# EFFECTS OF COGNITIVE CONFLICT INSTRUCTIONAL STRATEGY AND MOTIVATION ON CONCEPTUAL CHANGE AND ATTITUDE TOWARDS ALGEBRA AMONG TENTH GRADERS IN THE UAE

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**by**

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## TABLE OF CONTENT

## LIST OF TABLES

**Page**

## LIST OF FIGURES

## LIST OF ABBREVIATIONS

| | |
|---|---|
| ATAQ | Attitude Towards Algebra Questionnaire |
| CCAT | Conceptual Change Algebra Test |
| FFIP | Face to Face Interview Protocol |
| MECCQ | Motivation to Engage in Conceptual Change Questionnaire |
| UAE | United Aram Emirates |

## LIST OF APPENDICES

**KESAN STRATEGI PENGAJARAN KONFLIK KOGNITIF DAN MOTIVASI KE ATAS PERUBAHAN KONSEP DAN SIKAP TERHADAP ALGEBRA DALAM KALANGAN PELAJAR GRED SEPULUH DI UAE**

## ABSTRAK

Tujuan kajian ini adalah untuk menentukan kesan strategi pengajaran konflik kognitif dan motivasi ke atas perubahan konsep dalam algebra dan sikap terhadap algebra dalam kalangan pelajar gred sepuluh di Emiriah Arab Bersatu. Kajian ini menggunakan reka bentuk kajian eksperimen quasi, iaitu reka bentuk kajian kumpulan kawalan yang tidak setara. Kedua-dua kaedah kuantitatif dan kualitatif digunakan untuk pengumpulan data. Penyelidik menggunakan Protokol Temu Bual Bersemuka (FFIP) dan Ujian Perubahan Pra-Konsep dalam Algebra (PreCCAT) untuk mengenal pasti dan mengklasifikasikan miskonsepsi lazim dalam algebra. Penyelidik mengadaptasi Soal Selidik Motivasi Penglibatan Diri dalam Perubahan Konsep (MECCQ) untuk mengukur tahap motivasi penglibatan diri pelajar dalam perubahan konsep. Ujian pra, pos dan pengekalan Perubahan Konsep dalam Algebra telah dianalisis. Empat kelas Gred Sepuluh dari dua sekolah (dua kelas untuk kumpulan eksperimen dan dua kelas lain untuk kumpulan kawalan) dipilih secara rawak daripada 20 kelas melibatkan seramai 543 pelajar lelaki Gred Sepuluh. Statistik deskriptif seperti min dan sisihan piawai digunakan untuk menganalisis Soal Selidik Motivasi Penglibatan Diri dalam Perubahan Konsep (MECCQ). Ujian ANOVA dua hala digunakan untuk menguji hipotesis kajian ini. Dapatan kajian menunjukkan

bahawa semua pelajar dalam kajian semasa mempunyai pelbagai miskonsepsi algebra dalam aras yang berbeza. Terdapat kesan utama strategi pengajaran dan motivasi yang signifikan ke atas perubahan konsep dalam algebra dalam kalangan pelajar Gred Sepuluh di Emiriah Arab Bersatu. Walau bagaimanapun, tiada kesan interaksi strategi pengajaran dan motivasi yang signifikan ke atas perubahan konsep algebra. Terdapat kesan utama motivasi yang signifikan ke atas sikap terhadap algebra tetapi tiada kesan utama strategi pengajaran serta kesan interaksi strategi pengajaran dan motivasi yang signifikan ke atas sikap terhadap algebra. Untuk pengekalan, terdapat kesan utama strategi pengajaran dan motivasi yang signifikan ke atas pengekalan perubahan konsep dalam algebra. Walau bagaimanapun, tiada kesan interaksi strategi pengajaran dan motivasi yang signifikan ke atas pengekalan perubahan konsep dalam algebra dalam kalangan pelajar Gred Sepuluh di Emiriah Arab Bersatu. Akhirnya, terdapat kesan utama motivasi yang signifikan ke atas pengekalan sikap terhadap algebra tetapi tiada kesan utama strategi pengajaran serta kesan interaksi strategi pengajaran dan motivasi signifikan ke atas pengekalan sikap terhadap algebra.

**EFFECTS OF COGNITIVE CONFLICT INSTRUCTIONAL STRATEGY AND MOTIVATION ON CONCEPTUAL CHANGE AND ATTITUDE TOWARDS ALGEBRA AMONG TENTH GRADERS IN THE UAE**

