The Effect of the ELPSA Framework on Students’ Ability to Solve Function Problems

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Abstract. Mathematical functions are good to learn for solving problems in everyday life associated with the "input" and "output" processes. Mathematically, functions are expressed in terms of formulas. Students may be able to determine the functional value of a given function formula for an input value, but most students still have difficulties to do otherwise. The difficulties faced by students are related to the ability to transfer problem in context to mathematical problem. ELPSA (Experience, Language, Pictorial, Symbolic, Application) is a framework that views learning as an active process in which students build their own way of knowing (developing understanding) through both individual thinking and social interaction with others. This is an experimental research to measure the effect of mathematics teaching by using ELPSA framework on students' ability to solve function problems. The samples of this study were the 8th grade of Aletheia Christian Junior High School at Mataram city, West Nusa Tenggara. This research used a quasi-experimental with non-equivalent control group design. Data were collected by giving a test and observations during the learning process taken place. Data were analyzed by using data analysis tools in Microsoft. Based on the results of statistical tests and observations of students' performance during the mathematics learning process, then there was significant effect of the ELPSA framework on students' ability to solve function problems. Furthermore, it is can be used as a reference for mathematics teachers to use ELPSA framework as an innovative strategy of teaching mathematics in improving students' problem solving skills.

1. Introduction
Mathematics is a universal science that is beneficial to human life and also underlies the development of modern technology and has an important role in various disciplines and advancing the power of human thought. The rapid development in the field of information and communication technology today is based on mathematical developments in the fields of number theory, algebra, discrete mathematics, and opportunity theory.

In logic, the linkages between various propositions are not merely to form a series of propositions which have a certain pattern, but also have the purpose of determining truth values. To obtain the truth, each term in a proposition needs to be bound by rules. The rules that bind propositions in compiling this reasoning process are known as "functions". The term function appeared in Descartes analytic geometry in 1637. Leibniz entered this term in mathematics in 1694 and Bernoulli used the term in 1698. Today's use is often denoted by the "f(x)" notation introduced by Euler in 1734 [1].

The concept of function in mathematics is generally defined as mapping that connects two separate sets, namely the origin (domain) and the result area (range). Bertrand Russell expressed his opinion
about the function associated with the existence of the set in the logic concept of relations related to
relations between sets. Similarities will occur if the number of members of the corresponding set is the
same, so that one member of the domain relates only to one member range [2].

Standards of Curriculum and school mathematics evaluations issued by the National Council of
Teachers of Mathematics (NCTM) stated that one of the main themes in mathematics study
function. This standard emphasizes on exploration of patterns and relationships. The standard
suggested the establishment of a strong foundation on the concept of function by using informal
investigations at the primary and secondary levels by extending to the formal symbol and discussion
functions in high schools. At the basic level, relationships and functions provide good opportunities
for students to learn to make mathematical connections. As a unity of ideas in mathematics, the
concept of function helps students to connect different mathematical procedures and ideas [3].

In mathematics, functions can be stated in various representations such as tables, graphs, the set of
ordered pairs, and algebraic equations. Kusnanto's study states that students are easier to learn the
functions presented in the graph than the functions presented algebraically [4]. The presentation of
functions is graphically more communicative because the domain, codomain, and range are easier to
be seen. The problem encountered today is some mathematics textbooks in schools present algebraic
functions first rather than presenting a function graph. We recommend that the presentation of the
function graph shall be given at the beginning of the introduction of the function.

Some of the results of previous research can be new data to develop the teaching of the concept of
function through the constructivism model. Cobb and Steffe [5] suggested teachers to use the
constructivism model to teach mathematics. The constructivism model will help students learn to
construct their own conceptual functions learned through reasoning and their interactions with the
surrounding environment. ELPSA (Experience, Language, Pictorial, Symbolic, and Application) is a
framework based on constructivism learning theories and social nature. The ELPSA framework views
learning as an active process in which students construct their own way of understanding things
through individual thinking processes and social interactions with others. However, it is important to
remember that ELPSA is not a linear process. Learning is a complex process that cannot be fully
predicted and does not occur in a linear sequence. Thus, ELPSA elements can be thought as
interconnected and complementary elements [6].

