained were analyzed with descriptive and inferential statistics. The results showed that (1) the students' number sense ability of prospective mathematics teachers was in sufficient qualification. (2) the average learning achievement of prospective mathematics teacher students is 2.62 on a scale of 4, and (3) there is a relationship between number sense ability and mathematics learning achievement of prospective mathematics teacher students. Thus, improving the number sense of prospective mathematics teachers is an important goal for mathematics teacher education.

1. Introduction

Number sense is described as the ability to think flexibly and one's intuition about numbers which includes symbolic and non-symbolic foundational numbers as well as skills in using the operations for making mathematical judgments [1]–[3]. Number sense is the acquired ability of an individual based on the experience of learning mathematics from an early age, which begins from recognizing numbers and representing them in a meaningful form to recognize the operation and meaning of its use in everyday life [2]. Furthermore, number sense also had overlap with generalist genetic mechanisms in mathematics such as the ability to complete basic arithmetic calculations and general cognitive ability [2], [4]. Because mastery depends on learning experiences, the number sense ability that is owned when the child is in elementary school will be carried over to further education. Therefore, it is important to develop children's number sense abilities from an early age [5].

The content in the basic education curriculum is generally about whole numbers, decimals, and fractions, while in secondary education, it is extended to integers and real numbers. The two curricula emphasize understanding of operations, in parallel with the development of the ability to estimate and

mental calculation [6]. Thus, to be able to design appropriate learning, number sense ability is not only important for primary education teacher candidates to master but also secondary education teacher candidates. Besides, number sense is also an indicator to recognize mathematics disability from prospective teachers and students [7]. By knowing this, it is hoped that the teacher can design appropriate learning because this ability can be well-formed if the learning experience gained is meaningful [2].

While this ability is often associated with basic abilities mastered by elementary school students and teachers [5], [8], [9], research studies show that pre-service secondary teachers showed lower success than pre-service primary teachers in a number sense test [6]. This is of course a concern because prospective high school teachers can also have careers in basic education based on the current tertiary education curriculum in Indonesia. Besides, this ability is also useful for secondary education level students because it reflects their mastery of the basic concepts of the material being studied. Thus a mapping is needed regarding the number sense ability of students in the mathematics education study program so that it can be analyzed and then a future strategy is designed to address these findings. These findings can also be used as input to the department and lecturers in the concentration of mathematics as a reference and benchmark in the development of learning mathematics related to numbers. Therefore, this study aims to (1) analyze the number sense ability of prospective mathematics teacher students, (2) determine the mathematics learning achievement of prospective mathematics teacher students, and (3) analyze whether there is a relationship between number sense ability and mathematics learning achievement of prospective mathematics teacher students

Improving the number sense of prospective mathematics teachers is an important goal for mathematics teacher education, and researchers have found this goal to be difficult to accomplish [10]. Several studies have also shown that students' abilities related to number sense are still low [11] or are still experiencing difficulties in some processes [5]. [8] found that the number sense ability of prospective PGMI teacher students was still in the poor category. In line with this, the findings of Hadi [1] also show that some mathematics education students still face difficulty applying the concept of number sense.

Number sense capability includes 5 components, namely counting and computation, effect of operations, equivalent expression, multiple representations, and number concept [12]. The following is a description of each of these components.

- Counting and computation (calculation and counting strategies)

The counting and computation component is a method or way for students to solve problems in the questions and the accuracy of students' calculations. The counting strategy can be seen from the students' steps in solving a question, it is not limited and shows the extent to which students are creative in solving the questions given, while the students' calculations can be seen from the students' accuracy in calculating. For example by using mental calculations, making use of existing formulas, using appropriate shortcuts. For example, a cat eats 600 grams of fish in 4 days. How many grams of fish will the cat eat in 6 days?

- Effect of operations (Understanding the concepts and effects of number operations)

Understanding the concepts and effects of number operations is an understanding of the concepts and effects of operating a number on other numbers. This includes concluding the results obtained based on an understanding of the operation of numbers. For example, the effect of the 4: 0.9 division operation, is the result the same, less, or greater than 4? Students who understand the effect of the division operation already know that if the denominator is smaller than the numerator it will result in an even bigger result.