## ABSTRACT

The purpose of this study was to determine the effects of cognitive conflict instructional strategy and motivation on conceptual change in algebra and attitude towards algebra among Tenth Graders in United Arab Emirates. This study employs a quasi-experimental research design, namely non-equivalent control group research design. To collect data, both quantitative and qualitative methods were used. The researcher used Face to Face Interview Protocol (FFIP) and Pre-Conceptual Change in Algebra Test (PreCCAT) to identify and classify common algebra misconceptions. The researcher adapted a Motivation to Engage in Conceptual Change Questionnaire (MECCQ) to measure level of student's motivation to engage in conceptual change. Pre, post and retention of Conceptual Change in Algebra Test were analyzed. Four classes of Tenth Graders from two schools (two classes for experimental group and the other two classes for control group) were choose randomly from 20 classes of 543 Grade Ten male students. Descriptive statistics such as mean and standard deviation was used to analysis Motivation to Engage in Conceptual Change Questionnaire (MECCQ). Two-way ANOVA test was used to test the hypotheses of this study. The results showed that all students in current study had a variety of algebraic misconceptions in varying degrees. There is significant main effect of instructional strategy and motivation on conceptual change in algebra among Tenth Graders in the United Arab Emirates. However, there is no significant interaction effect of instructional strategy and motivation on conceptual change in algebra. There is significant main effect of motivation on attitude towards algebra but there is no significant main effect of instructional strategy and interaction effect of instructional strategy and motivation on attitude towards algebra. For retention, there is significant main effect of instructional strategy and motivation on retention of conceptual change in algebra. However, there is no significant interaction effect of instructional strategy and motivation on retention of conceptual change in algebra among Tenth Graders in the United Arab Emirates. Finally, there is significant main effect of motivation on retention of attitude towards algebra but there is no significant main effect of instructional strategy and interaction effect of instructional strategy and motivation on retention of attitude towards algebra.

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the Study

A rich mastery of concepts is a corner stone in mathematics understanding. Students use their concepts to understand mathematics relations and explain phenomena. Learners construct their concepts from different sources including every day experiments, teachers, peers, and teaching environment. In case that the concepts are not accurately devolved in one's mind, they may have misconceptions (Kaya, Karadeniz, & Bozkus, 2017).

It is common knowledge that misconceptions are a major challenge for students in school mathematics. These misconceptions accompany students when they move to the next stage of school and inhibit their understanding of new concepts. Many studies like Akhtar and Steinle (2013), Cansız, Küçük, and İşleyen (2011), Mulungye, O'Conner, and Dr. Ndethiu (2016), Muzangaw and Chifamba (2012), and Öçal (2017) found the existence of misconceptions and the direct effect on students' achievements.

Misconception is a view or opinion that is incorrect because it is based on faulty thinking or understanding (English Oxford Living Dictionaries, 2018). Ojose (2015) state that "*misconceptions are misunderstandings and misinterpretations based on incorrect means"* (p. 30). Students, in line with their beliefs and existing knowledge, consider the misconceptions that they have precise and depend on them in demonstrating many skills (Karadeniz, Kaya, & Bozkuş, 2017). In a general aspect, misconception is not an error that can be considered modest or innocent and overlooked by teachers (Cansız, Küçük, & İşleyen, 2011).

Allen (2007) argued that misconception must be altered internally partially through the student’s belief systems and partly through their own cognition.

In this study, the researcher used a set of terms that indicate and congruence to misconception term including conceptual errors, alternative concepts and preconceptions. Accordingly, misconceptions are errors in the cognitive structure of the learner which involve misunderstanding or misinterpretation of correct concepts. Students in case of misconceptions have alternate concepts (inaccurate concepts). Conceptual errors include students' preconceptions that are not valid for understanding new concepts or solving new problems. For example: some students have a preconception of adding non-like terms in an algebraic expression incorrectly (they simplified $3x + 4$ as $7x$) . They have a conceptual error of the concept of like terms. They presented an alternative concept that includes merging two non-like terms in one term as the simplest form. It is clear that the students in this misconceptions don’t have computation error, but rather built a conceptual error in their cognitive structure. They add $3 + 4$ correctly but add $3x + 4$ as $7x$ inaccurately.

The challenging issue lies in that students stick to their misconceptions and they sometimes refuse to review them. Therefore, it is not easy to change these conceptual errors. As researchers and mathematicians, we should acknowledge the necessity of detecting these misconceptions at each branch of mathematics and provide effective teaching strategies that can remedy these misinterpretations. Many studies like Assagaf (2013), Chow and Tregust (2013), Irawati, Zubainur, and Ali (2018), Kabaca, Karadag, and Aktumen (2011), Maharani and Subanji (2018), Toka and Aşkar (2002), suggested cognitive conflict as a teaching strategy to redress misconceptions that students have by introducing contradictory experiences that confront students' existing knowledge in order to reconstruct their concepts. Cognitive conflict strategy provides an opportunity for students to be dissatisfied with their prior inaccurate knowledge. It is expected that cognitive conflict strategy presented by teachers can make students aware of their misconceptions (Irawati, Zubainur, & Ali, 2018).

Chow and Tregust (2013) stated that application of cognitive conflict as an instruction strategy start by making students alert of their prior knowledge and then, confront them with anomalous data to replace their existing concepts with mathematically accepted ones. In the learning of cognitive conflict, teacher seeks to shake learners' confidence in their misconceptions by presenting one counter example or more. When students become dissatisfied with their own concepts and a doubt about them, the opportunity becomes favorable to replace these incorrect concepts by accurate ones.

