Study Note

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The Feasibility Study of Teaching Methods and Materials to Introduce Better Basic Algebra in the First Year of Colleges in Samoa

– Applying Hands-on-Equation Teaching Material to Teach Basic Algebraic Calculations –

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Abstract：The focus of the research is to find better methods or techniques to teach basic algebraic calculations and also for the students to better learn and understand it in schools in Samoa. The participants in this study were grade 7 students in high school; N=68. This grade 7 level is divided into three classes. All classes contain the same activities and exercises. The mediocre class and slow learner class were selected as experimental groups who received teaching using the hands-on-equation teaching material (HOE). Preliminary to the three intervention lessons, a pretest was conducted to detect any misconception students acquired at present through customary teachings. Subsequently, a posttest was given to analyze how efficient the new teaching material in improving the students' algebraic thinking and knowledge. The analysis for the pretest results showed major misconceptions regarding the value of variable x with the coefficient of 1, calculation involving negative numbers and adding and subtracting of unlike terms. The intervention using the HOE teaching material showed improvement of the students' knowledge, for instance, students can identify that x without a coefficient is same as 1x and students can differentiate like terms and unlike terms before calculation. The HOE teaching material proved to have improved the students' interpretation of the variables and segregation of the variables from constants. For the slow learner class the mean increased from 0.13 to 0.28 ($p = 0.00$) likewise the mean for the mediocre class increased from 0.14 to 0.37 ($p = 0.00$). Despite some misconceptions with the calculation involving negative numbers which still exist after the intervention, the results proved that the HOE teaching material shows promising results and a way to improve the mathematics competency in Samoa.

Keywords: Samoa, hands-on-equation, algebra

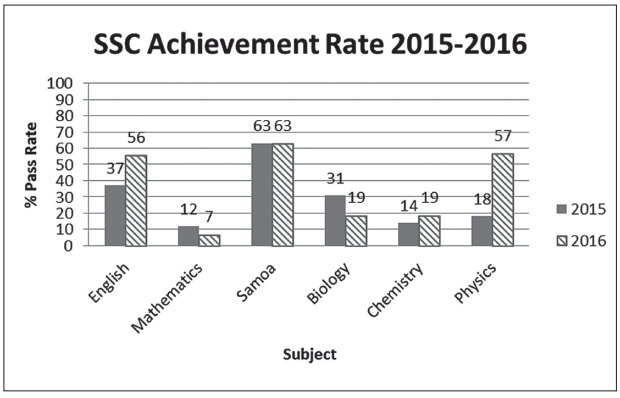
1. Introduction & Background

Mathematics is the key to the modern world, and yet the mathematics competency in Samoa is continuously below average for the past 20 years. Algebra has introduced in grade 7 and the transition from arithmetic skills learned in grade 6 into learning unknown values represented by letters is sudden and not smooth for a 12 and 13-year-old hence creates a deficient or a gap in learning algebra. With algebra as the mother of mathematics, plays an important role for the mathematics proficiency (Skakoor, 2011), it is obvious that in order to improve the mathematics competency[1] in schools in Samoa, there needs to be improvement in strengthening the students' algebraic skills from its early stages of learning algebra. The

[1] Competency is the ability to do something successfully or efficiently. (Competency, 2018)

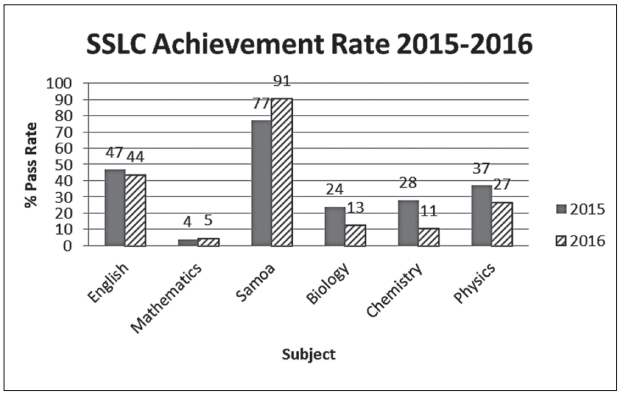
status of mathematics education in schools in Samoa is a major concern for the Ministry of Education as well as the Government of Samoa. Samoa has two level of compulsory education which are Primary (8 years) and College (5 years). There are three (3) National Assessments, which are conducted at the Primary level which is diagnostic and competency-based test in learning areas of Samoan Literacy, English Literacy and Numeracy (mathematics) for Year 4 (8 years old) and Year 6 (10 years old). On the final year of Primary education, an assessment called SPECA (Samoa Primary Education Certificate Assessment); this assessment is an aptitude test to find out about the natural strengths of the students.

