Level of achievement in algebra of grade seven learners

Leian U. Compayan[i]
Leyte National High School, Tacloban City Division,
Department of Education, Tacloban City, Leyte, Philippines

Maria Lina A. Dollete
College of Arts and Sciences, Eastern Visayas State University,
Tacloban City, Leyte, Philippines

Abstract

Utilizing a descriptive research design, this study determined the level of achievement and the common errors in algebra of grade 7 leaners. The respondents consisted of 109 grade 7 Science, Technology and Engineering learners of Leyte National High School in Tacloban City Division in the school year 2018-2019. The findings of this study revealed that the level of achievement of the respondents in the concept of algebraic expressions, specifically under basic knowledge and simplification, did not meet the expectation. In the concept of equations, their achievement level under basic knowledge and manipulation also did not meet the expectation. As to the concept of inequalities, the respondents have a fairly satisfactory achievement level under basic, but their achievement level under manipulation did not meet the expectation. In problem solving, the respondents have a satisfactory achievement level under basic knowledge, but their achievement level under interpretation did not meet the expectation. Errors in basic knowledge are very high under algebraic expressions and equations, high under inequalities, and average under problem solving. Errors in simplification are very high under algebraic expressions. Errors in manipulation are also very high under equations and inequalities. Errors in interpretation are likewise very high in problem solving. It is concluded that the respondents lack mastery of fundamental concepts of algebra in algebraic expressions, inequalities, equations, and problem solving. Conclusively, they have insufficient knowledge and understanding along these concepts. Two or more error types may be observed under any of the abovementioned algebraic concepts. As much as possible, the leaners should be provided with regular feedback on how they perform in algebra because if ignored and left not corrected, there is high tendency for leaners to have difficulty developing conceptual understanding of algebra as well as difficulty learning higher mathematics subjects, particularly when they move up to university level.

Keywords: algebraic expression, inequalities, equation, problem solving, error interpretation, simplification, achievement level

1.0 Introduction

Education systems of countries around the globe place great importance on mathematics education. Many aspects of human life largely depend on effective application of mathematical knowledge. Mathematics is fundamental in furthering human learning to greater heights. It is an instrument for the development of individuals to become rational and critical thinkers (Adu, Assuah and Asiedu-Addo, 2015).

[i]Corresponding author: Leian U. Compayani leiancompayan@ymail.com

Despite the importance of mathematics, leaners in many countries struggle in learning it, especially algebra. Algebra is one of the major branches of mathematics studied in school in order to promote and develop mathematical knowledge. This is one mathematics subject that provides the transition from arithmetic to higher mathematics learning, that is, from the elementary up to the college level and beyond (Adu, Assuah, and Asiedu, 2015). Hence, when students struggle in learning algebra in the secondary level, higher mathematics learning in the future is compromised. The Philippine education system likewise recognizes mathematics as a field of learning that touches any aspect of men's daily living at any point in time (Abocejo and Padua, 2010) and in whatever context there may be. Its importance permeates other areas of learning and many segments of the society. It is, then, imperative that leaners acquire mathematical knowledge and understanding extensively and thoroughly (Department of Education [DepEd], 2016).

However, Filipino learners, like any other learners in other countries, also experience difficulty learning mathematics (Jolejole-Caube, Dumlao and Abocejo, 2019). This is evident in the National Achievement Test (NAT) results; the NAT is regularly administered by the DepEd to gauge Filipino learners' level of knowledge and understanding of topics in the subject areas of mathematics, Science, and English as well as Filipino and "*Araling Panlipunan*" in grades 3, 6 and 10, in which the mean percentage score (MPS) to be attained, as set by DepEd, is at least seventy-five (75). The NAT MPS for the mathematics subject showed a declining trend from 2007 to 2012, where the highest within this period for both elementary and high school was only 68.41, approximately 7 percentage points below the standard passing percentage (The National Achievement Test in the Philippines, 2013).

Moreover, in 2003, the mathematics assessments report of the trends in international mathematics and science study (TIMSS) revealed that the Philippines placed 23rd among twenty-five participating countries in mathematics for fourth grade learners and 34th in eighth grade mathematics among 38 countries that participated. The result of the 2008 TIMSS advanced mathematics test, which involved only science high schools, showed that the Philippines ranked last among ten participating countries (DepEd, 2010).

The low mathematics achievement of Filipino learners in the NAT and in the TIMSS mathematics examination is a strong indicator of the low quality of mathematics education in the Philippines (DepEd, 2010). This issue, however, is only one of the many issues that the Philippine education and its system has been facing (Fernandez and Abocejo, 2014), as Filipino learners also demonstrate low achievement in other school subjects as shown by the NAT (The National Achievement Test in the Philippines, 2013) and the TIMSS Science examination results (DepEd, 2010), which shows to a certain extent that the quality of Philippine education, in its entirety, is relatively poor.

The standard of education offered impacts how well future graduates will function as part of the workforce and how much they will contribute to the country's economic progress (Abocejo, 2017). In fact, the Philippine skills report by the World Bank (2010) indicated that quality of education and training is one of the determinants of the success or failure of leaners in acquiring both the technical and non-technical skills needed in order to be relevant in the world of work. The report further revealed that, among others, the labor force lack skills in problem solving, leadership, communication, creativity, language, and mathematics.