**Algebra Misconceptions**

Algebra is one of the main branches of mathematics in which students start to transit from arithmetic to abstract and focus on symbols, representations, equations, relations, functions, and graphs. Akhtar and Steinle (2013) reflected:

*Algebra is known to be the most difficult part of school mathematics because of the need for students to master suitable interpretations of the abstract symbols which are involved.* (p. 37)

In addition to all its applications in the real life, algebra makes a foundation to understand the other mathematic branches like geometry, probability, and calculus. Deep understanding of algebra helps to study advanced Algebra subjects in school mathematics and helps students in other subjects, such as physics and engineering, as well as the continuing need for students who continue their post-school studies in subjects that are primarily related to algebra calculations.

The importance of algebra drives us to focus on algebra concepts in school mathematics, identify and promote an effective conceptual change in case of misunderstandings. Many researches are conducted to identify student's algebra conceptual errors in different stages of school education even in undergraduate students. Some studies are interested in classifying sources of algebra misconceptions and thinking strategies related to these perceptions. Ojose (2015) presented a misconception related to addition of exponents:

Question. Simplify: $y^4 + y^4$

Likely Answer. $y^4 + y^4 = y^8$

According to Ojose (2015), this misconception relates to misapplication of rules. Students think that they can add the powers in case of addition of exponents because the both terms have the same base, where the correct thing the learner would have been to do is to add the coefficient of the two terms to get $2y^4$.

Steinle, Gvozdenko, Price, Stacey, and pierce (2009) adapted two items within the Algebra Module from Fujii (2003). After some changes of the instructions, the items became as the following:

| | |
|---|---|
| *Problem 1:*<br><br>Some students had to find some values of *x* to make this equation true: *x* + *x* + *x* = 12<br><br>Mark the work of each student.<br><br>Mary wrote *x* = 2, *x* = 5 and *x* = 5<br><br>Millie wrote *x* = 9, *x* = 2 and *x* = 1<br><br>Mandy wrote *x* = 4 | *Problem 2:*<br><br>Some students had to find some values of x and y to make this equation true: *x* + *y* = 16<br><br>Mark the work of each student.<br><br>John wrote *x* = 6, *y* = 10<br><br>Jack wrote *x* = 8 and *y* = 8<br><br>James wrote *x* = 9 and *y* = 7 |

After applications, the researchers found that some students choose all answers in both terms as correct answers. According to the researchers, these students had a misconception of that they seem to treat the letters x and y as they might treat empty boxes. They found another kind of algebraic misconceptions that some students answered problem 1 correctly but they did problem 2 incorrectly as they rejected the option where x and y are equal. Mulungye (2016) also found some algebraic misconceptions classes like:

$(a+b)^2 = a^2 + b^2$;

$\sqrt{a^2 + b^2} = a + b$;

$3x + 5 = 8x$;

$\frac{a+x}{b+x} = \frac{a}{b}$.

For the item $(a+b)^2$, the researcher argued that students misinterpret the power of bracket which categorized as evolving from the application of the distributive law intuitively. The used of the property "$a(b+c)$" in a new situation inaccurately. The researcher stated that students in this case of misconceptions, the formal distributive property of multiplication over addition was deeply deposited in their mind that they intuitively misapplied the rule in similar situations.

### Conceptual Change and Cognitive Conflict Strategy

One of the basic assumptions of the constructivism theory is the importance of students' prior knowledge. Based on this idea, in order to encourage meaningful learning, students need to connect new concepts to be taught with their prior concepts. In case of misconceptions, learning new concepts collides with inaccurate existing concepts, which requires promoting conceptual change to replace students' inaccurate preconceptions by scientifically accepted ones.

In the knowledge acquisition process, teachers can simply add new concepts or fill in the incomplete concept gaps. Conceptual change needs different strategies rather than addition techniques because students have prior concepts but they are incorrect. Students' previous incorrect knowledge must conflict with new accurate concepts. For this reason, misconception can't be addressed by only alerting students for their conceptual errors and providing the mathematically accepted concepts directly. Teachers will not be able to add valid concepts that contradict those they already have once these concepts are presented as alternative concepts. It seems that teachers need to construct meaningful cognitive conflict as a strategy for conceptual change including aware students of their prior knowledge by introducing contradictory information.

According to Vosniadou and Verschaffel (2004), conceptual change is different from other kinds of learning because it needs different techniques to be accomplished. They argued that the use of additional techniques in situations necessitating conceptual change usually causes misconceptions. Kang, Scharmann, Kang, and Noh (2010) argued that students sometimes refuse modification even if they are aware of contradiction. They constructed a model of conceptual change in which cognitive conflict and/or situational interest induced by a discrepant event are likely to affect conceptual understanding and the retention of the conception directly as well as indirectly through attention and effort allocated to concept learning. They describe learning of new concepts as interaction between prior and new knowledge and suggested four conditions that are necessary for conceptual change (dissatisfaction, intelligibility, plausibility and fretfulness). If these conditions are not met in the new concepts, students' preconceptions will keep on, and conceptual change doesn't proceed (Kural & Kocakualah, 2016). Barlia (1999) agreed that conceptual change process starts when students find reasons to become dissatisfied with a preconception and then find an intelligible, plausible and fruitful new conception.

