CHAPTER I
INTRODUCTION

1.1 Background of Research

Education has been considered as a means to the success of an individual and to the success of a society as a whole. Failure of a society is placed on education. If a society fails, then it is because education has failed to mould the human being. It is therefore essential to look at the aspects that make education successful. For example, education is expected that education produces a human being who is a notable member of the society, who thinks logically (cognitively and socially), systematically and structurally (Zimbabwean Primary and Secondary School Syllabus, 2015-2022, Kemendikbud, 2014).

To achieve the above mentioned goals of education especially in this 21st century, it is necessary that children attend school from as pre-primary, through elementary, junior, senior secondary school and enter college or university. Schools have been regarded as best places to develop a child's cognitive, affective and psychomotor domains (Wolk, 2007). However, it is unfortunate that students who complete elementary school in most parts of the world, a certain percentage of these students will not progress to junior secondary school. Worst off at junior secondary school, a greater percentage of these students from junior school experience drop outs and do not progress with education due to failure and/or some other factors.

For Indonesia, it is stated that "...among the pupils who successfully graduate from junior secondary schools, 10% of them do not continue to senior secondary education." (OECD, 2015 pg. 138). It is actually the same story even with Zimbabwe; students have been failing examinations and are dropping out of school simply because they lack necessary skills required in learning, one of these skills are the lack of mathematical flexibility, creativity and failure to make connections in solving problems (Tejeda & Gallardo, 2017). Since schools are considered the major centres of training for the development of these skills, there is need to intervene in the process of learning at secondary schools and beyond in an effort to minimize these dropouts.

Several subjects are learnt at school which are put to develop the cognitive, affective and psychomotor domains of the mind of the child. Mathematics is one of the important subjects that are learnt at school and it acts as a tool to achieve these domains. Mathematics is a basic science that is very important in the life of a person (Schoenfield, 1992, Ojose, 2011). The nature of Mathematics is that it is spiral; concepts are built on top of each other, starting from the basic (bottom) to the complex (top) and these concepts are never isolated but they interact with each other **(See Figure 1.1)** but still the concepts relate to and depend on each other.

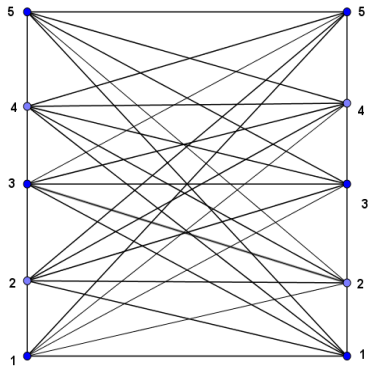

Figure 1.1
An illustration of the Interaction of Mathematical Concepts
(Adpted and modified from Treffers, 1991)

In mathematics learning, algebraic concepts form greater part of mathematics content. It has been proved beyond doubt that basic algebra forms the foundation of further abstract algebra, calculus and bases for almost all the courses in Secondary School Mathematics and beyond (Ziegler & Sterns, 2014). Algebraic proficiency becomes a world concern (Van Stiphout, 2011). If algebraic abilities are not strengthened at high school and below, that can be a source of learning obstacle for university courses since algebra has been considered as a "gate keeper" to students' further education and career (Ziegler & Stern, 2014, Katz & Barton, 2014) and this gate has to be opened.

Because algebra is considered a "gate to life" on learning mathematics, it is very necessary that students are given opportunities to think in diverse and more flexible manner. One of the ways is to give them algebraic structure sense problems to solve. In

addition, Indonesia has since joined PISA programme (Programme for International Student Assessment) of which the performance of the 15-year olds in the mathematics examination was unsatisfactory in which algebraic questions form grater part of the examination question. Indonesia has been found on the bottom rank being number 55 out of 69 countries that participated in the PISA programme for 2015 examinations (Jupri & Drijvers, 2016).

Recent researches which were carried on Indonesian students on algebraic learning indicated that junior high school students are failing PISA examinations because of some algebraic difficulties in initial algebra, one of which is difficulties is *mathematization* (Jupri, Drijvers, & van den Heuvel-Panhuizen, 2014) that is failure to connect mathematics concepts to the real world and vice versa and failure to connect basic concepts to higher order thinking problems.