For the Secondary Education, Samoan School Certificate (SSC) and Samoan School Leaving Certificate (SSLC) examinations are conducted at the end of the school year in a number of subjects, including Gagana Samoa, English, and Mathematics for Year 12 (Grade 11) and Year 13 (Grade 12) students. It is until these examinations that the issue of mathematics education is conspicuously revealed. (Educational Statistical Digest, 2017).



Graph1: SSC Achievement Rate
Source: MESC (2017)

Graph 1 shows the national examination results for SSC students and it clearly indicates only 12% of students managed to pass in 2015 and only 7% in 2016. To proceed to the next year of education (Year 13) depends on the SSC examination, and the dropouts from Year 12 to Year 13 are considerably high (28.6% in 2016) (MESC, 2017). The SSLC examination results are shown in the following graph which shows the similar trend of mathematics results. The number of students who passed the mathematics examination drops in SSCL examination with only 4% passed in 2015 and 5% passed in 2016.



Graph 2: SSLC Achievement Rate
Source: MESC (2017)

These results illustrated that mathematics dramatically contributes to the learning of science subjects, as the science examination results also show low achievements.

From this perspective, the introduction of algebra to the first year of Junior High School was chosen to be the research area. As stated by numerous researches, algebra is the foundation of mathematics, and it is where nurturing and developing is needed the most. In 2011, Skakoor stated that "Algebra can never be considered as a branch of mathematics; it plays an important role in mathematics proficiency" (p. 155). For development to stay firm and concrete, the foundation has to be strengthened and well nurtured. Darling (2010) mentioned that "**Algebra,** a mathematical system referred to as the language of the information age, is considered a gateway course that if completed early positions students on a path of accelerated mathematical learning at the secondary level. (p. 8). In addition, the transitioning from arithmetic learning in Primary education into algebraic learning in Junior High School creates a gap for students' cognitive development. A rapid change from strictly learning numbers and shapes to incorporating letters in learning of mathematics also contributes to the flaw. This research selected algebra as a component that requires strengthening in order to improve the overall competency of mathematics education in Samoa. Therefore, incorporating HOE into algebraic lessons help alleviate the transition by allowing the students to easily understand the meaning of algebraic terms such as variables, constants to name a few by actually touching and feeling each term. Also students can directly interact concretely with how the

process of simplification of algebraic equations and solving for the value of unknown number is done through the use of HOE.

2. Purpose

The sole purpose of this research is to find teaching methods and teaching materials to better teach and learn algebra in schools in Samoa. Aiding the purpose a field research was conducted to assess the relevancy of Hands on Equation teaching material. As mentioned by the inventor of this teaching method, (Dr Borenson, 2003) this teaching material has the potential to make students fully differentiate variables from constants and coefficient; furthermore, apprehend the meaning of a variable. To sum it up, this teaching material will demystify the learning of algebra. Some concerns stated that student's cannot fully conceptualize the involvement of negative numbers in algebra language (Gallardo, 2002), therefore the research purpose now includes "Identifying the gaps in learning of algebra particular in the transitioning from arithmetic learning to algebraic learning". Follow-Up research is due to be conducted to address this new issue.