Limón (2001) stated that cognitive conflict forms one of the most common instructional strategies for conceptual change in which a student as an active learner needs to be aware of his / her existing concepts by introducing contradictory information. If learners recognize the insufficiency of their own ideas, there is likely to be a conceptual conflict. Chow and Treagust (2013) used a model of conceptual change based on the four key elements: making students aware of their existing concepts before instructional intervention, confronting them with contradictory information, using conflict teaching (contradictory information or anomalous data) to replace prior concepts with scientifically accepted ones, and measuring the resulting conceptual change. They argued that cognitive conflict is the initiating factor for conceptual change. According to them, cognitive conflict establishes when students' confidence in their preconceptions becomes destabilized. They define cognitive conflict as an individual's alertness of inconsistent data affecting a belief in that individual's cognitive structure. Chain and Brewer (1993) stated that learners become dissatisfied with their current theories by introducing "anomalous data" to them with evidence. In Piaget's theory of cognitive development, learners acquire new knowledge through three main principles: assimilation, accommodation and equilibration. Equilibration refers to the process in which learners explain phenomena through encountering new experiences and attempt to appropriate their current structure with conflict to reach equilibration. Lee et al. (2003) claimed that cognitive conflict refers to the equilibration principle in Piaget's model. In general aspect, conceptual change instructional models in which cognitive conflict is an initiating factor has several steps including: detecting students preconceptions by making them aware of their own ideas, discussing and evaluating these preconceptions for its intelligibility, plausibility and fruitfulness, creating cognitive conflict when learners become dissatisfied with their own ideas and more open to replace them, and finally, encouraging learners to restructure their concepts by reconciling differences between their preconceptions and scientific accurate ones.

Some models support positive result of cognitive conflict to promote conceptual change (Chow & Treagust, 2013; Hewson & Hewson, 1984; Kabaca, Karadag, & Aktumen, 2011; Kwon, Lee, & Beeth, 2000; Toka & Aşkar, 2002). Fumador and Agyei (2018) also noted the positive effect of diagnostic (cognitive) conflict in treating student's misconceptions in algebra for students (average age of 16 years). They compared the effect of cognitive conflict teaching with conventional teaching on conceptual change in student's algebraic misunderstanding. The cognitive conflict teaching was applied as proposed by Swan (2001) by giving prepared activities on worksheet inbuilt with misconceptions to together with teaching materials and teaching plans. The tasks were given to the students individually and then, in pairs for discussions. The teacher provided feedback to the learners and allowed them time to check the answers, doing the activities using two or more methods, all with the consideration to create cognitive conflict followed by asking further cognitive conflict thrilling questions. Finally, further problems for new stations were given. It was found that both teaching strategies had a significant effect on reducing misconception in algebra, but the cognitive conflict strategy was more effective.

Despite the positive results of cognitive conflict as a teaching strategy for conceptual change, some negative effects were obtained. These cases urge us to analyze the difficulties that make students unable to change their own prior ideas. Why do students sometimes refuse modification even if they are aware of contradiction? Kang, Scharmann, Kang, and Noh (2010) claimed that cognitive conflict alone could not be as influential as expected in prompting conceptual change. They discussed the likely role of some non-cognitive factors such as motivational factors, situation interest, attention and efforts. Limón (2001) argued that cognitive conflict forms a fitting experience for students that it can help them to avoid misconceptions, nevertheless, many difficulties faces the application of this strategy in classrooms which are related to the intricacy of factors interfering in the context of learning. He stated that most of the thermotical model for conceptual change focused mainly on the individual's cognitive conflict and neglected many variables that influence students' learning such as motivation, epistemological beliefs, attitudes, etc. He claimed that it is necessary to take these factors in account because cognitive conflict strategy requires learners with a higher level of cognitive engagement more than traditional teachings strategies do. He recommended that further studies should investigate the influence of all these aspects independently and the interaction among them.

Kural and Kocakualah (2016) distinguished between cold conceptual change models which focuses merely on cognitive factors and do not consider effective factors like motivation. They suggested a model of hot conceptual change supported by metacognition and motivational strategies. Their model includes these eight headings: motivating students to learning, elicit student's preconceptions, overview which preconceptions will conflict with discrepant event, create a cognitive conflict, group work, introducing new concept, transmitting new concept to different situations and evaluation. Vosniadou (2006) agreed with the argument of the importance of motivational factors to facilitate student's engagement in conceptual change. They argued that to change students' prior knowledge, motivation is indispensable.

However, cognitive conflict up till now is still the most effective conceptual change teaching strategy implemented in the classrooms. but it is necessary to take the criticisms directed to this strategy into account. To consider these problems, there is need to focus on the conditions that are necessary to conduct a meaningful cognitive conflict in order to make student dissatisfied with their prior knowledge and then, encourage them to challenge their misconceptions and eventually replace them by scientifically accepted ones. Teachers should know how to create cognitive conflict situations for their students. In addition, teachers should prepare carefully the counter examples or contradictory experiences that make learners dissatisfied with their preconceptions. Literature shows that motivation is likely to be an important factor to encourage students to resolve the case of dissatisfaction when they are confronted with anomalous data.