- Equivalent Expression (Understanding and using equivalent statements)

Understanding and using equivalent statements is an understanding and use of equivalent statements. This includes the transition from a statement converted into an equivalent form. Often used to evaluate a more efficient calculation process. For example, to simplify statements and develop settlement strategies, such as comparing operations in multiplication with operations in division. This includes understanding and benefiting from the nature of arithmetic operations (commutative, associative, distributive). For example, to simplify statements and develop solving strategies, such as comparing operations in multiplication with operations, in addition, being able to determine the number in a box so that 243 x .... = ... x 24.3.

- Multiple Representations (Understanding and using equivalent number representations)

Understanding and using equivalent number representations is an understanding of how to use the equivalent form of numbers and represent the equivalence of numbers. This understanding includes the recognition of numbers by ordering different numbers in an equivalent form. It also includes the ability to identify and / or reformulate numbers to get their equivalent form. For example, connecting and / or comparing the sizes of numbers through various forms of representation. You can also change a fraction to another fraction, a fraction in decimal form, an integer into an extended form, or the location of a decimal number on a number line. For example, students know the location of the numbers 1/2 and 0.8 on a number line.

- Number Concepts (Understanding the concepts and quantities of numbers)

Understanding the concept of numbers allows students to know the basics of number systems such as integers, fractions, and decimals including patterns and place values of numbers (units, tens, and thousands). This concept can involve relationships and/or comparing numbers into a particular form. This includes comparing the magnitudes of numbers using a single form of representation. An example is how many numbers there are between 2.84 and 2.85. Students who master the concept of numbers will surely know that there are many numbers between 2.84 and 2.85, namely 2.841, 2.842, 2.8401, 2.84001, and so on.

2. Method

This research is a descriptive quantitative research. What will be described in this study is the number sense ability of prospective mathematics teacher students and their correlation with the achievement index in mathematics. The population in this study were students of the mathematics education study program at Lambung Mangkurat University while the subjects were 81 third semester students of mathematics education study program.

Data collection in this study was carried out through a test and a questionnaire. The test is used to measure number sense ability is an instrument developed by Mcintosh et al.[12]. The test consists of 35 test questions in the form of multiple choice and short entries and includes 5 components, namely counting and computation, effect of operations, equivalent expression, multiple representation, and number concept. Whereas, the questionnaire in the form of filling in the scores of mathematics courses is distributed through a google form.

Table 1. Qualification of Number Sense Ability [8]

Range	Qualification
85 – 100	Excellent
70 – 84	Good
50 – 69	Fair
< 49	Poor

Meanwhile, in determining the category of the correlation coefficient is shown in Table 2.

Table 2. Interpretation of Correlation Coefficient

| Correlation Coefficient	Interpretation
0	No correlation
$0 < C \leq 0{,}20$	Very weak
$0{,}20 < C \leq 0{,}40$	Weak
$0{,}40 < C \leq 0{,}70$	Moderate
$0{,}70 < C \leq 0{,}90$	Strong
$0{,}90 < C \leq 0{,}99$	Very strong
1	Perfect correlation

3. Results and Disscussion

The initial stage of this research was to design a number sense test which consisted of 35 questions consisting of multiple-choice questions and a short entry with the number of each question for each component being 7. The questions were adapted from a test developed by Mcintosh et al. and Beswick et al. [12], [13]. At the time of data collection, the students were asked to take the test in 25 minutes, which means that on average each question must be done in approximately 42 seconds. Students are also not allowed to make scribbles in counting, the calculations they do must be done mentally (mental calculation). In addition, students are also asked to fill out forms related to the achievement index of the mathematics courses they have taken, namely Trigonometry, Geometry, Calculus I & II, Algebra, Matrices, Basic Introduction to Mathematics, Theory of Opportunity, and Analytical Geometry. The results of the student number sense test components and student achievement index are presented in Table 3, Table 4, and Figure 1, respectively.