Started in 2015 this framework has been introduced in West Nusa Tenggara through a GPF D
Project. ELPSA consisted of five components, namely; Experience, Language, Pictorial, Symbolic,
and Application. ELPSA is based on social constructivism theories that see learning as an active
process in which students construct their own way of understanding things through individual thinking
processes and social interactions with others [6]. However, it is important to remember that ELPSA is
not a linear process. Learning is a complex process that cannot be fully predicted and does not occur in a
linear sequence. Thus, ELPSA elements can be thought of as interconnected and complementary
elements [6]. Through this concept, it appeared that the ELPSA framework provided space for the
creation of such didactic anticipation. In this way, the teaching of mathematics from teachers to
students can be richer (varied in teacher teaching strategies and didactic anticipation), weighted
(streamlining learning time through appropriate activities and optimizing learning resources), and
meaningful (using mathematics to solve problems in daily life).

ELPSA framework is applied in the form of lesson plans on function material in 8th grade junior
high schools which are then practiced in the classroom. These lesson plans contain teacher and
student activities that are presented explicitly complete with the form of questions posed by the
teacher and possible student responses. Besides that in the lesson plans there are alternative actions of
the teacher if the student's response is not in accordance with the teacher's expectations as planned at
the beginning. This research is important to be carried out especially in the Indonesian context with
the following reasons: (1) teachers in Indonesia are required to develop learning plans as part of their
professional duties; and (2) the results of a critical analysis study on Indonesian mathematics learning
videos from the TIMSS video study showed that mathematics learning in Indonesia lacked emphasis
on reasoning and problem solving, lacking time effectiveness, and presenting a few new mathematical
material in each mathematics learning. Based on this, this study aims to determine whether there are effects of ELPSA framework on students’ ability to solve function problems.

2. Research Methods
This type of research is quasi-experimental using non-equivalent control group design. The sample of this study was the 8th graders of the Aletheia Christian Junior High School in Mataram City, West Nusa Tenggara. This research has been conducted in the odd semester of 2017/2018 academic year.

Data were collected through observations carried out during the learning process and written tests after all learning processes had been completed. Data were analyzed using descriptive statistical analysis and inferential statistics (t-test). Descriptive statistical analysis performed by using data analysis feature in Microsoft Excel program by using the Descriptive Statistics menu as given in Figure 1.

![Figure 1. Descriptive statistics feature](image)

Data normality test were analyzed by using skewness while kurtosis data were obtained previously from descriptive statistical analysis. This result then processed to obtain Z-Skewness using the formula (1) below.

\[
Z\text{-Skewness} = \frac{Skewness}{\sqrt{6/N}}
\]

The interpretation of Z-Skewness data at the significance level \( \alpha = 0.05 \) was given in Table 1.

| Z-Skewness Interval | Data Interpretation |
|---------------------|---------------------|
| Z-Skewness < -1.96  | Data skewed right   |
| Z-Skewness > +1.96  | Data skewed left    |
| -1.96 < Z-Skewness < +1.96 | Data nearly symmetrical |

In same way the data were analyzed to obtain Z-Kurtosis by using formula (2) below.

\[
Z\text{-Kurtosis} = \frac{Kurtosis}{\sqrt{24/N}}
\]

The interpretation of Z-Kurtosis data at the significance level \( \alpha = 0.05 \) was given in Table 2.

| Z-Kurtosis Interval | Data Interpretation |
|---------------------|---------------------|
| Z-Kurtosis < -1.96  | The data has leptokurtic cracks |
| Z-Kurtosis > +1.96  | The data has platykurtic cracks |
| -1.96 < Z-Kurtosis < +1.96 | The data has mesokurtic cracks |
The class is stated to be normally distributed if Z-Skewness and Z-Kurtosis show data nearly symmetrical and have mesokurtic cracks.

The sample homogeneity test is performed by using data analysis feature in the Microsoft Excel program and select F-Test Two-Sample for Variances as given in Figure 2.