In this study, the researcher uses some models that support positive results of cognitive conflict to promote conceptual change (Chow & Treagust, 2013; Hewson & Hewson, 1984; Kabaca, Karadag, & Aktumen, 2011; Kwon, Lee, & Beeth, 2000; Toka & Aşkar, 2002). These models include four main common elements: make students aware of their preconceptions, comforting them by anomalous data, using conflict teaching to change student's prior knowledge and finally evaluate the results of conceptual change. The researcher of the current study considers the criticisms that faced the classical approach of conceptual change by taking in account motivation factor (self-efficacy and goal orientation) as a separate factor and integrating it with cognitive conflict. The items of self-efficacy and goal orientation scales are strongly related to the role of motivation as a non-cognitive factor in conceptual change process. Goal orientation refers to the reasons why a student engages in a learning task and self-efficacy includes judgments about one's ability to master a task in addition to one's confidence in one's skills to accomplish that task (Pintrich et al.,1991). The researcher suggests a new part named “Achieve Scientific Concept” which is not included in other approaches of conceptual change. This part aims to ensure that student-student and teacher-student discussions lead to understanding the scientific concept. The process of this approach is shown through the example: solve the equation $\frac{x+7}{4} = 8$ under these headings:

(a) Detect Students Preconceptions

In this part, teachers can elicit students' preconceptions using ‘exposing situation’ which urges students to use their existing conceptions to interpret the situation. Teachers should prepare carefully for these situations which are usually in the form of problems. Repeatedly, students' misconceptions appear when they try to use them in new situations or apply them to resolve problems. Overall, conceptual approach relies on eliciting students' preconception as a part of teaching process (Chow & Treagust, 2013; Irawati, Zubainur, & Ali (2018); Kural & Kocakualah, 2016; Lee, et al., 2003; Limón, 2001; Maharani and Subanji (2018); Merenluoto & Lehtinen, 2002; Posner, Strike, Hewson, & Gertzog, 1982). Once students' preconceptions are detected, teachers can use them as a basis for the next instruction. In the previous example, the expected misconception is that students subtract “7” from the both sides instead of multiplying by “4” as a first step to solve the equation: $\frac{x+7}{4} = 8$ to get $\frac{x}{4} = 1$ and then $x = 4$.

(b) Evaluate Students Preconceptions

After detecting students’ existing knowledge, teachers start to discuss and evaluate these preconceptions for its intelligibility, plausibility and fruitfulness. Teachers in this part facilitate discussion between students in pairs or groups and the spokesperson presents the group’s ideas to the whole class, which helps to check if the whole class accepts an inaccurate conclusion (Chow & Treagust, 2013). Teachers in this part ask students ‘critical questions’ that can make students aware of their preconceptions and prepare them for cognitive conflict (Merenluoto & Lehtinen, 2002). Teachers try to make students dissatisfy of their incorrect choosing of the inverse operation by asking them: can we write $\frac{x+7}{4}$ as $\frac{x}{4} + 7$.

(c) Create Cognitive Conflict

Cognitive conflict can be created when learners become dissatisfied with their own ideas and more open to replace them. Teachers should give students a counter example or more that contradicts their theory to destabilize student’s confidence in their existing knowledge (Chow & Treagust, 2013). Students should be given enough time to reflect and reconcile differences between their preconceptions and mathematically- accepted ones. This reflection could initiate their curiosity about the new concept taught (Limón, 2001). Lee et al. (2003) stated that in case of conflict, students’ anxiety about their existing knowledge would show such responses of discomfort, confusion and feeling of oppression. According to them, a student in situation of conflict would reevaluate his/her state to decide whether to abeyance the state, think more, or seek a more plausible base. In all parts of conceptual change process, especially in cognitive conflict state, students need to be motivated by teachers to engage in conceptual change learning. Motivation beliefs may influence students' readiness to accept new conceptions that contradict their prior knowledge. Many researchers claimed that motivation is necessary to facilitate students' engagement in conceptual change process (Kang, Scharmann, Kang, & Noh, 2010; Kural & Kocakualah, 2016; Limón, 2001; Pintrich, 1999; Vosniadou, 2006). Teachers ask students: how to check if $x = 4$ is the solution of the equation $\frac{x+7}{4} = 8$ or not?. Teachers asks students in groups to substitute their solution " $x = 4$" in the equation " $\frac{x+7}{4} = 8$".

(d) Achieve Scientific Concept

The researcher suggests this new part which is not included in other approaches of conceptual change. The part aims to ensure that student-student and teacher-student discussions lead to understanding the scientific concept. Teachers and some students may give more evidence at the end of a meaningful cognitive conflict process that support the accurate mathematical concept. To ensure that students achieve the scientific concepts, teachers ask some students to explain this concept to whole class. Teachers ask students in groups to do exercises like $\frac{7-x}{3} = 4$ as new problems are related to the new concept.

