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Effect of Cognitive Conflict Instructional Strategy and Motivation on Attitude towards Algebra among Tenth Graders

Yasseen Rabab'ah
Arab Oben University-Jordan
Email: y_rababah@aou.edu.jo

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Abstract

This paper aims to determine the effects of cognitive conflict instructional strategy and motivation on Attitude Towards Algebra Among Tenth Graders in the UAE. To collect data, the author adapted a Motivation to Engage in Conceptual Change Questionnaire (MECCQ) to measure the level of student's motivation to engage in conceptual change. Pre and post questionnaires were analyzed to measure students' attitude towards algebra. Four classes of Tenth Graders from two schools (two classes for experimental group (n=60) and the other two classes for control group (n=57)) were choose randomly from 20 classes of 543 Grade Ten male students. The two-way ANOVA test was used to answer questions of this study. The results showed that there is no significant main effect of cognitive conflict on attitude towards algebra. However, the results showed some increase in the students' attitudes towards algebra in the experimental group. The results also showed that there is significant main effect of motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates.

Keywords: Algebra, Algebra Misconceptions, Cognitive Conflict Strategy, Attitude towards Algebra.

Introduction

Students acquire a variety of conceptual errors during algebra lessons, due to teaching strategies, peers, or parents. These misconceptions often hinder students' understanding of various algebra lessons and impact negatively their comprehension of new concepts in later lessons or grades. Ultimately, these errors affect students' achievement and performance in algebra. Examples of these errors include:

(1) Adding algebraic fractions like $\frac{5x}{2} + \frac{2x}{6}$ incorrectly. Some students add numerators and denominators instead of rewriting each fraction with a common denominator. The expected incorrect answer is $\frac{7x}{8}$.

(2) Using wrong inverse operation. For example, some students They worked $x - 5 = 9$ as $x - 5 - 5 = 9 - 5$ and then, $x = 4$.
(3) Using distributive property incorrectly. Some students expand an expression like $(x + 4)^2$ as x^2+ 16.

(4) Simplify algebraic expressions incorrectly like simplify an expression $2x + 3y$ as 5xy.

Ojose (2015) defined misconceptions as misunderstandings and misinterpretations based on incorrect means. 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). The challenging issue lies in that students stick to their misconceptions, and they sometimes refuse to review them. In search of solutions to address these conceptual errors, many researchers have proposed cognitive conflict as an instructional strategy to minimize students' misconceptions by introducing contradictory experiences that confront students' existing knowledge in order to reconstruct their concepts (Chow & Tregust, 2013; Irawati, Zubainur, & Ali, 2018; Kabaca, Karadag, & Aktumen, 2011; Toka & Aşkar, 2002). Cognitive conflict strategy provides an opportunity for students to be dissatisfied with their prior inaccurate knowledge. In this case, the opportunity becomes ripe for replacing students' alternative concepts with mathematically correct ones.

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 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. 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.

In the current study, the author adopted some models that support positive results of cognitive conflict to promote conceptual change. These models include four main common elements: making students aware of their preconcepts, comforting them by anomalous data, using cognitive conflict to change student's prior knowledge and finally evaluating 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 factors (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 process of this approach under these headings: (a) Detect Students Preconceptions, (b) Evaluate Students Preconceptions, (c) Create Cognitive Conflict, (d) Achieve Scientific Concept and (e) Explore New Problems.

Problem Statement & Study Rationale

It is common knowledge that students in different levels of school mathematics have harmful misconceptions in algebra. 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. 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.

Many studies have indicated that students have negative attitudes towards mathematics (Atnafu, 2010; Uygun & Tertemiz, 2014; Julius, Abdullah & Suhairom, 2018). There is an urgent need to develop students' attitudes towards algebra, which will help increase their engagement in solving algebra problems. The researcher of the current study intends also to investigate the effect of cognitive conflict strategy 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.

Literature Review

Many studies found a positive effect for cognitive conflict as an instructional strategy for conceptual change. Christou and Vosniadou (2005) found that the conceptual change framework provided better explanation of students' difficulties in interpreting literal symbols in algebra. The same result was found by Irwati and Ali (2018) when they investigate the effect of cognitive conflict in minimizing students' misconceptions about addition and subtraction of algebraic expression.

Fitri, Johar, and Ahmad (2018) designed a lesson plan using cognitive conflict strategy to minimize students' misconceptions related to fraction. According to the researchers, students have misconceptions in comparing two fractions. They compare fractions by looking at the differences between the numerator and the denominator. Students are surprised to learn that multiplication of fractions does not necessarily lead to larger answers. Also, Students are surprised that multiplying fractions does not necessarily lead to larger answers. This suggests that learners remain on their previous knowledge of integers. Students are unable to integrate their previous experience with newly acquired skills. The lesson plan was designed using conceptual conflict and included four key elements: (a) Detecting of initial concepts for students; (b) Assessing the basic concepts of students; (c) Creating cognitive conflict, and (d) Guiding students to restructure the initial concept. This lesson plan satisfied the valid criteria and can be tested in terms of its application and effectiveness.