![Figure 2. F-test two-sample for variances feature](image)

Hypothesis testing has been carried out using the parametric t-test. This test can be done if the sample data has been stated to have a normal distribution and the sample variance is homogeneous. Testing techniques have been carried out using the data analysis feature in the Microsoft Excel program and selected t-test: Two-Sample Assuming Equal Variance as given in Figure 3.

![Figure 3. T-test two-sample for variances feature](image)

3. Results and Discussion

3.1 Results

This study was preceded by the provision of pre-tests in the experimental class and control class. This test was given to determine the ability of the initial two classes before treatment given. The result of the pre-test was shown in Figure 4.

![Figure 4. Pre-test results](image)
Figure 4. Student prior ability chart – experimental class and control class – before treatment

Based on Figure 4 it was known that the initial ability of students in both classes was similar. After that treatment was given to the two classes, ELPSA framework was applied to the experimental class while direct learning (the learning method used by the teacher) was applied to the control class. The stages of the process of teaching mathematics on the material function with ELPSA framework was given in Table 3.

Table 3. The stages of the process of teaching mathematics on the material function with the ELPSA framework

| Core Competency | Basic Competencies | Indicators of Competences Achievement | ELPSA Component | Teaching Materials |
|-----------------|--------------------|---------------------------------------|-----------------|--------------------|
| Knowledge       | Describe and express relationships and functions using various representations (words, tables, graphs, diagrams, and equations) | | E, L | Lesson Plan and Student Worksheet - 1 |
|                 |                    | Identifying the problems of everyday life that have relationships | L, P, S | Lesson Plan and Student Worksheet - 2 |
|                 |                    | ▪ Determine the domain, codomain, and range of a relation | | |
|                 |                    | ▪ Identify relationships that are functions | | |
|                 |                    | Express functions in various representations (tables, arrow diagrams, sets of sequential pairs, and points in cartesian coordinates) | P | Lesson Plan and Student Worksheet - 3 |
|                 |                    | Determine the domain, codomain, and range of a function | P, S | Lesson Plan and Student Worksheet - 4 |
|                 |                    | ▪ Model a mathematical problem with a function formula | P, S | Lesson Plan and Student Worksheet - 5 |
|                 |                    | ▪ Determine the function value if the function formula is known | S | Lesson Plan and Student |
At the end of the learning process both classes were given post-test. This post-test data will be used to determine whether there are any significant differences in students' abilities after being given treatment. The results of descriptive statistical data analysis for the experimental class after treatment was shown in Table 4.

Table 4. Descriptive statistical data of experimental class after treatment

| Experimental Class |          |
|--------------------|----------|
| Mean               | 8.315    |
| Standard Error     | 0.133825299 |
| Median             | 8.35     |
| Mode               | 8.6      |
| Standard Deviation | 0.598484929 |
| Sample Variance    | 0.358184211 |
| Kurtosis           | -0.641444286 |
| Skewness           | 0.002369267 |
| Range              | 2.1      |
| Minimum            | 7.4      |
| Maximum            | 9.5      |
| Sum                | 166.3    |
| Count              | 20       |
After obtaining the results of data analysis using descriptive statistics, the next step conducting data analysis by using inferential statistics. Before conducting this test, there were two conditions should be met first, namely the normality and homogeneity of the data.

Based on Table 4 and using the formula (1) and formula (2), Z-Skewness = 0.004326 and Z-Kurtosis = -0.58556. This means -1.96 < Z-Skewness <+1.96 which meant data were close to symmetrical. Likewise that -1.96 < Z-Kurtosis <+1.96 meant that the data has mesokurtic cracks. Thus it can be concluded that the experimental class was normally distributed. Visually this was shown in Figure 5.

Descriptive statistical data on control class after treatment was shown in Table 5.