It is also evident that much of the researches done on students' algebraic activities have concentrated on students' understanding of variables and equivalence relations (Knuth, Alibali, Mcneil, Weinberg, & Stephens, 2005,Weinberg, Dresen, & Slater, 2016), algebraic representation (graphic and pictorial representations and generalizations) (Palatnik & Koichu, 2017, Montenegro, Costa, & Lopes, 2018) and in Indonesia, researchers had focused on difficulties of students in algebraic activities with word problems (*horizontal mathemitization*) (Jupri, Drijvers, & Van den Heuvel-Panhuizen, 2014, Andini & Suryadi, 2017, Puspita et al., 2017). In this current research, it is argued that algebraic structure sense has been applied on university students (Novotna, Stehlikova, & Hoch, 2006) and on mathematical experts (Jupri & Sispiyati, 2017) and has been researched and practised outside Indonesia thus leaving the gap of investigating algebraic structure sense when unfolded to the students at junior and senior schools of Indonesia.

In addition, the current research has been provoked by the results from a preliminary study which was done in Bandung by the writer and two mathematics experts on junior secondary school students prior to this study. The results were presented in the International Conference of Mathematics and Science Education (May, 2018) at Universitas Pendidikan Indonesia where the aim of the preliminary study was to analyse students' algebraic expertise. Results from this preliminary study

have shown that students need to be more flexible in their strategies of viewing and/or solving algebraic problems (Muchoko et al., 2019). Subjects in the preliminary study showed difficulties in "algebraic visualization", thus failure to recognise structures in familiar form.

One of the tasks given to students in the article task required students to evaluate the numerical structure: $145^2 - 147 \times 143$ without using a calculator. Many of the students have failed to see the algebraic structure of the form $a^2 - (a+2)(a-2)$ where a would represents the value 145. So they used the normal procedural way of long multiplication learnt at elementary school in-order to obtain the solution. Such junior school students showed lack of ability to make use of algebraic properties, (distributive, commutative and associative properties). Therefore the researcher wishes to investigate a similar concept of structure sense to more mature students at senior high school in Indonesia.

In addition, from the researcher's own long term service in the teaching and learning of mathematics at secondary school in Zimbabwe, secondary school students lack exposure to algebraic structure sense problems to enhance creative and connection abilities in solving mathematical problems. In this sense therefore, students need to experience unique kinds of concepts in algebra and use non-routine strategies in solving algebraic problems and thus promoting the development of their proficiencies in solving problems flexibly. Such unique ways is to give the students the opportunity to solve problems with algebraic structure sense, hence the need of the current research.

Similarly, based on a mini qualitative study done on mathematics experts in Bandung (Jupri & Sispiyati, 2017), results indicated that giving algebraic structure sense problems is an important process that can help teachers to investigate and develop students' mathematical proficiency, of which one of the proficiencies is algebraic structure sense flexibility. Structure sense problems have been used in many countries but unfortunately, according to Jupri & Sispiyati (2017), this idea of algebraic structure sense has not been practised fully and little has been done to assess students' structure sense in junior and senior secondary schools of Indonesia.

This brings forth the need for current research that is focusing on analysing and investigating students' performance with algebraic structure sense problems as an effort

to strengthen the ability of students to reason and think flexibly. The investigation is based on students' "*vertical mathematization*", a theory founded by Heuvel-panhuizen, (2000) to know how students are able to utilize basic algebraic ideas to solve higher order algebraic problems which are embedded within a seemingly complex structure. The writer chose to research on vertical mathematization because many researches on Indonesian school students were based on horizontal mathematization, for example Andini and Suryadi (2017, Sari (2014) and Jupri and Drijivers (2016).

If students are given a chance to solve algebraic structure sense problems, how do they do it, which strategies do they use and what are the problems associated with such experiences? It is expected that students will display a high level of procedural knowledge but have limited algebraic structure sense in manipulating algebraic expressions. These questions will best be answered only by an in-depth research through a qualitative case study such as the current study. The study shall serve as a contribution to the literature on algebraic teaching and learning at secondary school. However on how students' algebraic structure sense can be improved is open for further research.

Taking the above background into account, it is necessary to get a deeper insight on the nature of algebraic structure sense abilities for high school students of Indonesia and identify the strategies that some students use in solving algebraic structure sense problems as well as identifying students' algebraic difficulties. Therefore the research that will be done is titled "**Investigating Algebraic Sructure Sense of Grade Ten Indonesian School Students in Solving Algebraic Equations".**

1.2 Statement of the problem

Education being the key to life and success in education is greatly determined by success in mathematics where algebraic concepts are important aspects that form a greater part of mathematics learning, significant number of school dropouts due to failure in mathematics. Despite the fact that algebraic structure sense has been researched and practised in other countries, it has not been so for high school students of Indonesia. In addition, recent research on algebraic activities for high schools of Indonesia has not fully focusing on *vertical mathematization* rather on *horintal mathematization*. How then can students' algebraic proficiency be known in order to

reduce these failures and drop outs? One of the ways to know students' algebraic proficiencies is to investigate their algebraic structure sense ability in solving algebraic equations. This calls for the current qualitative study that will provide tentative hypotheses on algebraic structure sense abilities of High Schools of Indonesia. More research on secondary school students of Indonesia is highly recommended.