Table 3. Descriptive statistics of number sense test result of each aspect

	Counting & Computation	Effect of Operations	Equivalent Expressions	Multiple Representations	Number Concept	Overall
Lowest	42,86	0	14,29	0	0	28,57
Highest	100	100	100	100	100	94,29
Mean	79,01	68,08	69,14	56,97	48,15	64,27
Mode	100	85,71	57,14	71,43	42,86	68,57
Median	85,71	71,43	71,43	57,14	42,86	68,57
St. Dev	18,08	22,73	20,51	22,98	25,5	16,85
Qualification	Good	Fair	Fair	Fair	Poor	Fair

Table 4. Students Performance Index of Mathematics Course

Lowest	Highest	Mean	Mode	Median	St. Deviation
1,37	3,82	2,62	2,47	2,50	0,66
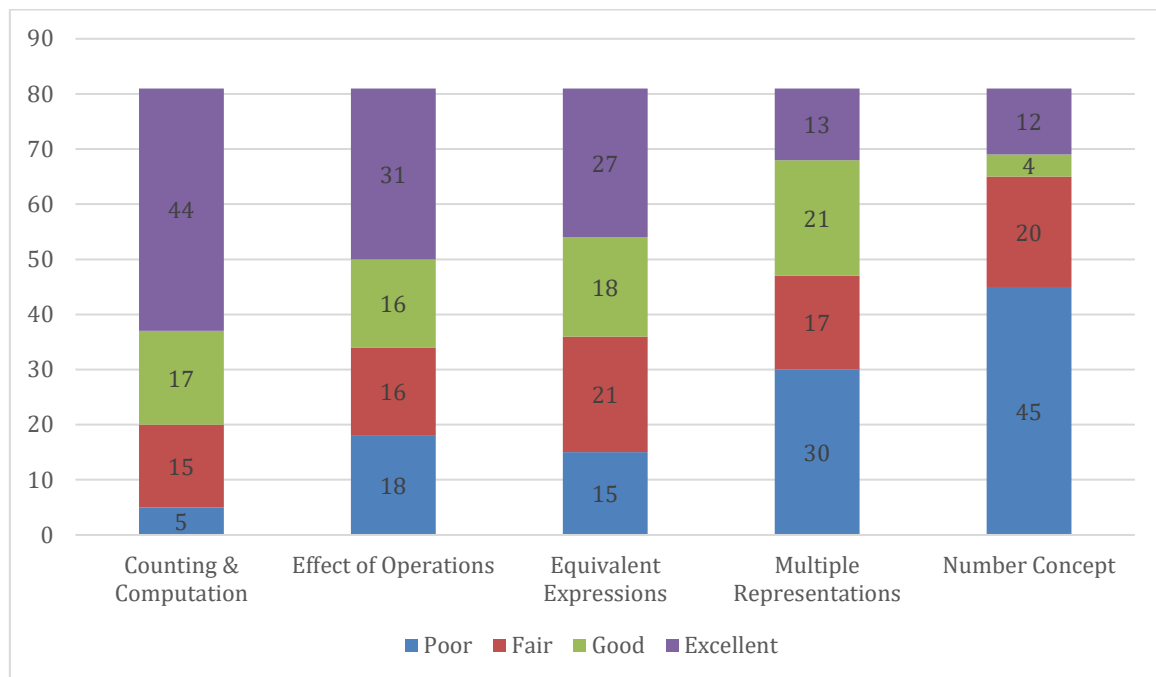
Figure 1 Comparison per aspect of the number sense test result

The results of the number sense ability of prospective mathematics teacher students in this study were taken from the number sense ability test score data. The number sense ability component in this study consists of five components, namely counting and computation, effect of operations, equivalent expressions, multiple representations, and number concepts [12].

The highest score from the student's number sense ability test was 33 with a value of 94.29 while the lowest score was 10 with a value of 28.57. Of all the students who took the test, none of them got a score of 100. This may be due to the inability of students to work on questions such as the number sense ability test given. In doing this test, the students were not allowed to use calculating tools such as scribbles, calculators, or other calculation tools. This made many students find it difficult to do it. It is proven when researchers explain not using scribbled paper, they were surprised and thought that it was impossible to do math problems without scribbling or counting on scribbled paper. However, when working on the questions they gradually got used to it, and many students were curious about the answers to the given questions.