(e) Explore New Problems

Students would be given opportunities to establish new problems that are related to the new conception (Chow & Treagust, 2013). The researcher agrees with Kural & Kocakualah's (2016) approach which stated that teachers in this part, should ask students to compare their preconceptions and new conceptions, how they are different, and to what extent these new conceptions are useful in resolving new problems. Teachers use exercises like $\frac{2y-3}{5} = 4$ to assess the new concept and to motivate students to make conclusions using their own words about the new concepts.

## 1.2 Statement of the Problem

It is common knowledge that students in different levels of school mathematics have harmful misconceptions in algebra. Even mathematics undergraduate students sometimes have some misunderstandings in calculus (Muzangaw & Chifamba, 2012). The existence of misconceptions, as many researchers asserted, inhibits mathematics understanding of algebra and has a negative effect on understanding other branches of mathematics that are directly related to algebra such as geometry, probability, functions, and calculus. Students who have conceptual errors may face difficulties when they try to resolve problems using algebra in other related subjects such as physics, chemistry and even economics. Bardini, Vincent, Pierce, and King (2014) supported that misconceptions hinder the students' ability to develop problem formulation skills and weakens their performances in algebra. Ojose (2015) asserted that misunderstandings that remain undetected for a long time would negatively influence the future learning of mathematics.

Failure to address these algebraic conceptual errors at some level leads to persistence of these misconceptions in the students' cognitive structure when they move to the next level. This means that new algebraic misconceptions will be added to old ones. Consequently, misconceptions will accumulate which may impede students' understanding of mathematics. Generally, algebraic misconceptions may be one of the main causes of students' weakness in mathematics.

Muzangaw and Chifamba (2012) argued that learners stick to their preconceptions and they aren't enthusiastic to relinquish their them because they could have deeply ingrained in the mental map of an individual. Therefore, it is not easy to replace these inaccurate conceptions with alternative accurate ones. Just making students aware of their misunderstanding of one concept is not sufficient to drive conceptual change, but it is the first important step of the process. It seems that teachers in classrooms, just draw students' attention to their misconception or they directly present the alternative concepts. That is why the conceptual change process generally fails.

In the United Arab Emirates (UAE), where this research will be conducted, students in pre-secondary schools (6, 7, 8 and 9 graders) transit from arithmetic to algebra. In this stage of school, students are taught a variety of algebraic concepts and relations including variables, expressions, equations, and functions. They carry these concepts and relations when they move to secondary schools, where they will find more abstract subjects and advanced algebra applications. In the UAE, grade ten is the first grade in secondary school and considered a basic grade in secondary education. The mathematics curriculum for grade ten in the United Arab Emirates consists mainly of algebra and other topics such as statistics, probability, conic sections and trigonometric functions (moe.gov.ae). Algebraic curriculum for grade ten focuses on a group of topics including:

(a) System of linear equations: graph equations of lines, solve linear equations and solve systems of linear equations and linear inequalities.

(b) Quadratic Functions and Equations: graph quadratic functions, solve quadratic functions and graph and solve quadratic functions inequalities.

(c) Polynomials and Polynomials Functions: operations with polynomials, analyze and graph polynomial functions, evaluate polynomial functions and solve polynomials equations and find factors and zeros of polynomial functions.

(d) Inverse and Radical Functions and Relations: find compositions and inverse of functions, graph and analyze square root functions and inequalities, simplify and solve equations involving roots, radicals and rational exponents.

Several recent researches like Akhtar and Steinle (2013), Holmes, Chelsea, Nieuwkoop, and Haugen (2013), Mulungye, O'Conner, and Dr. Ndethiu (2016), and Öçal (2017) conducted researches to identify and categorize misconceptions in the algebra of secondary school and classify the sources of these misconceptions. For example: Mulungye (2016) observed that some students simplified $\frac{a+x}{b+x} = \frac{a}{b}$. Also, Irawati and Ali (2018) found that students simplified $3x + 4$ as $7x$ and $4 + 3x^2$ as $7x^2$. Moreover, an "omission error" was observed when students try to solve the equation " $2x - 5 = 10 - 3x$". They rewrote it as $2x - 5 - 5 = 10 - 3x$, and then $2x = 10 - 3x$ (Dodzo, 2016).

Some recent studies like Fumador and Agyei (2018), Maharani and Subanji (2018), Öçal (2017), Zubainur and Ali (2018) investigated different approaches of conceptual change in order to eliminate students' misconceptions. Some fruitful efforts have been made in this area, but more research is needed in this field especially in the United Arab Emirates where the researcher lives and works as a mathematics teacher.

Students in school algebra, including those in the United Arab Emirates, where this study will be conducted, need to expose their misconceptions and then apply an appropriate model of conceptual change in order to replace their harmful misconceptions with mathematically correct ones. The present research is intending to investigate tenth graders' misconceptions in algebra and apply an approach of conceptual change based on cognitive conflict to replace the most common algebraic misconceptions that students have in this grade by accepted ones.