(Chow & Treagust, 2013) used a model of cognitive conflict strategy to foster conceptual change consisting of four main elements: make students aware of their preconceptions, comforting them by anomalous data, using cognitive conflict to change

student's exist knowledge and finally evaluate the results of conceptual change. It was found that cogitative conflict strategy had a positive effect on improving students' conceptual understanding, attitudes toward mathematics and achievement in algebra. Morgan and Ritter (2002) found that Cognitive Tutor Algebra program was effective in improving learner's attitude towards mathematics. They are more likely to think that mathematics is useful and feel more confident about their abilities in mathematics.

The conceptual change process based on cognitive conflict was not influential as might be predictable in some cases (Kang, Scharmann, Kang, & Noh, 2010). These negative results led to analyzing the reasons that make students unable to change their own prior ideas even if they have been made aware of contradiction. Limón (2001) referred these findings to that most of the theoretical 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 into account because cognitive conflict strategy requires from learners a higher level of cognitive engagement more than that of traditional teachings strategies. The researcher argued that to consider new information meaningful for students, they need to be motivated about the problems and topics introduced. According to him, motivational beliefs are extremely dependent on the classroom's context rather than on individual beliefs. He recommended that further studies should investigate the influence of all these aspects independently and the interaction between them. Vosniadou (2006) agreed with the criticisms that faced the classical approach of conceptual change in which metaconceptual, motivational, affective and social/cultural factors were not considered. The researcher argued that motivational factors are insistently needed for students to change their prior knowledge. According to Assagaf (2013), motivation is one of the essential variables that could induce meaningful cognitive conflict for conceptual change is motivation.

Research Design

In order to acquire information for the first area, two intact treatment groups (each group consists of two classes) were assigned randomly to the experimental group (X_1) and the control group (X_2). The target two groups were assigned to the Motivation to Engage in Conceptual Change Questionnaire (MECCQ) and categorized each group into two levels of motivation. Attitude Towards Algebra Questionnaire (ATAQ) was administrated two times for each group: before treatment to measure tenth graders' pre-attitude towards algebra, after ten weeks of treatment to measure post attitude towards algebra. The research design is shown in Table 1.

Table1
Research Design

Group	Motivation	Pre-questionnaire	Treatment	Post-questionnaire
Exp Group	Low	O_1	X_1	O_2
	High	O_1	X_1	O_2
Control group	Low	O_1	X_2	O_2
	High	O_1	X_2	O_2

Where,
O_1: Represents Pre- questionnaire scores of experimental & control groups,
O_2: Represents Post- questionnaire scores of experimental & control groups,
X_1: Represents cognitive conflict instructional strategy,
X_2: Represents conventional instructional strategy.

Participants

The population of the study consisted of all Grade Ten male students in public schools of ALAIN city in the United Arab Emirates. Specifically, target population was 20 classes of 543 Grade Ten male students. In addition, all Tenth Graders' teachers in all secondary schools of ALAIN city were involved in this study. Therefore, simple random sampling was conducted to choose (4) classes of Tenth Graders from two schools (two classes for experimental group from the first school (N=60) and the other two classes for control group from the second school (N=57)).

Instruments

In order to collect data for this study, the MECCQ was used to measure student's motivation to engage in conceptual change. Based on the results of MECCQ, students were categorized into two levels of motivation: low and high. For MECCQ, the researcher adapted the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich et al. (1991). The MSLQ consists of two sections, motivation and learning strategies. The motivation section contains 31 items that evaluate goal orientation (intrinsic and extrinsic), task value, self-efficacy for learning and performance, control beliefs and test anxiety. The ATAQ was used to measure student's attitude towards algebra. The researcher adapted the items corresponding to confidence and usefulness scales from Fennema-Sherman Attitude Scales developed by Fennema and Sherman (1976). ATAQ will be used to measure tenth graders' pre-attitude towards algebra and post attitude towards algebra.

Data Collection

The researcher conducted training for the participating teachers in the expanded experimental study about the different types of treatment. The MECCQ was used to measure student's motivation to engage in conceptual change. Pre-ATAQ to measure tenth graders' pre-attitude towards algebra was conducted before treatment. Ten weeks of treatment were conducted and then Post-ATAQ was administrated.

Findings

Results of Two-way ANOVA Test for Pre-ATAQ

The two-way ANOVA test was conducted to determine whether there was a significant difference according to treatment groups, motivation levels and interaction between them in Pre-ATAQ scores. The results of the two-way ANOVA test for Pre-ATAQ are given in Table 2.

Table 2
Results of Two-way ANOVA Test for Pre- ATAQ

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Treatment Group	42.604	1	42.604	.248	.619
Motivation Level	5361.184	1	5361.184	31.239	.000
Treatment Group * Motivation Level	67.172	1	67.172	.391	.533
Error	19393.106	113	171.620		
Total	24863.966	116			

Based on the results in Table 2, it was found that there was no significant difference in the Pre-ATAQ scores according to treatment groups, F (1, 113) = .25, p = .62 (>.05). However, there was a significant difference between motivation levels, F (1, 113) = 31.24, p = .00 (<.05). It was also found out that there was no significant two-way interaction effect between treatment groups and motivation levels in terms of Pre-ATAQ, F (1, 113) = .39, p = .53 (>.05). Thus, the two-way ANOVA test will be used to analyze Post-ATAQ scores.