To address the aforementioned educational issue, the Philippine Government and the DepEd implemented the "Enhanced K to 12 Basic Education Program." Under this program, the mathematics curriculum covers five content areas, namely, "Numbers and Number Sense, Measurement, Geometry, Patterns and algebra, and Probability and Statistics," that leaners need to learn. In addition, leaners are expected to be proficient in comprehension (Yayen, 2018), estimation, computation, and problem-solving skills. They are expected to create models and representations, conjectures, and proofs. They are expected to develop values and attitudes such as being accurate, creative, objective, and productive (K to 12 Mathematics Curriculum Guide, 2013).

This study addressed the need to ascertain the extent of success of the mathematics education under the Enhanced K to 12 Education Program by assessing the level of achievement of leaners in algebra. It is necessary to assess leaners' level of achievement in algebra, because acquisition of knowledge and understanding of the subject is crucial to learning higher mathematics beyond the high school level. Having weak knowledge and understanding of algebraic concepts leads to committing errors in algebraic processes and achieving unsatisfactorily in mathematics.

1.1 Study objectives

The study determined the level of achievement and errors in algebra of grade 7 science, technology and engineering leaners during the school year 2018-2019. Specifically, the study endeavored to (1) determine the level of achievement of the leaners in algebraic expressions, equations, inequalities, and problem solving; (2) assess the common errors of the leaners in the indicated algebraic concepts in terms of basic knowledge and skills in simplification, manipulation, and interpretation.

2.0 Literature Review

Algebra is viewed as a generation of arithmetic, a tool to solve problems, and for representing and modelling. Under these views, the concepts of "variables, powers involving variables, generalization of patterns, and forming and solving equations" are considered as basic components of algebra content (Usiskin, as cited in Nataraj and Thomas, 2016). In learning algebra, students in the middle and secondary schools are expected to the acquire basic skills in generating rules which describe patterns, applying and formulating algebraic expressions and equations, and finding solutions to equations, among others (Nataraj and Thomas, 2016).

Eddy et al. (2015) identified six key ideas of algebra, which are concepts fundamental to learning the subject. The six key ideas of algebra include variables, functions, patterns, modelling, technology, and multiple representations. These ideas are considered essential elements of algebra as they establish the backbone of the subject's content, and hence must be deeply understood as to meaning and uses.

Under the "Enhanced K to 12 Basic Education Program" of the Philippines, the mathematics curriculum is divided into five content areas such as, "Numbers and Number Sense, Measurement, Geometry, Patterns and Algebra, and Probability and Statistics," in which learners from grade 1 up to grade 10 need to display knowledge and skills in fundamental concepts. In the content area of "Patterns and Algebra", in particular, leaners in grade 7 are taught with the fundamentals of algebra such as expressions, real numbers and their properties, and mathematical statements such as equations and inequalities containing one variable (DepEd, 2016).

The gained knowledge and understanding of the subject profoundly influence many aspects of leaners' life and future career (Rodriguez and Abocejo, 2018). Specifically, the RAND mathematics study panel (as cited in Eddy et al., 2015) identified four main reasons why leaners should study algebra. First, studying algebra enables leaners to "solve problems by modelling, evaluate quantitative relationships, and express and justify generalizations." Such skills are now needed in the world of work and to be at par with other professionals in the global arena. Second, mastery of algebra as a subject prepares leaners for the study of college mathematics. It determines success or failure in higher mathematics courses, which in turn influence one's career choices. Third, it introduces and develops among leaners the skills in algebraic thinking which prepares them for a comprehensive and in-depth study of the subject in higher mathematics courses. Fourth, leaners need to demonstrate mastery of algebraic skills for "high-stakes assessments."

Research evidence shows that many leaners are struggling to develop conceptual understanding of algebra (Nataraj and Thomas, 2016; Jolejole-Caube, Dumlao and Abocejo, 2019). Leaners have low algebraic thinking ability under the following aspects: algebra as a generalization for arithmetic, algebra as a tool to communicate mathematics, and algebra as a tool for representation and modelling. More specifically, they have low algebraic thinking ability across indicators of these aspects, namely: strategies in computing and estimating; comprehending variables, expressions and solutions; and formulating equations and other mathematical statements to describe mathematical ideas; and discovering patterns and corresponding rules (Nurhayati, Herman, and Suhendra, 2017). Over the years, many leaners have acquired misconceptions on many topics in algebra such as negative sign, variables, exponents, algebraic operations and operation order, fractional or rational expressions, equations, inequalities, and functions (Booth, McGinn, Barbieri, and Young, 2016; Nataraj and Thomas, 2016).

Concerning leaners' conceptual understanding of equality, leaners frequently demonstrate operational rather than relational understanding of the equality symbol, that is, they see the equal sign as a signal that an answer to a mathematical problem needs to be provided. Similarly, leaners deal with inequalities the same way they deal with equalities. They have a limited understanding of words related to inequalities such as "*more*" and *"less*" and are unable to understand inequality solutions (Booth, McGinn, Barbieri, and Young, 2016).