3. Methodology

A total of 68 students participated in this study, divided among three classes; Advanced class 32, Mediocre class 20 and slow learner class 16 from one school in Samoa. Three lessons were developed and taught using the new teaching material called "Hands on Equation" in the mediocre class and the slow bloomer class. The lesson content and sequence were extracted from the mathematics textbook used in grade 7. To assess the effectiveness of introducing new teaching materials in learning mathematics, HOE was used for the treatment in contrast with the traditional rote learning being used as a traditional way of teaching in Samoa. The advanced class, having bright students, the usage of Hands on Equation could be considered boring. Therefore, they were given worksheets and drill activities. The methods for collecting data are pretest and posttest for all the classes and interviews with students.

3.1 Lesson content

The flow of the three lessons was directly from the grade 7 textbook used by teachers in Samoa schools. Lesson 1 was focused on simplifying simple algebraic expressions. This is the first time letters are being expressed together with numbers as an expression, and the students simplify these expressions by identifying and grouping like terms. Lesson 2 was based on reading the English statement, and from that English statement, the student has to write its mathematical statement. For example English statement "An unknown number is added to 4"; the students read the statement and write down the answer in mathematics sentence which should be "4 + x". At this stage, the student is replacing an unknown number with the letter x. Letter x is exclusively used as the unknown number for this research. Lesson 3 focuses on the purpose of learning algebra which is, to find the value of the unknown number x by simplifying the whole equation using their prerequisite knowledge learned from lesson 1. To find the value of unknown number x, the equation must be a balance which implies whatever operation you do on one side; you must apply the same on the other side taken that this operation is applied on like terms only. Using the concept of a balance scale is a good tool to convey the meaning of an equation clearly.

3.2 Hands-on Equation

The hand on equation teaching material was invented by Dr Henry Borenson of New York with the sole purpose of demystifying the learning of algebra to young students. During an interview by the Agency for Instructional Technology with Borenson (2003) mentioned that the teaching of algebra has been abstract and it is difficult for the student to learn its concept. However, with the use of the HOE, the students have the chance to submerge into learning algebra fully and can obtain algebraic concepts such as addition property of equality, the additive identity element, and other key algebraic properties. The idea of the students actually touching and feeling the variable and constants builds a friendly and natural algebraic environment for learning. This teaching tool contains counterparts that student can actually touch and manipulate physically which represents the equation written on the blackboard. These counterparts are shown in figure 1; pawns are used to represent positive variable(blue) and negative variable (white) and cubes which represents negative constant(green) and positive constant (red).

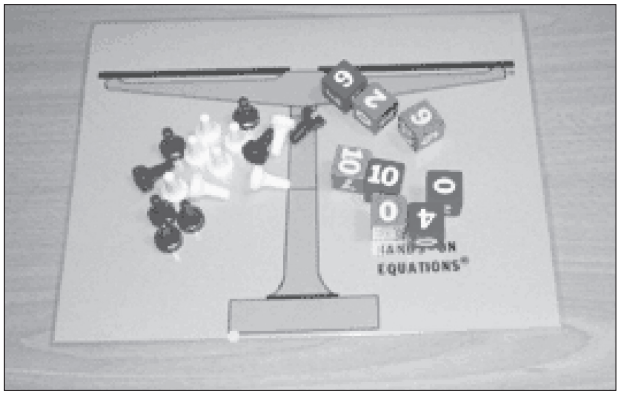


Figure 1: Hands on Equation model
Source: http://www.borenson.com

It also includes a paper with the drawing of a balance scale which is a representative of an equation. As the process to balance the equation is being solved, the student can move the pieces and solve and can see what process is being applied. Figure 2 shows the model of the HOE that was used in this research; Round caps were used as a variable with x written on it, and paper cubes used to represent constants (red for negative and blue for positive). The water bottle and ruler were used as a balance scale to describe the equation concept.