Motivation seems to be an essential non cognitive factor for conceptual change because cognitive conflict strategy requires a higher level of cognitive engagement for learners more than conventional strategies do (Limon, 2010). He stated that cognitive conflict strategy demands from the students a higher level of cognitive engagement than more traditional instructional strategies. As Pintrich remarks, motivational beliefs may not have a direct influence on conceptual change, but as theories or beliefs about the self and about learning, they may influence the process of belief formation that takes place when students acquire new knowledge or, in our case, when they are presented with new information that contradicts their prior conceptions. They also may be involved in the degree of cognitive engagement students may reach. Students need a powerful motivation to reduce the conflict caused by contradictory between their prior knowledge and new information (Rahim, Noor, & Zaid, 2015). For this reason, the researcher of current study takes in account the motivation factor besides cognitive conflict in order to foster conceptual change. The researcher focus on two scales of motivation: self-efficacy and goal orientation beliefs (intrinsic and extrinsic).

Students also need to retain accurate concepts after the conceptual change process. Retaining these concepts helps to solve new problems associated with these concepts. The researcher seeks to reach an effective instructional strategy not only to promote conceptual change, but also to ensure that students retain this change of algebraic concepts.

The researcher of the current study intends also to investigate the effect of cognitive conflict strategy and motivation in improving positive attitude towards algebra. The researcher assumes that students' recognizing of their conceptual errors and replacing them by new concepts develop positive attitude for students towards algebra. Chow and Treagust (2011) found that conceptual change approach based on cognitive conflict strategy changed students' attitudes towards algebra positively. The results indicated that there might be potential for improving students' attitude by employing the cognitive conflict approach to learning.

**1.3 Research Objectives**

The purpose of this study is to determine the effects of cognitive conflict instructional strategy and motivation on conceptual change in algebra and attitude towards algebra among Tenth Graders in United Arab Emirates. Specifically, the research aims to investigate:

(1) The most common algebra misconceptions among Tenth Graders in the United Arab Emirates.

(2) The main effect of instructional strategy (cognitive conflict instructional strategy and conventional instructional strategy) on conceptual change in algebra among Tenth Graders in the United Arab Emirates.

(3) The main effect of motivation on conceptual change in algebra among Tenth Graders in the United Arab Emirates.

(4) The interaction effect of instructional strategy and motivation on conceptual change in algebra among Tenth Graders in the United Arab Emirates.

(5) The main effect of instructional strategy on attitude towards algebra among Tenth Graders in the United Arab Emirates.

(6) The main effect of motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates.

(7) The interaction effect of instructional strategy and motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates.

(8) The main effect of instructional strategy on retention of conceptual change in algebra among Tenth Graders in the United Arab Emirates.

(9) The main effect of motivation on retention of conceptual change in algebra among Tenth Graders in the United Arab Emirates.

(10) The interaction effect of instructional strategy and motivation on retention of conceptual change in algebra among Tenth Graders in the United Arab Emirates.

(11) The main effect of instructional strategy on retention of attitude towards algebra among Tenth Graders in the United Arab Emirates.

(12) The main effect of motivation on retention of attitude towards algebra among Tenth Graders in the United Arab Emirates.

(13) The interaction effect of instructional strategy and motivation on retention of attitude towards algebra among Tenth Graders in the United Arab Emirates.

### 1.4 Research Questions

This study attempted to answer the following research questions:

(1) What are the most common algebra misconceptions among Tenth Graders in the United Arab Emirates?

(2) Is there any significant main effect of instructional strategy (cognitive conflict instructional strategy and conventional instructional strategy) on conceptual change in algebra among Tenth Graders in the United Arab Emirates?

(3) Is there any significant main effect of motivation on conceptual change in algebra among Tenth Graders in the United Arab Emirates?

(4) Is there any significant interaction effect of instructional strategy and motivation on conceptual change in algebra among Tenth Graders in the United Arab Emirates?

(5) Is there any significant main effect of instructional strategy on attitude towards algebra among Tenth Graders in the United Arab Emirates?

(6) Is there any significant main effect of motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates?

(7) Is there any significant interaction effect of instructional strategy and motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates?

(8) Is there any significant main effect of instructional strategy on retention of conceptual change in algebra among Tenth Graders in the United Arab Emirates?

(9) Is there any significant main effect of motivation on retention of conceptual change in algebra among Tenth Graders in the United Arab Emirates?

(10) Is there any significant interaction effect of instructional strategy and motivation on retention of conceptual change in algebra among Tenth Graders in the United Arab Emirates?

(11) Is there any significant main effect of instructional strategy on retention of attitude towards algebra among Tenth Graders in the United Arab Emirates?

(12) Is there any significant main effect of motivation on retention of attitude towards algebra among Tenth Graders in the United Arab Emirates?

(13) Is there any significant interaction effect of instructional strategy and motivation on retention of attitude towards algebra among Tenth Graders in the United Arab Emirates?