The concept of variable is challenging for many leaners, because the concept may mean any of the following: specific unknown, generalized number, variable, parameter, and constant, depending on the conditions present or the context in which it is used. Likewise, it adds to the difficulty that leaners experience when combinations of two or more variables are presented (Nataraj and Thomas, 2016). Leaners misconceive that a variable, say, an equation represents an object or is a label (Booth, McGinn, Barbieri, and Young, 2016).

The misconceptions of leaners about exponents are evident when they are given tasks that involve performing operations on quantities containing positive integer exponents such as multiplication, division, and subtractions (Nataraj and Thomas, 2016). Leaners' errors in these tasks only show that they have faulty understanding of the definition of exponent and the laws governing the simplification of operations involving numbers with exponents.

Leaners' misconceptions of fractions prior to learning algebra affect their conceptual understanding of fractional algebraic expressions. Adding, subtracting, multiplying, dividing, and simplifying fractional algebraic expressions are found to be problematic for many leaners. They fail to correctly apply processes such as cross multiplication and inverse operations to name a few (Booth, McGinn, Barbieri, and Young, 2016).

Another misconception of leaners pertains to order of operations. When given with expressions containing more than two operations, many leaners tend to perform the operations from left to right without regard to grouping symbols present such as a pair of brackets, braces, or parentheses, resulting in many cases to incorrect answers. This signifies that they have poor knowledge and understanding of the conventions on order of operations (Booth, McGinn, Barbieri, and Young, 2016).

Many leaners have also developed misconceptions about functions. For instance, they see a graphical representation of a function as a picture of a particular situation (Booth, McGinn, Barbieri, and Young, 2016), implying that they do not have the understanding that the graphical representation is one that illustrates the relationship between the x and y variables given by the function.

The study of Makonye and Khanyile (2015) determined the extent to which probing leaners' mistakes in simplifying rational algebraic expressions would reduce these errors. A group of 15 grade 10 female leaners participated in both pre-test and post-test on simplifying algebraic fractions. Leaners' errors in the pre-test were probed before they took the post-test. Analysis of the pre-test results led to the identification of several categories of errors, namely, cancellation error, errors due to confusing the factors, error due to inability to recognize a common factor, errors in factoring a trinomial, errors in finding lowest common denominator, errors due to carelessness, errors due to application of an incorrect mathematical rule but somehow arrived at a correct answer, and errors due to dropping of the denominator.

Makonye and Khanyile (2015) found a total of 72 errors having an almost equal distribution across all error categories they have identified. The probing of errors committed by the leaners during the pre-test showed a promising result as the number of errors were reduced to a great extent after taking the post-test. Post-test result revealed only 2 errors which were only due to carelessness.

Pournara et al. (2018) analyzed the errors of 250 leaners from grade 9 to 11 in answering basic algebra questions. Common errors found were in conjoining and premature closure, negative sign and negative numbers, subtraction and multiplication operations, indices, equations, and performing indicated operations on algebraic expressions. Guner et al. (2017) assessed the knowledge in finding zeros of quadratic equations, examined the solution approaches, and determined the errors in the solutions of 50 grade 10 leaners. Guner et al. (2017) found several categories of errors which were associated with signs, coefficients, rules, and operations, including: errors involving signs, errors in computation, errors in simplifying, missing root, errors in determining common factors, one method errors, factorization errors, rule errors, and meaningless solutions.

Erabadda, Ranathunga, and Dias (2017) analyzed the errors of 42 leaners in multi-step algebra questions that require solving fractional equations and quadratic equations. The findings revealed two types of errors in solving fractional equations: addition of numerators after finding the least common denominator and cancelling terms separated by addition and minus sign. On the other hand, three types of errors have been found in leaners' solutions to quadratic equations: incorrectly calculating perfect square, not calculating two values for the independent variable, and incorrect substitutions of values in square-roots.

Naseer (2015) analyzed leaners' errors and misconceptions in pre-university mathematics courses. He explained that errors and misconceptions of leaners in problems involving inequalities are similar to those in problems involving equations. He explained that some errors are due to lack of conceptual understanding, while others can be attributed to lack of procedural fluency. In particular, leaners commit errors when they apply algebraic rules, which they do not really understand, to solve an inequality.

In the study that involved 3,682 male leaners who were enrolled in and completed a preparatory year program in pre-Calculus in a certain university, El-khateeb (2016) analyzed leaners' errors in solving three types of inequalities namely: linear, absolute value, and fractional inequalities. Among the classifications of errors identified were conceptual errors, errors due to incorrect use and application of the rules for inequalities, errors in the algebraic operations, simplification and elimination, errors arising from confusion between the solution of the equation and inequality, and errors arising from using the basic arithmetic operations.

Elia et al. (2016) found several errors in leaners' solutions of equations and inequalities involving absolute values in the study that involved 289 grade 9 leaners. When attempting to determine roots of equations containing absolute values, the leaners made errors in finding the second solution because they thought that it is the additive inverse of the first solution. They also committed the error of removing a negative sign in the equation as well as computational error, but somehow coincidentally arrived at a correct answer

In their analysis of junior high school leaners' solutions to an inequality problem, Taqiyuddin, Sumiaty and Jupri (2017) observed such errors as incorrectly carrying out algebraic operations, giving numerical answers to questions which ask for algebraic expressions, and adding or subtracting unlike terms in an expression to arrive at a reduced one. Leaners' lack of conceptual understanding is reflected by their mechanic way of solving.