Results of Two-way ANOVA Test for Post-ATAQ

The two-way ANOVA test was conducted to determine whether there was a significant difference according to treatment groups, motivation levels and interaction between them in Post-ATAQ scores. The results of the two-way ANOVA test for Post-ATAQ scores are given in Table 3.

Table 3
Results of Two-way ANOVA Test for Post-ATAQ

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Treatment Group	227.144	1	227.144	1.145	.287
Motivation Level	3547.379	1	3547.379	17.883	.000
Treatment Group * Motivation Level	87.289	1	87.289	.440	.508
Error	22415.341	113	198.366		
Total	26297.077	116			

Based on the results in Table 3, it was found that there was no significant difference in the Post-ATAQ scores according to treatment group (i.e., instructional strategy), F (1, 113) = 1.15, p = .29 (>.05). The Post-ATAQ scores of the Tenth Graders in the United Arab Emirates in the experimental group (mean = 82.28, see Table 3) who learned algebra through cognitive conflict instructional strategy was not significantly higher than their counterparts in the control group (mean = 79.23, see Table 3) who learned algebra through conventional instructional strategy. The results implied that there is no significant effect of instructional strategy on attitude towards algebra among Tenth Graders in the United Arab Emirates.

However, based on the results in Table 3, it was found that there was a significant difference in the Post-ATAQ scores according to motivation level (i.e., motivation levels to engage in conceptual change), F (1,113) = 17.88, p = .00 (<.05).

The Post-ATAQ scores of the Tenth Graders with high level of motivation in the United Arab Emirates (mean = 86.27, see Table 3) was significantly higher than their counterparts with low level of motivation (mean = 75.22, see Table 3). The results implied that there is significant main effect of motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates.

Based on the results in Table 3, it was found that there was no significant difference in the Post-ATAQ scores according to interaction between treatment groups and motivation levels in the Post-ATAQ scores, F (1, 113) = .44, p = .51 (>.05). The results implied that there is no significant interaction effect of instructional strategy and motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates. In other words, the effect of the motivation level (i.e., motivation levels to engage in conceptual change) on attitude towards algebra among Tenth Graders in the United Arab Emirates in the Post-ATAQ scores does not depend on the treatment (i.e., instructional strategy) among Tenth Graders in the United Arab Emirates. This therefore suggests that, irrespective of the treatment (i.e., instructional strategy) among Tenth Graders in the United Arab Emirates, the Post-ATAQ scores of the Tenth Graders with high level of motivation in the United Arab Emirates was significantly higher than their counterparts with low level of motivation.

The result of this study shows that there is no significant effect of instructional strategy on attitude towards algebra. This result is consistent with the result that found by Zetriuslita, Wahyudin, and Jarnawi (2017) in which they found that problem-based learning and cognitive conflict strategy can improve students' mathematical critical thinking skill, it has not improved their mathematical curiosity attitude. This result contradicts the result that was found by Chow and Treagust (2013) in which the researchers found that cogitative conflict strategy had a positive effect on improving students' conceptual understanding, attitudes toward mathematics and achievement in algebra. The result of current study shows that there is significant main effect of motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates. This result is consistent with the result that found by Olusanmi (2010) which have reported that students' motivation has a significant effect on their attitude towards mathematics. This result is also in accordance with Mata, Monteiro, and Peixoto's (2012) study in which the researchers found that attitudes toward mathematics are deeply related to motivation and social support. The result of this study agrees with Kim's (2009) study which indicated that motivation was an effective factor in improving learners' attitudes toward mathematics. The result of this study also shows that there is no significant interaction effect of instructional strategy and motivation on attitude towards algebra.

Conclusion

Misconceptions limit students' ability to properly understand algebra and related subjects which require addressing these conceptual errors. In spite of the result of this study that there is no significant effect of cognitive conflict instructional strategy on attitude towards algebra, this study suggests that fruitfulness conceptual change may improve students' attitudes toward algebra. This result may be due to students' high attitudes towards

algebra. However, the results showed some increase in the students' attitudes towards algebra in the experimental group. The results implied that there is significant main effect of motivation on attitude towards algebra among Tenth Graders in the United Arab Emirates. Further studies could search for effects of cognitive conflict instructional strategy on attitude towards algebra especially for those students who have a low attitude towards algebra.

This research explores how cognitive conflict, a strategy that challenges existing knowledge, can be used to promote conceptual change and positive attitudes in algebra learning. This research is significant because it was conducted in the United Arab Emirates and provides insights into the effectiveness of cognitive conflict and motivational strategies in this specific educational setting. It also provides perceptions into the specific challenges faced by tenth-grade students in learning algebra and how these challenges can be addressed using cognitive conflict and motivational techniques. This could inform educational practices and curriculum development in the UAE and similar contexts.

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