**1.5 Research hypotheses**

The following null hypotheses were drawn from research questions 2 to 13:

$H_{O1}$: There is no significant main effect of instructional strategy (cognitive conflict instructional strategy and conventional instructional strategy) on conceptual change in algebra among Tenth Graders in the United Arab Emirates.

$H_{O2}$: There is no significant main effect of motivation on conceptual change in algebra among Tenth Graders in the United Arab Emirates.

$H_{O3}$: There is no significant interaction effect of instructional strategy and motivation on conceptual change in algebra among Tenth Graders in the United Arab Emirates.

$H_{O4}$: There is no significant main effect of instructional strategy on attitude towards algebra among Tenth Graders in the United Arab Emirates.

$H_{O5}$: There is no significant main effect of motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates.

$H_{O6}$: There is no significant interaction effect of instructional strategy and motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates.

$H_{O7}$: There is no significant main effect of instructional strategy on retention of conceptual change in algebra among Tenth Graders in the United Arab Emirates.

$H_{O8}$: There is no significant main effect of motivation on retention of conceptual change in algebra among Tenth Graders in the United Arab Emirates.

$H_{O9}$: There is no significant interaction effect of instructional strategy and motivation on retention of conceptual change in algebra among Tenth Graders in the United Arab Emirates**.**

$H_{O10}$: There is no significant main effect of instructional strategy on retention of attitude towards algebra among Tenth Graders in the United Arab Emirates.

$H_{O11}$: There is no significant main effect of motivation on retention of attitude towards algebra among Tenth Graders in the United Arab Emirates.

$H_{O12}$: There is no significant interaction effect of instructional strategy and motivation on retention of attitude towards algebra among Tenth Graders in the United Arab Emirates**.**

**1.6 Significance of the Study**

The significance of the study lies in the treatment of students' conceptual errors in algebra to help them get a deeper understanding of algebraic concepts, relationships, expressions, equations and functions as well as prepare them for advanced and more abstract mathematics knowledge. No doubt, students with accurate scientific concepts are much abler to solve real life problems.

The researcher assumes that a meaningful motivated cognitive conflict experience forms an essential opportunity for a student to be aware of his/her preconception. This sense of contradiction may encourage students to review their existing data, converse with peers and resolve contradiction. This opportunity may provide students with enthusiasm and constructive interaction necessary to build sound mathematics knowledge. One more importance of this study is its interest in retention of mathematically-accurate concepts after the process of conceptual change takes place. The researcher seeks to reach an effective teaching strategy not only to promote conceptual change, but also to ensure that students retain this change of algebraic concepts.

Finally, this research is an occasion to investigate a model of cognitive and non-cognitive factors (cognitive conflict and motivation) for fostering conceptual change after the criticisms directed to the conceptual change which is based on cognitive processes only (Kang, Scharmann, Kang, & Noh, 2010; Kural & Kocakülah, 2016; Limón, 2001).

### 1.7 Limitations of the Study

This study will be conducted during the school year 2019/2020. The study will be limited to Tenth Graders in government schools in the United Arab Emirates. Precisely, this study attempts to identify students' misconceptions in algebra. This study only focuses algebra misconceptions related to (1) Algebraic Expressions, (2) Linear Equations, (3) Polynomials, Exponents and Radical Expressions, and (4) Functions and Graphs only. Other misconceptions related to factorization, algebraic formulae and problem solving are not included. The current study does not endeavor to deal with misconceptions in all branches of mathematics. The researcher is interested in investigating an approach of only two factors that may influence conceptual change: cognitive conflict and motivation. This study will be concerned with only two factors of motivation: goal orientation and self-efficacy. It is also limited to measuring conceptual change in algebra and is not attempting to determine the level of algebra understanding of Tenth Graders.

The research design will be quasi-experimental because the population of the study is part of an educational system that mandates keeping intact classrooms, which limited the ability to popularize to a larger population. The sample of the study will be limited to four classes of the population: two classes for experimental group and the other two for control group. The researcher will use only a questionnaire to measure student's motivation. Another limitation of this study is the ten-week duration of treatment as this is the standard trimester duration in the UAE where this study will be conducted. Increasing the duration of intervention may lead to more positive effects.

In the current study, conceptual change and retention of conceptual change of students' preconceptions will be assessed using only algebraic conceptual test. The experimental and control groups will be taught by two teachers; there will be no control for the variability introduced by the teachers. The teachers may affect post-test scores through means not related to the intervention.

## 1.8 Definitions of Terms

**Conventional Instructional Strategy:** Balliu and Belshi (2017) defined conventional instructional strategy as an instructional strategy in which teachers are the center of teaching during classes. They provide direct lecturing and guidelines and lay emphasis on teaching processes. Students in this strategy, expect to listen and learn by their teachers. Metwally, Ebrahim, and husseiny (2017) defined conventional instructional strategy as teacher-centered teaching method designed about subject areas in which teachers prepare structured packages of knowledge, insight and conclusions while students take notes, memorize and master imparted information. As it is related to this study, conventional instructional strategy is a teacher-centered strategy in which a teacher will explain algebraic target concepts, present some examples, draw students' attention to their conceptual errors in case