Molina, Rodriguez-Domingo, Cañadas and Castro (2016) explored and compared the errors made by two groups of secondary leaners in translating verbal statements into mathematical statements, and vice versa. The study involved 16 second year and 26 fourth year secondary education level leaners. After the translation task has been given to the two groups of respondents, the results revealed three types of errors, namely: incomplete statements, errors in arithmetic processes, and errors related to the use of symbols and notations in algebra.

Molina et al. (2016) compared the proportion of errors between the two groups of leaners and the findings showed that the second-year leaners made more mistakes than the fourth-year leaners in both symbolic to verbal and verbal to symbolic translations. In symbolic to verbal translation, the second-year leaners committed more errors than the fourth-year leaners across all 10 sub-categories of errors. In verbal to symbolic translation, the second-year leaners made mistakes in 9 out of 10 sub-categories of errors, where the exception was the sub-category division-product.

Using Newman's Error Analysis Model, Abdullah, Abidin, and Ali (2015) determined the errors of 96 form one secondary leaners in solving word problems involving fractions across word problem-solving stages: (1) reading, (2) comprehension, (3) transformation, (4) process skills, and (5) encoding. The findings revealed that leaners did not commit errors in reading, however, they made errors in other stages of problem-solving. That is, approximately 21 percent of the errors were made in comprehension stage, 24 percent in transformation stage, 27 percent in process skills, and 28 percent in encoding.

The study of Adu, Assuah, and Assiedu-Addo (2015) likewise utilized Newman's Error Analysis to determine the errors of 130 leaners in the senior high school in solving word problems involving linear equations, focusing on integer, age, and fraction problems. It was revealed that the distribution of errors across stages varies according to problem-type. For integer problems, most errors were made in transformation stage. This is followed by errors made in process skills stage, then by errors in comprehension and encoding stages. For age problems, most errors were committed in comprehension stage, and then errors in transformation stage. This is followed by errors committed in transformation and encoding stages. Similarly, for problems involving fractions, majority of the errors made were in comprehension stage. This is followed by errors made in transformation, process skills, and encoding stages.

In the study of Tong and Loc (2017) that involved 160 third grade leaners, it was found that they commit errors when solving word problems because of carelessness, incorrect computation and application of laws and properties, and inability to recognize types of problems.

In all word problems answered by the respondents, misapplication of solution rules emerged as the main reason for committing errors.

In the Philippines, several studies on algebraic word problem solving have been conducted. For instance, Trance (2013) conducted a study utilizing Newman's error analysis. He recorded a total of 132 errors in which 3.85 percent were reading-errors, 24.62 percent were comprehension-errors, 47.69 percent were transformation-errors, 18.46 percent were process-skill-errors, and 5.38 percent were encoding-errors. The errors in comprehension and transformation, combined, yield a proportion of 72.31 percent.

The study of Mangulabnan (2013), for example, revealed four types of errors. Language-based error occurs when leaners do not understand the words, phrases, or sentences in the word problem resulting in the formation of an incorrect equation, while operational-influenced error is committed when operations are used illogically and irrationally as part of the equation (Mangulabnan, 2013). Algebraic-translation error pertains to incorrect representations of the unknown quantities in the word problem, the inability to distinguish one representation from another, and the tendency not to represent other unknown quantities, whereas relational-symbol error is committed when the relational symbols such as "=", "<", and ">" are incorrectly used. Mangulabnan (2013) reported that language-based error is the most common type of error committed by the leaners.

Ricks (2013) and Dela Cruz and Lapinid (2014) observed error patterns in leaners' word problem translations, some of which share similar features with those identified by Mangulabnan (2013). Specifically, errors observed by Ricks (2013) include: using equal sign and inequality symbols in forming algebraic expressions, and interchanging the positions of minuend and subtrahend or of dividend and divisor. On the other hand, Dela Cruz and Lapinid (2014) identified the following errors: using an operation opposite or contrary to what is reflected in the problem, placing quantities within the equation in the order as they appear in the word problem, guessing the operation to be used, and incorrectly swapping the positions of the quantities within the equation.

Most of the translation errors identified by Mangulabnan (2013), Ricks (2013), and Dela Cruz and Lapinid (2014) have already been noticed by researchers in early 2000. In his review of related studies on word problem translation, Wright (2014) made mention of the classifications of translation errors put forth by Pape (2004). Pape (2014) labelled the mistake of using an operation that is contrary to what the word problem requires as reversal error. In addition, he called the mistake of leaving out a procedural step reflected in the word problem as linguistic error, and the event when the problem solver misconstrues relational statements or operational cues as mathematics error.

In their study, Capate and Lapinid (2015) assessed the mathematics performance of two hundred seventy-nine Filipino leaners in grade 8 and determined their difficulties across competencies in the K to 12 grade 8 mathematics. The study's findings indicated that leaners' achievement in the content area of patterns and algebra is only at the beginning level, while their achievement in both geometry and statistics and probability are at the developing level. It is also noted that grade 8 learners are having difficulty in the comprehension of the given assessments suggesting poor command and sufficient knowledge of the English language commensurate to their grade level (Cuñado and Abocejo, 2018; Trazo and Abocejo, 2019).