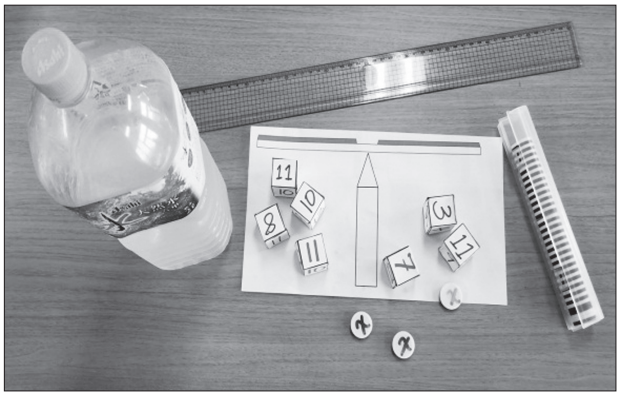


Figure 2: HOE - author's version
Source: Author made this model

3.3 Pre-test & Post-test

Preliminary to the three intervention lessons, a pretest was conducted to detect any misconception students acquired at present through customary teachings. Subsequently, a posttest was given to analyze how efficient the new teaching material in improving the students algebraic thinking and knowledge. A total of 83 students take the pretest however only 68 were considered valid. Students who missed one or more of the three lessons their pretest and posttest were not counted in the result to ensure the validity of the research. Pretest consists of 3 questions; Question 1 has ten sub-questions which focused on simplifying of algebraic expressions such as $2x + 4x + 5 =$. This question targets the students' ability to identify the like terms of the expression, group the like terms together and simplifies the expression to its simplest form; Question 2 was about writing expressions from reading English sentences.

3.4 Interview

After administrating the posttest, a semi-structured interview was administered with 18 students randomly selected from the three classes. The interview was more focused on the students' perception of mathematics; their understanding of how important to learn mathematics for their future. The interview did not address the students' insight into the three intervention lessons.

4. Participants

The first year students of college (Year 9) were chosen specifically for this study from an average college in Samoa. This school particularly, before entering Year 9 level, the students have to sit a streaming test. The test assesses the student's prerequisite knowledge on 3 subjects, English, Mathematics and Samoan language. The result of this test is used to stream the students into three classes according to the criteria shown below:

Table 1: Criteria to stream the three classes

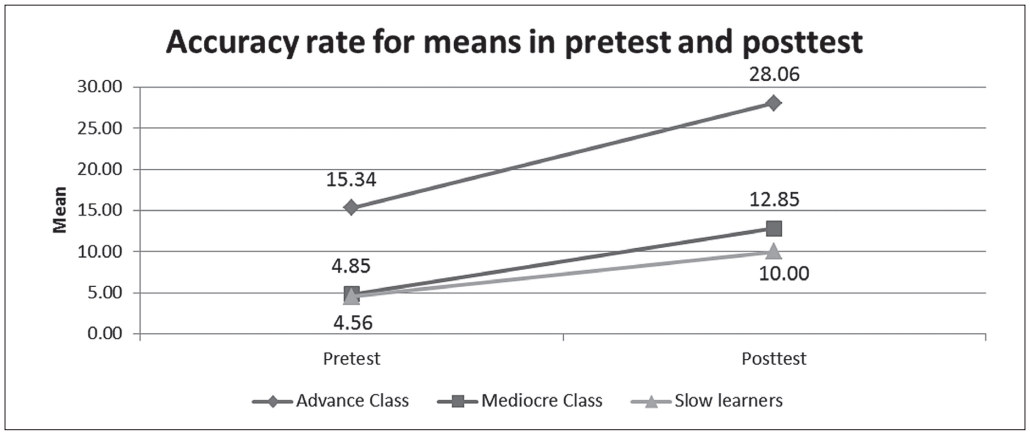
Year 9 Class 1	Year 9 Class 2	Year 9 Class 3
Advanced Class	*Mediocre Class*	*Slow-bloomers Class*
For students who achieved an overall mark of 70% and upwards.	For students who achieved overall mark from 35% - 69%.	For students who achieved an overall mark of 34% or lower.
N = 32	N = 20	N = 16

Source: Author made this table

5. Results & Analysis

5.1 Quantitative result

The graph shows the mean shift from pretest to posttest for each of the three classes.