Table 5. Descriptive statistical data of control class after treatment

| Control Class |       |
|---------------|-------|
| Mean          | 6.765 |
| Standard Error| 0.148017602 |
| Median        | 6.6 |
| Mode          | 6.6 |
| Standard Deviation | 0.66195484 |
| Sample Variance | 0.438184211 |
| Kurtosis      | -0.66907278 |
| Skewness      | -0.104428543 |
| Range         | 2.3 |
| Minimum       | 5.5 |
| Maximum       | 7.8 |
| Sum           | 135.3 |
| Count         | 20 |

Based on Table 5 and using formula (1) and formula (2), Z-Skewness = -0.19066 and Z-Kurtosis = -0.61078 was obtained. This means -1.96 < Z-Skewness <+1.96 which meant data were close to symmetrical. Likewise that -1.96 < Z-Kurtosis <+1.96 meant that the data has mesokurtic cracks. Thus it can be concluded the control class was also normally distributed. Visually this was shown by Figure 6.
The results of the sample homogeneity test on the post-test results from the control class and experimental class were shown in Table 6.

Table 6. F-test two-sample for variances

|                | Control Class | Experimental Class |
|----------------|---------------|--------------------|
| Mean           | 6.765         | 8.315              |
| Variance       | 0.438184211   | 0.358184211        |
| Observations   | 20            | 20                 |
| Degree of freedom | 19            | 19                 |
| F              | 1.223348762   |                    |
| P(F<=f) one-tail | 0.332413803   |                    |
| F Critical one-tail | 2.168251601   |                    |

Based on Table 6, the value of F Stat < F Critical one-tail at a significance level $\alpha = 0.05$ was obtained, it can be concluded that the two classes were homogeneous.

Furthermore, because the experimental class and the control class were normally and homogeneously distributed, then test of difference in students' abilities in the two classes was carried out by using parametric t-test statistics. Suppose $X_E$ is the ability of experimental class students in solving function problems and $X_C$ is the ability of control class students in solving function problems, then the hypothesis of statistics proposed in this study are as follows.

$$H_0: X_E = X_C$$  \hspace{1cm} (3)

$$H_a: X_E > X_C$$

Hypothesis tested using one-tailed t-test statistics parametric with significance level $\alpha = 0.05$ and degree of freedom = 38. T-test results were shown in Table 7.
Table 7. Statistic parametric t-test data

|                  | Experimental Class | Control Class |
|------------------|---------------------|---------------|
| Mean             | 8.315               | 6.765         |
| Variance         | 0.358184211         | 0.438184211   |
| Observations     | 20                  | 20            |
| Pooled Variance  | 0.398184211         |               |
| Hypothesized Mean Difference | 0                  |               |
| Degree of freedom| 38                  |               |
| t Stat           | 7.767650577         |               |
| P(T<=t) one-tail | 1.15331E-09         |               |
| t Critical one-tail | 1.68595446      |               |
| P(T<=t) two-tail | 2.30662E-09         |               |
| t Critical two-tail | 2.024394164     |               |

Based on Table 7, it is known that t Stat = 7.7676 > t Critical one-tail = 1.6859 so that the null hypothesis was rejected. Thus it can be concluded there is significant effect of the ELPSA framework on students' ability in solving function problems. Figure 7 was shown a graph of students' abilities in the order of the 1st to 20th students in each experimental class and control class.

Figure 7. Student Ability Chart – Control Class and Experimental Class – After Treatment

3.2 Discussion

Based on the hypothesis testing it was found that t Stat = 7.7676 and t Critical one-tail = 1.6859 at significance level $\alpha = 0.05$ and degree of freedom = 38. This means that t Stat is greater than t Critical one-tail, thus null hypothesis was rejected and alternative hypothesis was accepted. Therefore, it could be interpreted that there any significant effect on student’s ability to solve mathematics problem in the group of students who learned function by using ELPSA framework compared to the group of student who learned function by using direct learning.
Learning mathematics on the topic of function has been carried out in eight meetings with the allocation of time at each meeting was 2 x 40 minutes or 3 x 40 minutes. The learning stage used ELPSA framework which consisted five components, namely Experience, Language, Pictorial, Symbolic, and Application. The learning process was carried out in accordance to the planned Learning Implementation Plan. Learning was also equipped with Student Worksheets or other manipulative materials to facilitate student activities in learning mathematics.