2.1 Theoretical and conceptual framework

The present study is anchored on the following theories: Information Processing Theory (Miller, as cited in Lucas and Corpuz, 2011) and Theory of Cognitive Constructivism (Piaget, as cited in

Lucas and Corpuz, 2011). Information Processing Theory (Miller, as cited in Lucas and Corpuz, 2011) describes the cognitive process through which an "*external information*" is received by an individual, stored in and retrieved from his memory. According to this theory, information-processing has three main phases, namely: encoding, storage, and retrieval.

In encoding phase, an individual receives sensory information from an external source. The information received can be placed into categories or types of knowledge, specifically, general/specific, declarative, procedural, episodic, and conditional. General knowledge is one that is applicable to various situations while specific knowledge is one applicable to only one situation. Declarative knowledge includes facts, concepts and principles. Procedural knowledge includes information on how to carry out processes or perform procedures. Episodic knowledge includes events and experiences. Conditional knowledge pertains to one's awareness when other types of knowledge are applicable (Miller, as cited in Lucas and Corpuz, 2011).

During the storage phase, the information received will go to and temporarily be stored in the sensory memory within three seconds. From the sensory memory, it will go to the short-term memory while it is being internally processed. Irrelevant information will be forgotten, while relevant information will be placed at the long term memory (Miller, as cited in Lucas and Corpuz, 2011). Finally, retrieval phase occurs when an individual is performing a task and the application of stored knowledge is needed. The needed information is "*reactivated*" and retrieved for use (Miller, as cited in Lucas and Corpuz, 2011).

Meanwhile, the Theory of Cognitive Constructivism (Piaget, as cited in Lucas and Corpuz, 2011) stresses that an individual understands new information based on his background knowledge. That is, an individual actively thinks about and interprets new information with the aid of previously learned ones. The proponents of this theory believe that leaners should be "*allowed to discover principles through their own exploration*".

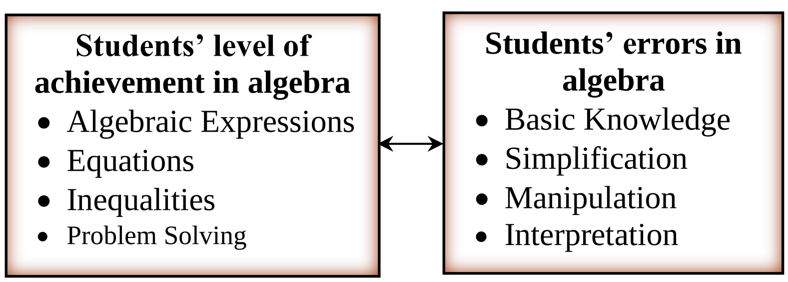

Figure 1. Conceptual Framework of the Study

The variable errors in algebra has four categories, namely, basic knowledge, simplification, manipulation, and interpretation, which are measured by determining the frequency of errors committed by the respondents under each category of errors and across the four algebraic concepts. Figure 1 also indicates that the variable level of achievement in algebra is measured in terms of scores of leaners in algebraic expressions, equations, inequalities, and problem solving.

3.0 Research Methodology

3.1 Research design

This study utilized the descriptive research design. This research design was employed because this study aimed to determine the leaners' level of achievement in algebra focusing on algebraic expressions, equations, inequalities and problem solving as well as determine their common errors in basic knowledge, simplification, manipulation, and interpretation, with the end-goal of developing an intervention scheme geared towards the improvement of the achievement level and the reduction of common errors of the leaners in algebra.

3.1 Research locale

This study was conducted at Leyte National High School (LNHS), Tacloban City, Leyte, Philippines. The LNHS is one of the biggest secondary schools in the eastern Visayas Region with more than six thousand leaners in both junior and senior high school and more than two hundred teaching and non-teaching personnel. For junior high school leaners, the school implements Special Curricular Programs including Special Program for the Arts (SPA), Special Program for the Sports (SPS), and Science, Technology and Engineering (STE) in addition to Basic Education Curriculum (BEC). For senior high school leaners, it offers a variety of academic tracks or strands, specifically, Accountancy, Business and Management (ABM), Humanities and Social Sciences (HUMSS), Technical-Vocational-Livelihood (TVL), General Academic Strand (GAS), and Science, Technology, Engineering and Mathematics (STEM).

3.3 Research respondents

The target population consisted of 109 grade 7 Science, Technology, and Engineering leaners of Leyte National High School during the school year 2018-2019. This study employed complete enumeration of respondents because of the population's relatively small size. The inclusion criteria for the respondents of this study are: (1) the leaners must belong to the grade 7 Science, Technology, and Engineering Program of the Leyte National High School, and (2) they must be officially enrolled and registered online in the Learners' Information System of the DepEd.

3.4 Ethical considerations

Prior to the collection of data from the target respondents, participant's right to voluntary participation in the study was taken into consideration. Full consent was obtained from the target respondents and those, who expressed their participation by their own free will, were the only ones given the research questionnaires. The study's main and specific objectives were clearly explained to the willing research respondents. Measures were undertaken to ensure that the respondents would not in any way be harmed throughout the conduct of the study. The respondents were assured that all derived information will be dealt with utmost confidentiality and solely used for the study.