Graph 3: Pretest & Posttest mean shift
Source: Author made this graph

Since the research was done on a school which stream their classes according to the student's test results, the result shown in graph 3 was highly expected. A significant improvement is conspicuously spotted in the advanced class with an increase of more than 40%. The mediocre class and the slow learner class show some improvement in the posttest after the intervention lessons but not as substantial as the improvement rate made by the advanced class. The difference between the pretest and posttest for the three classes' was analyzed using ANOVA tool yields a p-value of 0.0044 proving there exists a significant difference among the data. The research was conducted on the month of September, and at that stage, students have already been taught algebra through using the textbook and typical rote learning and following instructions. These teaching methodologies are standard through all the subjects, and the students are accustomed to it. Introducing the new teaching material to teach a topic the students already learned causes conflict among the students learning sequence.

5.2 Qualitative result

Each students pretest was analyzed and thoroughly checked for any misconceptions and errors made. It is important to find where the teaching lacked and how it was filled and corrected. The students were also encouraged to show their workings throughout the test papers. This way it is easier to spot what is the root error, or the root of the misconception demonstrated in the test. From this analysis, three common mistakes frequently appeared in student's test paper.

5.2.1 Misconception 1

The students lack the ability to identify like terms and unlike terms. As shown in figure 3 students engage in adding variables together with constants to get the answer. It shows the students' knowledge of variables or unknown values is not well nurtured. Hence, it

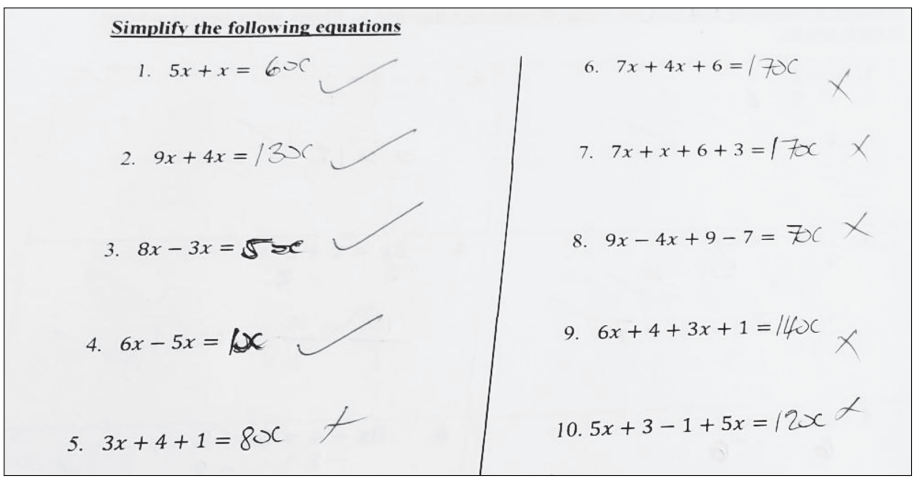


Figure 3: Evidence for misconception 1

results in many students failed to get the correct answer for question items N4 to N10 as these questions contain a mixture of variables and constants. A possible reason for this misconception is students have not yet fully transitioned from their arithmetic learning into algebraic learning. Students adding all the numbers and ignoring letters (variables) reflects they are still dwelling in their arithmetic learning process. The concept of like terms and unlike terms has not yet been nurtured well into the student's algebra's cognitive development.

5.2.2 Misconception 2

Often students confused how the law of addition and multiplication works in algebra. The problem is most likely rooted from the textbook requiring the students to memorize the rules instead of understanding it. This misconception shows students adding the variables and giving their answer with the power/exponent of 2. It illustrates student instead of adding the variables, he/she multiplies the variables getting the answers shown in figure 4.