The Experience component is a very important beginning in recognizing the concept of function. In this case the teacher should be able to choose precisely the problems in everyday life which lead to the material. In mathematics, a function is defined as a relation that pairs each member of a set exactly one to another member. During this time students were generally taught to pair members of the two sets without knowing what exactly is underlying the installation. When students were given the question "Why were you paired members of set A with members of set B in such a way?", Students were often confused to answer it. This gave us information that students did not really understand what was meant by function.

In this study to introduce functions, the teacher started by asking the problem about "Housing". This problem was chosen because the context was very close to the daily life of students in the schools. Most of them lived in residential housing around the city of Mataram. In this study, choosing the right context of the problem is the main key in starting a subject matter. This is in accordance to Herman's [7] opinion which stated that selection of problems that would be given to students in teaching-learning process was very important. Students need experience and practice in formulating and solving problems.

The second component in the ELPSA framework is Language. Here students were asked to state the meaning of the function in their own sentence. Students were also asked to explain why members of a set could be mapped to other set members. This activity was intended so that students could develop everyday language into the language of mathematics, in this case in term or definition of function in mathematics. This consistent to Wijaya’s opinion [8] which explained the Language component of the ELPSA framework is a driving force for learning activities that actively develop certain mathematical languages to be interpreted by learners. Johar and Hajar [9] also stated that language is an important element in learning process. It could be happened; the students did not understand a mathematical concept, not because the concept was too difficult for him but because the teacher presented using words or sentences that students could not understand.

**Table 8** showed a small part of the dialogue between teachers and students who were learned to relate something that is around students.

|   |   |
|---|---|
| **Table 8. Dialogue between teacher and students** |   |
| _T_ : "Can you mention something related to the housing where you live?" |   |
| _S_1 : "There are one-story houses and multi-story houses" |   |
| _S_2 : "There are various types of vehicles such as bicycles, motorbikes and cars" |   |
| _S_3 : "Odd house numbers in block A where I live are 1, 3, 5, 7, 9, 11, 13, 15" |   |
| _S_4 : "The color of the vehicle in the block where I live is dominant in red, blue, white and black" |   |
| _T_ : "Accordance with the conditions of each in the housing where you live, what things can be connected to each other?" |   |
| _S_1 : "The bicycle can be connected with red, the motorcycle can be connected with black, and the car can be connected with white" |   |
| _T_ : "Why did you connect in that way?" |   |
| _S_1 : "Because I have a red bicycle and a black motorbike, while my close neighbor has a white car" |   |
The dialogue showed us how teachers help students use their reasoning to relate things to others based on logical reasons. This is very good for students as a basis for understanding why things can be related to others where this concept is called a mathematical function. This is in line with the opinion of Resnick, Michaels and O’Connor [10] which stated that language is the foundation of being human and talk is the foundational act of language. Without talk, minds can neither grow nor become disciplined. Without disciplined talk, scientific, mathematical, and humanistic knowledge remains static and unused.

It is very important for the teacher to always check what was considered to be understood by students. Therefore, it was necessary to implement the third component in the ELPSA framework, which is Pictorial. Pictorial is a component related to mathematical representations. According to Goldin and Shteingold [11], mathematical representations can be classified within two systems, namely internal and external. Internal representations are commonly classified as pictures “in the mind’s eye”, while external representations are forms such as graphical representation (e.g., graphs and maps), schematic representations (e.g., networks) and mathematical symbolic systems (e.g., algebraic notation or number lines).

Through dialogues which have been done by teacher and his/her students, will enable the students to have a picture in their minds about a mapping. At this stage the teacher should not too much satisfied with the results. The teacher should ensure that what is in the student's mind is the same as the teacher's understanding of the mathematical function. To ensure this, the teacher asks students to draw an arrow diagram that showed the mapping. Figure 8 showed an arrow diagram made by one of the students.

![Figure 8. Arrow diagram-1.](image)

The fourth component of the ELPSA framework is Symbolic. In this case students were asked to state in the form of sets of the two groups of things that were connected. Figure 9 showed mathematical notation of function from non-empty set A to B.

$$A = \{bicycle, motorbike, car\}$$

$$B = \{red, blue, white, black\}$$

$$f: A \rightarrow B$$

**Figure 9. Mathematical notation of function.**
The teacher asks students to define functions according to what they have understood. Some students stated that "function is relationship between members of set A to members of set B". Other students state that "function is mapping that connects each member of set A to members of set B". Based on the students' answers it appeared that there were some students who defined a function inappropriately. The response were given by student then made the teacher asked students to associate from member B set to member A. Figure 10 showed an arrow diagram made by one of the students.