3.5 Research instruments

This study utilized a 50-item researcher-made multiple-choice test to assess leaners' achievement in algebra, particularly in algebraic expression, polynomials, equations, and inequalities. The test was pilot tested at Cirilo Roy Montejo National High School, involving a grade 7 STE class that is deemed similar in characteristics to the target respondents of this study. Then, the test was item-analyzed, and its internal-consistency was computed using Kuder-Richardson Formula 20. The internal-consistency of the test was measured at 0.79 which is considered acceptable.

The items in the achievement test in algebra assess the basic knowledge, simplification skills, manipulation skills, and interpretation skills of the respondents across the concepts of algebraic expressions, equations, inequalities, and problem solving; hence, obtaining an incorrect answer means an error due to lack of basic knowledge, error in simplification, error in manipulation, or error in interpretation may have been committed. The test items were classified according to the algebraic concepts they tackle with and the skills they assess.

3.6 Research procedures

Prior to the collection of data, permission for the conduct of the study was sought through sending a letter to the principal of Leyte National High School. The principal was also informed of the purpose of the study, the duration of data gathering, the use of the data to be collected, the benefits the school and its leaners would obtain from the study, and the study's provisions with regard to the preservation of the respondents' anonymity. After obtaining approval from the principal, the mathematics teachers of the respondents were informed about the data collection to be conducted. To ensure full cooperation from the teachers, the approved letter was presented.

Furthermore, participant's right to voluntary participation in the study was taken into consideration. That is, full consent was obtained from the target respondents and those, who expressed their participation by their own free will, were the only ones given the research questionnaires. The study's main and specific objective were clearly explained to the willing research respondents. Measures were undertaken to ensure that the respondents would not in any way be harmed throughout the conduct of the study. The respondents were guaranteed that the data taken from them will be handled with utmost privacy and solely used for the study.

To analyze the data collected, both descriptive and inferential statistics were used. Frequencies and percentages were used to summarize and describe the number of leaners who committed errors in algebra, specifically in basic knowledge, simplification, manipulation, and interpretation across the concepts of algebraic expressions, equations, inequalities, and problem solving. Mean and standard deviation were used to summarize and describe the level of achievement of the respondents in algebra, particularly in the concepts of algebraic expressions, equations, inequalities, and problem solving.

4. Results and Discussion

4.1 Level of achievement in algebra

As can be gleaned from Table 1, the achievement level of the respondents in the concept of algebraic expressions, whether in basic knowledge or in simplification, did not meet the expectation. On average, the respondents got a mean of 9.19 correct answers out of 16 items (57.45 percent) under basic knowledge of algebraic expressions. As implied by the result, the respondents have insufficient knowledge of the concept of algebraic expression, that is, they lack mastery of the topics under this concept such as the definitions of variable, constant, polynomials and other related terms, classifications of polynomials, and mathematical rules and properties applicable to operations on algebraic expressions, among others.

Furthermore, on average, the respondents got a mean of 6.85 correct answers out of 11 items (62.30 percent) under simplification. This result suggests that the respondents lack mastery of the procedures for performing operations on algebraic expressions, which includes inability to carry out addition, subtraction, multiplication, or division of algebraic expressions, and failure to arrive at simplified answers to such operations or a combination of these operations.

The results suggest that the respondents have very poor mastery of the concept of algebraic expressions, and this accounts for their lack of procedural understanding of the concept. This is to say that in order for the leaners to obtain a higher achievement level in simplification, they must develop a strong foundation of basic knowledge of algebraic expressions, because performing and simplifying operations on algebraic expressions involve the retrieval of prior knowledge, including knowledge of rules and properties to be applied, among others.

Table 1. Achievement level of learners in algebraic expressions

Concept / Skills	Algebraic expression No. of items	Mean correct answers	Percent correct answers	Description
Basic knowledge	16	9.19	57.45	Did not meet expectation
Simplification	11	6.85	62.30	Did not meet expectation
Manipulation	0	-	-	-
Interpretation	0	-	-	-

Correct answer percentage score range	Description
0 – 74	Did not meet expectation
75 – 79	Fairly satisfactory
80 – 84	Satisfactory
85 – 89	Very satisfactory
90 –100	Outstanding

As depicted in Table 2, the achievement level of the respondents in the concept of equations, specifically under basic knowledge and manipulation, did not meet the expectation. On average, the respondents got a mean of 0.41 correct answers (41.28 percent) under basic knowledge of equations, which includes knowledge of the rules, properties, and procedures for solving equations. This result indicates that they have inadequate knowledge of these topics which are necessary for manipulation of equations.

Table 2. Achievement level of leaners in equations

Concept / Skills	Equation No. of items	Mean correct answers	Percent correct answers	Description
Basic Knowledge	1	0.41	41.28	Did not meet expectation
Simplification	0	-	-	-
Manipulation	7	4.03	57.54	Did not meet expectation
Interpretation	0	-	-	-

Correct answer percentage score range	Description
0 – 74	Did not meet expectation
75 – 79	Fairly satisfactory
80 – 84	Satisfactory
85 – 89	Very satisfactory
90 –100	Outstanding

Moreover, on average, the respondents got a mean of 4.03 correct answers out of 7 items (57.54 percent) under manipulation. The skill in manipulation involves solving an equation or finding the value(s) of the independent variable in an equation that satisfies the equation. The result suggests that the respondents have inadequate procedural understanding of equations. This can be explained by their lack of mastery of rules, properties, and procedures. Deficits in knowledge and understanding of these topics lead to erroneous process of solving equations.