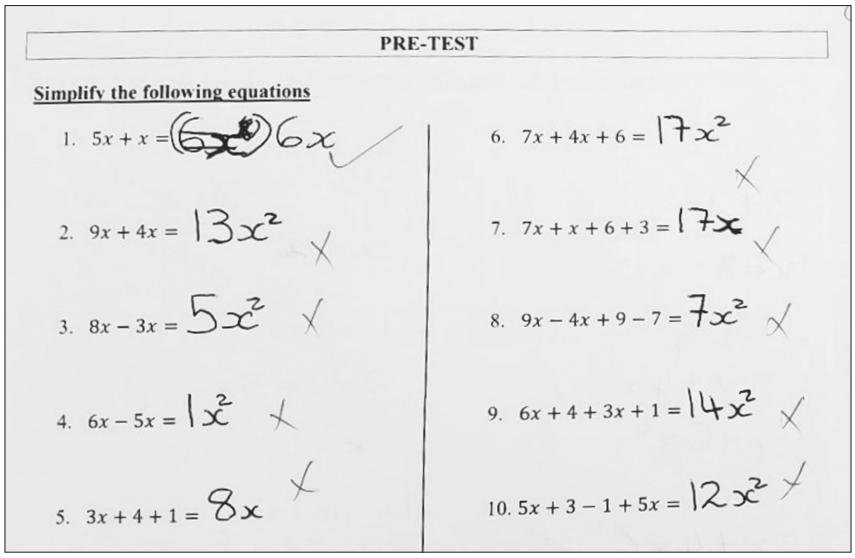


Figure 4: Evidence for misconception 2

5.2.3 Misconception 3

In algebra, a variable without a coefficient is by default having 1 as its coefficient, and it is usually not written for example; x, y, z, these are variables with a coefficient of 1. This misconception deals with students lacking the knowledge to understand that the variable x has a coefficient of 1. Inside the textbook, it is not mentioned about this hidden coefficient and the student has to find out through doing exercises about this variable with coefficient of 1 or lucky enough the teacher explains about it. The evidence shown below represents the common answers written by students. The students treating x as 0 is shown in A1 as for A2 the students treat x and 2x as an unlike term, therefore, yielding the answer as it is. The item A3 shows the lack of students' knowledge in the algebraic world.

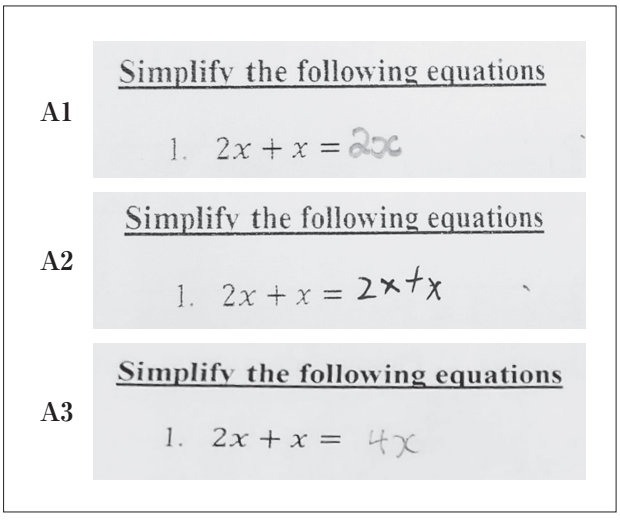
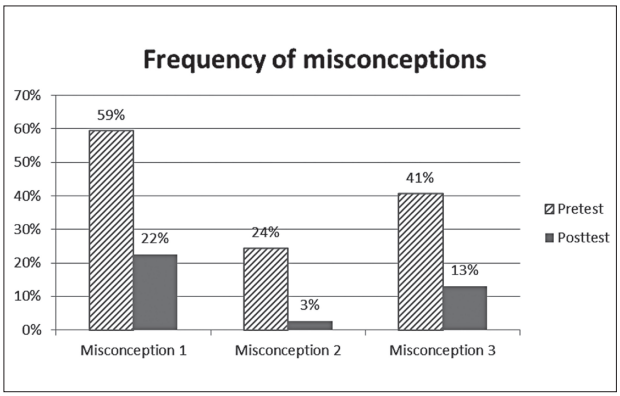


Figure 5: Evidence for misconception

5.2.4 Frequency of misconception

The graph as follows shows the above-mentioned misconceptions made in pretest and posttest.