![Figure 10. Arrow diagram-2](image)

The teacher asks students to define functions according to what they have understood. Some students stated that "function is relationship between members of set A to members of set B". Other students state that "function is mapping that connects each member of set A to members of set B". Based on the students' answers it appeared that there were some students who defined a function inappropriately. The response were given by student then made the teacher asked students to associate from member B set to member A. Figure 10 showed an arrow diagram made by one of the students.

Table 9 showed the dialogue between teachers and students in the process of correcting students' understanding of functions.

| Table 9. Dialogue between teacher and students |
|-----------------------------------------------|
| $T$ : "What do you think about the arrow diagram (picture 10)?" |
| $S$ : "The arrow diagram (figure 8) is different to the arrow diagram (figure 10)". |
| $T$ : "Can you explain the difference?" |
| $S$ : "In the arrow diagram (figure 8) each set A is mapped to set B, while in the arrow diagram (figure 10) there is member A that is not mapped to B" |
| $T$ : "Can it be said as a function (picture 10)?" |
| $S$ : "..." (no answer) |
| $T$ : "Try to remember again about the relation. Maybe this can help you" |
| $S$ : "Relationships are rules that connect each member of set A to set B. The relation does not require a condition that the map of A must be unique in B" |
| $T$ : "So what can you explain now about functions?" |
| $S$ : "A function has a condition that all members of set A are mapped exactly one to member set B" |
| $T$ : "Good Job. Now you have learned about function" |

The dialogue in Table 9 showed us that teachers also provide scaffolding to students when they did not have good understanding. The dialog in table 8 were showed us that teachers also provided scaffolding to students when they did not have good understanding. Scaffolding provided by the teacher directed students to be able to make connections between the relationships students have learned in the past with the functions that students learn at this time. The main thing of goal of the Symbolic component is that students were able to represent mathematical concepts in the form of symbols. So the teacher gave some mathematical cases which should be solved by students. The example of one math problems was shown in Figure 11.
Function were given in the form ordered pairs set as below.

\[ \{(0.3), (1.4), (2.5), (3.6), (4.7), (5.8)\} \]

The value of \( f(x) \) was obtained from the value of \( x \) plus 3, so the function formula could be written as follows:

\[ f(x) = x + 3 \]

**Figure 11.** Example of one of the math problem

This activity is in accordance to Lowrie and Patahuddin [6] opinion which stated that the symbolic component involves the student’s capacity to represent, construct, and manipulate analytical information in a symbolic manner. The symbols included definitions, algebraic expressions, formulas, and other representation that use symbolic nation.

The last component in ELPSA framework is Application. The main activity in this component was the students were able to apply the concept of function to solve problems in everyday life. In this component students really learned the real mathematics. Students were struggling with all their abilities to solve problems. That problem may have never been met by students, so they should be able to make connection, use their reasoning, and do math correctly to get a solution. Students should be able to truly understand the context well. This could be an obstacle for students who never knew the context at all. In this case the teacher should enrich students with variety of mathematical problems therefore their intuition will become stronger in recognizing problems, determining strategies, and interpreting the results into solutions.

4. **Conclusion**

Based on the results of statistical tests and observations of students' performance during the mathematics learning process, then it could be concluded this research was successful. Thus it could be determined there was significant effect of the ELPSA framework on students' ability to solve function problems and this ability was built gradually through components E, L, P, S, and A. The results of this study can be used as a reference for mathematics teachers to use ELPSA framework as an innovative strategy of teaching mathematics in improving students' problem solving abilities. In addition, teachers who develop lesson plans with the ELPSA framework can increase their pedagogical content knowledge, because teachers must be able to organize between mathematical content and their expertise in pedagogics to create pedagogical situations that are meaningful to students.

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