The component that has the lowest average value is the number concepts component with an average value of 48.15 which is in poor qualification. This component requires students' ability to know the basics of number systems such as integers, fractions, and decimals, including patterns and place values of numbers (units, tens, and thousands). For example, how many numbers are there between 1.52 and 1.53? Students who master the concept of numbers will surely know that there are many numbers between 1.52 and 1.53, namely 1.521; 1.522, 1.5201, 1.52001, and so on.

In Figure 1, it can be seen that the mastery of number concepts is still low with more than 50% of students included in the poor category. Similar findings [8] among the five components tested, the qualifications lacking in mastering number concepts were shown by 84% of the research subjects and was the highest number compared to other components. The number concept is a component that contains the basic concepts of the number system and this is an important ability in carrying out various

operations and applying theorems in mathematics. Steps that can be taken by educators in dealing with this can be seen from the following findings.

Woods et al. [14] provide an idea of the number concept as follows.

Research suggests that visual representations, like a number line, support students' development of number sense by helping them create a mental representation of the order and magnitude of numbers. Besides, explicitly sequencing instruction to transition from concrete to visual to abstract representations of mathematics concepts supports students' conceptual understanding.

Another finding was that through the learning by playing teaching method, students developed their number sense on addition and subtraction of integers and they also have fun in the process [15]. While this suggestion can be applied for young students, it is still should be considered in teaching the prospective teacher students with another form of playing activities and this suggestion will also be helpful for them when they are teaching their students later. More fully Burns [8] reveals several strategies that can be applied to improve number sense abilities, namely (1) model different methods for computing, (2) ask students regularly to calculate mentally, (3) have class discussions about strategies for computing, (4) make estimation an integral part of computing, (5) question students about how they reason numerically, and (6) pose numerical problems that have more than one possible answer. The strategy chosen to be applied by educators is of course adjusted to the conditions of their students and emphasis is needed, especially in components that are still weaknesses of these students.

The number sense component that has the highest average score achievement is the counting and computations component with an average value of 79.01 with good qualifications. This component requires students to solve problems in the questions and the accuracy of the calculations. The counting strategy can be seen from the students 'steps in solving a question, not limited, and shows the extent to which students are creative in solving the given questions, while the student's calculations are seen from the students' accuracy in calculating. When viewed from the average value, student mathematics teacher candidates already have good counting and computation skills.

Overall the qualifications of the number sense test results from the subjects in this study were sufficient. However, the deficiencies shown by students should be of concern to educators considering the importance of this ability in supporting higher arithmetic and mathematics skills and as resources to become a professional teacher [4], [16], [17].

Table 5. Correlational test result between Performance Index and Number Sense Test Result

Correlations		Performance Index	Number Sense Test Result
Performance Index	Pearson Correlation	1	.453**
	Sig. (2-tailed)		.000
	N	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

Based on the results of the correlation test shown in Table 5, it was found that the correlation between the performance index and the number sense test result was statistically significant at $\alpha = 1\%$ with a correlation coefficient of 0.453. This coefficient is included in the moderate range in the interpretation [18]. These results indicate that the correlation between number sense ability and students' mathematics learning achievement, especially in mathematics. This is in line with the results of research that number sense ability contributes to learning achievement and the more often someone is exposed to numbers, the more their numerical abilities and achievements in mathematics will increase [3], [19].

4. Conclusion

Based on the results of the research on the number sense ability of prospective mathematics teacher students at FKIP, Lambung Mangkurat University, the following conclusions can be drawn. First, the number sense ability of prospective mathematics teacher-students is in moderate qualification. Second, the average learning achievement of prospective mathematics teacher-students is 2.62 on a scale of 4. Third, there is a correlation between the number sense ability and the mathematics learning achievement of student mathematics teacher candidates with a correlation coefficient of 0.453. Thus, improving the number sense of prospective mathematics teachers is an important goal for mathematics teacher education.

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