1.3 Focus of the Study

This study is limited in only to linear and quadratic equations as tools of research for structure sense ability. Investigation on structure sense may probably give different results if other algebraic topics could be used. The study is also limited in that general conclusions will not be possible based on the results of the current study since the study is focusing on fewer subjects in one school and therefore results from the current study may be biased based on the conditions prevalent in the area of study. It is recommended that structure sense can be investigated on a larger number of Indonesian high school students using a different method to observe if results can differ. The study is also constrained because of limited time hence a longitudinal study on high schools of Indonesia on this topic is highly recommended.

1.4 Research questions

Following the problem highlighted above, the following questions arise that the current research study seeks to answer:

1. How are the algebraic structure sense abilities for high school students of Indonesia in solving algebraic equations? This question is further specifiesd into the following questions:
    a) Can students recognise familiar structures in their simplest from a complex structure?
    b) How do students deal with compound terms in complex algebraic equations?
    c) Do students make appropriate manipulations to make best use of the structure from (i) complex numerical problems (ii) complex algebraic problems?
2. How flexible are high school students in solving algebraic structure sense problems? Again this question is further reduced to:
    a) Can students solve algebraic structure sense in diverse manner?

b) Can students solve algebraic structure sense equations in new/self-invented ways?

3. What are the difficulties encountered by students during solving algebraic structure sense problems?

1.5 Research Purpose

Following the research questions listed above, the current study seeks to:

1. Analyse Structure Sense ability for Indonesian High School Students of Indonesia and provide a tentative conjecture on their algebraic structure sense ability in solving algebraic equations.
2. Describe Indonesian High school students' flexibility in solving algebraic structure sense equations.
3. Identify difficulties that students face in solving algebraic structure sense problems and other aspects of algebra.

1.6 Significant of Study

2. Theoretical Benefits of the study

   The theoretical benefits of this study are that:

   a. The study is done to add knowledge to the reader about the strategies used and difficulties faced by high school students in solving algebraic structure sense problems.
   b. The study will add literature on the knowledge on the current nature of Indonesian high school students' algebraic proficiency in terms of structure sense flexibility.

3. Practical Benefits of the study

   The practical benefits of the study:

   a. To the teacher, this research will act as an item for evaluation and contribute in the plan and other algebraic learning activities in the classroom.
   b. To the students, because of this research, students will benefit in the process of problem solving as they will be developing their algebraic proficiency which is necessary when they are faced with algebraic courses and other related concepts as they enter university level. Being able to use expert

strategies in solving algebraic problems will in turn help them to solve complex real life problems.

c. To the researcher, the research will enable the researcher to gain experience in doing scientific research in mathematics education. In addition, the knowledge that will be gained by doing this academic research will help the researcher in her profession later when the researcher re-joined teaching later in her own country or elsewhere.

d. To the reader, it is hoped that results of this research will help in the identification of a research gape in-order to establish future research study on students' algebraic learning.

1.7 Operational Definitions

Based on the tittle of this study, there are a number of terms that need to be explained so that there is no difference in perception between the researcher and the reader. These are:

1. Algebraic structure sense

   A student who exhibits algebraic structure sense ability is the one who:

   a) Recognises a familiar structure in its simplest form from a complex entity. Recognising linear and quadratic structures in a given complex structure. This aspect is coded **SS1**

   b) Is able to deal with a compound term as a single entity and through an appropriate substitution to solve the equation. This aspect is coded **SS2**

   c) Choose appropriate manipulations on i) a numerical structure and ii) on an algebraic structure to make best use of the structure through recognizing mutual connections between structures and recognises which manipulations are possible to perform. Again these two aspects are coded **SS3a** and **SS3b** respectively.

2. Flexible Strategies

   A student who has structure sense flexibility is the one who:

   a) Uses diverse (more than one way) in solving the algebraic structure sense problem. This aspect is coded **FS1**

b) Uses unique ways/new and self-invented strategy in solving the algebraic structure sense problem other than the standard procedure. This aspect is coded **FS2**

3. Algebraic difficulty is seen when a student exhibits aspects of misunderstanding of algebraic terms and concepts, and has shown a misconception in equations representations. Finally, difficulties are also identified when a student does computational, omission or transfer errors, misunderstanding of variables and equivalence relations and difficulties in algebraic manipulations (use of algebraic properties and factors). Difficulties have no codes, they will be noted based on the nature of their appearance.