As shown in Table 3 above, the achievement level of the respondents in basic knowledge of inequalities is fairly satisfactory. On average, the respondents got a mean of 0.75 correct answers (75.23 percent) under basic knowledge of inequalities, which is exactly at the minimum acceptable extent of success. Basic knowledge of inequalities includes rules, properties, and procedures for solving inequalities, among others.

Table 3. Achievement level of leaners in inequalities

Concept / Skills	Inequalities No. of items	Mean correct answers	Percent correct answers	Description
Basic knowledge	1	0.75	75.23	Fairly satisfactory
Simplification	0	-	-	-
Manipulation	4	1.33	33.26	Did not meet expectation
Interpretation	0	-	-	-

Correct answer percentage score range	Description
0 – 74	Did not meet expectation
75 – 79	Fairly satisfactory
80 – 84	Satisfactory
85 – 89	Very satisfactory
90 – 100	Outstanding

Under manipulation of inequalities, their achievement level did not meet the expectation. Manipulation involves applying certain rules, properties, and procedure to find the values of the independent variable in an inequality that satisfy the inequality. On average, the respondents got a mean of 1.33 correct answers out of 4 items (33.26 percent). This result suggests that the respondents failed to put into application their knowledge of rules, properties, and procedures for solving inequalities, implying that they have a deficient procedural understanding of inequalities. Moreover, leaners must not proceed to solving inequalities without a better if not complete grip of the prerequisites.

As shown in Table 4, the achievement level of the respondents in problem solving is satisfactory with regard to basic knowledge. Basic knowledge necessary for problem solving includes awareness of the various methods and approaches in solving problems, for instance, transforming word problems in algebra into equations and inequalities, and solving them to arrive

Table 4. Achievement level of leaners in problem solving

Concept / Skills	Problem solving No. of items	Mean correct answers	Percent correct answers	Description
Basic knowledge	4	3.22	80.50	Satisfactory
Simplification	0	-	-	-
Manipulation	0	-	-	-
Interpretation	6	2.86	47.71	Did not meet expectation

Correct answer percentage score range	Description
0 – 74	Did not meet expectation
75 – 79	Fairly satisfactory
80 – 84	Satisfactory
85 – 89	Very satisfactory
90 –100	Outstanding

at the answers. The result reveals that the respondents have more than sufficient basic knowledge of problem solving; on average, they got a mean of 3.22 correct answers out of 4 items (80.50 percent).

However, Table 4 further shows that the respondents have an achievement level in problem solving that did not meet expectation when it comes to interpretation. On average, the respondents got a mean of 2.86 correct answers out of 6 items (47.71 percent) in problem solving under interpretation. This result suggests that the respondents have difficulty comprehending problems in algebra. Accordingly, interpreting problems in algebra requires more than just knowing the methods and approaches in problem solving; it also requires determining the relevant pieces of information as well as the irrelevant ones contained in the problem, and understanding the relationship among the relevant pieces of information based on the conditions provided by the problem.

Table 5. Achievement level in algebraic expression, equations, inequalities and problem solving

Concept / Skills	No. of items	Mean correct answers	Percent correct answers	Achievement level
Algebraic expressions	27	16.04	59.41	Did not meet expectation
Equations	8	4.44	55.50	Did not meet expectation
Inequalities	5	2.08	41.60	Did not meet expectation
Problem Solving	10	6.08	60.80	Did not meet expectation

Correct answer percentage score range	Description
0 – 74	Did not meet expectation
75 – 79	Fairly satisfactory
80 – 84	Satisfactory
85 – 89	Very satisfactory
90 –100	Outstanding

Table 5 reveals that percentage of correct answers is highest under problem solving (60.80 percent); this is closely followed by algebraic expressions (59.41 percent). Furthermore, equations (55.50 percent), and then by inequalities (41.60 percent). It appears that items on problem solving were less difficult to answer than those on the other algebraic concepts; items on inequalities were the most difficult. The percentages of correct answers fall below the minimum standard of 75 percent, hence the achievement level of the respondents across algebraic concepts did not meet the expectation.

4.2 Common errors in algebra

Table 6 shows that under basic knowledge, the highest percentage of wrong answers (58.72 percent) is on items that involved equations. This is followed by items on algebraic expressions (42.55 percent), inequalities (24.77 percent), and problem solving (19.50 percent). These percentages indicate that the errors of the respondents on items involving algebraic expression and equations under basic knowledge were *very high*; errors in items on inequalities were *high*; and errors in items on problem solving were *average* in number. It appears that the most difficult items to answer are those that involved equations, and the easiest are those that involved problem solving.

Guner (2017) stated that lack of knowledge on basic concepts may lead to committing other types of errors. This association between inadequate basic knowledge and other types of errors implies that leaners must develop strong foundational knowledge in order to minimize, if not eliminate, the commission of other error types. Acquisition of pre-requisite knowledge must then be given great importance in the teaching of algebra.