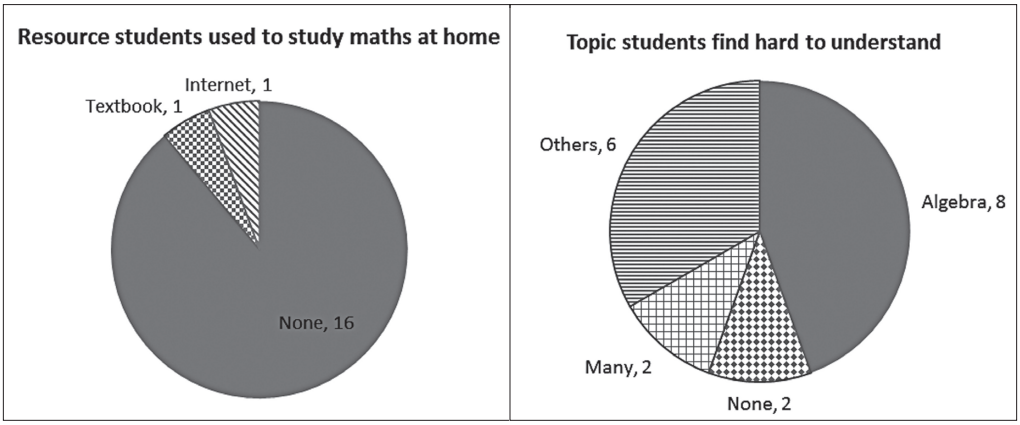


Graph 4 - Source: Author made this graph

A significant decrease in the mistakes made shows how the three intervention lessons rectified the student's misconceptions.

5.1.5 Interview

Interviews were recorded, transcribed and coded before further analysis. Majority of the students understood the importance of mathematics in their future and for finding jobs. From the interview questions, two questions stood out as shown in the pie graph as follows; Question 5 asked "Which is the most difficult topic in mathematics they find hard to understand?" and the majority of the students answered "Algebra" and the reason is, suddenly letters appeared in mathematics. Students learned only numbers in mathematics, and when alphabets started to be introduced, they had difficulties interpreting it. Question 6 focused on the resources student use when studying mathematics at home. As shown in the graph almost all the students answered none, while only 1 student stated to have access to the internet, and also only one student owned a textbook. The lack of resources used by these students may possibly contribute in the learning of algebra as the students do not have a mean for checking the answers.



Graph 5: Interview response
Source: Author made this graph

6. Discussion & Conclusion

Mathematics Education in Samoa requires a severe change in order for this subject to survive. Through the findings, it revealed that misconceptions made by the students in the introduction of algebra are due to the students lacking basic algebra concepts. Additionally in the transition from arithmetic learning to algebraic learning; there exists a gap that requires attention. Students are not developing their algebraic skills causes simple misconception at this juncture can ripple across the student's school life, and it is accumulated when reached the final grade of high school. The earlier the students understand these concepts, the easier it is for the student to avoid fabricating misconceptions. Using the HOE supports the purpose of this study since teaching tools can emulsify the learning of algebra, and in addition, the students can easily identify and differentiate a variable from a constant. This way the students developed an understanding behind a variable and a constant. Through using this new teaching material, the students showed positive results yielding a p-value of 0.000 which is less than the significant value of 0.05 for all

three classes. This research shows the possibility of HOE in reducing the misconceptions made by the students in learning algebra.

A long-term research is needed to assess the actual ability of the HOE for the students' learning development. Students taught using HOE will most likely have a sustainable algebraic knowledge compared with students' learning using memorization of rules and steps. Since only two weeks were given to conduct the research, there was no time to have another test to ensure the usefulness of the HOE.

The lesson sequence also requires improvement since the three lesson sequence was extracted from the textbook used in junior high school shows less correlation among each other. The flow of the lessons also has contribution to the students learning. Lesson 2 did not really capture the exact algebraic contents that needed to be developed at the juncture as it deals with different part of learning. In addition, introducing a new teaching method to teach a topic that the students already learned had some effects in the algebraic results. From this research, HOE is better used for introducing algebra but not strengthening the learning of algebra.

Overall the results showed that HOE has the potential to develop and cultivate students' algebraic learning.

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