Table 6. Errors in basic knowledge

Concept / Skills	Basic knowledge: No. of items	Mean wrong answers	Percent wrong answers	Description
Algebraic expression	16	6.81	42.55	Very high error
Equations	1	0.59	58.72	Very high error
Inequalities	1	0.25	24.77	High error
Problem solving	4	0.78	19.50	Average error

Wrong answer percent range	Description
1 – 10	Very low error
11 – 15	Low error
16 – 20	Average error
21 – 25	High error
26 –100	Very high error

As to errors in simplification, Table 7 shows that the respondents committed 37.70 percent incorrect answers in items on algebraic expressions that require skills in simplification, which is *very high*. Guner (2017) explained that this type of error occurs when leaners miss an important step of a procedure being applied when attempting to arrive at a simpler expression or answer. According to El-khateeb (2016) this type of error is also committed when leaners incorrectly apply mathematical rules and properties such as cross-multiplication property. These suggest that teachers must make sure that leaners have mastered the basic mathematical rules and properties before they are exposed to activities that require the application of these rules and properties or that necessitate transfer of learning.

Table 7. Errors in simplification, manipulation, interpretation

Concept / Skills	Simplification: No. of items	Mean wrong answers	Percent wrong answers	Description
Algebraic expression	11	4.15	37.70	Very high error
Equations	7	2.97	42.46	Very high error
Inequalities	4	2.67	66.74	Very high error
Problem solving	6	3.14	52.29	Very high error

Wrong answer percent range	Description
1 – 10	Very low error
11 – 15	Low error
16 – 20	Average error
21 – 25	High error
26 –100	Very high error

In terms of errors in manipulation, Table 7 shows that the respondents committed *very high* percentages of errors in items on equations (42.46 percent) and inequalities (66.74 percent) that require skills in manipulation. These signify that the respondents experienced difficulty in solving equations and inequalities. This type of error is similar to calculation error found by Guner (2017) in his study. According to Guner, this error is made when leaners incorrectly perform the four fundamental operations, rules and properties in algebra in finding solutions to equations and inequalities. This signifies that leaners need to have mastery of the fundamental operations is necessary in order to be successful in solving equations and inequalities.

In terms of errors in interpretation, Table 7 reveals that the respondents committed *very high* percentage of errors in problem solving (52.29 percent), a task that requires skills in interpretation. This only show that the respondents had difficulty comprehending the problems posed which may have resulted in arriving at incorrect answers. This category of error shares the same characteristics with comprehension errors revealed in the study of Abdullah, Abidin, and Ali (2015) as well as in the study of Adu, Assuah, and Assiedu-Addo (2015). These studies indicated that comprehension errors occur when leaners do not understand the mathematical questions posed. When leaners do not understand the questions presented, some of them guess the answer while others do not provide an answer at all.

Table 8. Summary of common errors

Algebraic concept	Error type			
	Basic knowledge	Simplification	Manipulation	Interpretation
Algebraic expression	Very high error	Very high error	-	-
Equations	Very high error	-	Very high error	-
Inequalities	High error	-	Very high error	-
Problem solving	Average error	-	-	Very high error

Wrong answer percent range	Description
1 – 10	Very low error
11 – 15	Low error
16 – 20	Average error
21 – 25	High error
26 –100	Very high error

It is revealed in Table 8 that error in basic knowledge is very high under algebraic expressions and equations, high under inequalities, and average under problem solving. Error in simplification is also very high under algebraic expressions. Similarly, error in manipulation is very high under equations and inequalities, and error in interpretation is very high under problem solving. This result suggests that the respondents experience difficulty in the four algebraic concepts, thereby signifying that they lack mastery of these concepts.

5.0 Conclusion and Recommendations

In the light of the findings of this study, it is concluded that the respondents lack mastery of the fundamental concepts in algebra, particularly in performing operations on algebraic expressions, finding solutions of equations and inequalities, and solving word problems and therefore considered to have poor knowledge and understanding along these concepts. Considering that these are key concepts in algebra, lack of knowledge and understanding of any of these concepts will negatively affect higher mathematics learning of the leaners as they progress from one education level to another. Meanwhile, the errors committed by leaners when dealing with algebraic expressions, equations, inequalities, and problem solving are varied in terms of features. Leaners committed errors in basic knowledge, simplification, manipulation, and interpretation. Two or more of these error types may be observed under any of the abovementioned algebraic concepts.

It is recommended that the mastery level of the leaners along the competencies under concepts of algebraic expressions, equations, inequalities, and problem solving should be monitored regularly to determine what competencies they are weak at and should be focused on for improvement. The errors of the leaners along the concepts of algebraic expressions, equations, inequalities, and problem solving should be corrected as early as possible through giving regular feedback, because if ignored and left not corrected, leaners will have difficulty developing conceptual understanding of algebra as well as difficulty learning higher mathematics subjects, particularly those in college, considering the fact that algebra is a pre-requisite to these subjects. As much as possible, interventions specific for an error type should be developed and employed, because most of these errors do not share the same characteristics. In some cases, these errors need to be addressed separately.

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