

Improving Junior High School Students' Achievement in Algebraic Expressions: The Pre-test-Post-test Non-equivalent Control Group Design

ABSTRACT

This study explores junior high school students' achievement in algebraic expressions using the think-pair-share learning method. The study used the pre-test-post-test non-equivalent control group design. The participants were selected from two intact classes (already-formed groups), and received either an intervention (the treatment group) or not an intervention (the control group). The participants consisted of one hundred (100) form three (3) junior high school students of equal mathematics ability (control group = 54 students; experimental group = 46 students) in a high school in the central region of Ghana. Before the intervention, the results of the independent samples t-test indicated a non-statistically significant difference between the experimental and control pre-test scores ($t = -.48, p > .05, C. I = [-1.78, 1.08]$). After the intervention, a one-way ANOVA indicated that the effect of the method of instruction was significant for student scores, $F(1, 98) = 353.98, p < .05$. Also, the paired-sample t-test for the pre-test and post-test scores indicated the students' post-test scores were statistically higher than their pre-test scores ($t(98) = -8.44, p < .05$). Further, the results of the independent samples t-test for the post-test also indicated statistically significant differences between the experimental and control post-test scores ($t = -22.68, p < .05, C. I = [-24.29, -20.40]$). This study implies that students gain leadership and decision-making skills, enhance their communication skills, develop confidence in their problem-solving abilities, nurture positive attitudes toward their colleagues and take personal responsibility. The study concludes that the think-pair-share learning method improves students' mathematics achievement.

Keywords: Algebraic expressions, the pre-test-post-test non-equivalent control group design, intervention, think-pair-share collaborative learning method, intact classes.

1. INTRODUCTION

Mathematics teachers often face many challenges in choosing the appropriate and effective instructional method to improve student mathematics achievement. Sometimes, a particular instructional method alone may not be enough to improve student mathematics achievement, a combination of some of these instructional methods and their usage in the classroom could render them very beneficial to enhance student mathematics learning and achievement. These innovative instructional methods and techniques should be effectively developed to ensure that students become successful learners. Teachers must, therefore, use effective instructional methods for students to attain high mathematics achievement [1]. These instructional methods provide a systematic process and a framework for teachers to plan,

develop, and adapt mathematics instruction [2]. Aside from these instructional methods that could improve student mathematics learning, demographic, social, economic, and educational factors affect student mathematics achievement [3, 4, 5]. Other factors such as gender, family structure, parents' educational level, socio-economic status, parent and student attitudes toward school, and parent involvement [5,6], are known to improve student mathematics achievement.

Literature review

Students' educational success depends strongly on their parents' social-economic [6]. A student's parental socioeconomic status (SES) explains a lot of the variation in achievement among students [7]. [8] contend that students whose parents are socially, educationally, and economically advantaged, always have high achievement levels. Teachers' training background coupled with quality professional development improves student achievement [9]. Further, the quality of teaching and learning, which enhances academic achievement is dependent on teaching and learning materials. A strong relationship exists between the use of recommended textbooks and academic achievement [10].

Students' levels of engagement and beliefs about their competence and expectations, successfully promote or interfere with their ability to succeed academically [11]. Student engagement predicts their academic achievement [12-14]. Therefore, the relationship between student engagement and academic achievement has been studied widely [15,16]. There is a correlation between cognitive engagement and student achievement [17]. Many studies have indicated that student learning strategies about cognitive engagement are related to achievement [18]. There is also a correlation between behavioural engagement and academic achievement [19,20]. For example, diligence, which pertains to behavioural engagement, affects academic achievement [21]. Diligent students always improve their academic achievement because they do their assignments and are attentive in class [22]. Cognitive engagement correlates more strongly with achievement than behavioural and affective engagement [22]. Student affective engagement significantly correlates with academic achievement [23]. Thus, students who interact well with their teachers obtain better results than students who do not [24]. Additionally, students' interest in mathematics enables them to obtain high achievement in mathematics.

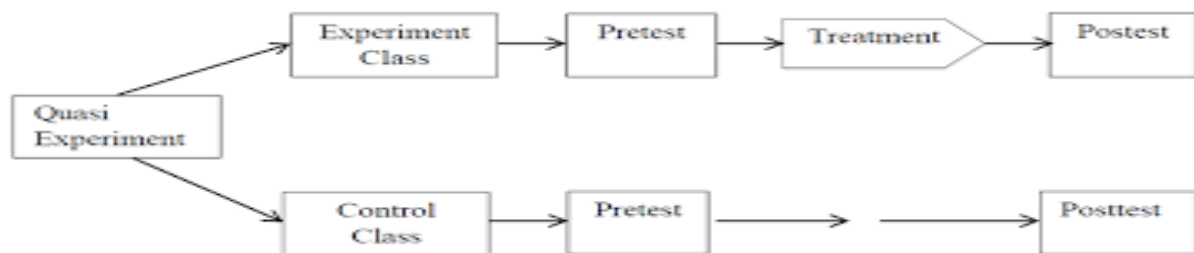
Research findings indicate that teachers' mathematics knowledge and beliefs are linked to their instructional choices [25, 26, 27, 28, 29, 30]. These teachers need to be experts in their fields to apply their philosophy in teaching. They need adequate knowledge to prepare their students for challenging work in school [31]. Aside from the knowledge they need of a particular subject matter, they also need to have good pedagogical knowledge [32]. Their knowledge and skills related to these areas are linked closely to student thinking, understanding, and learning of mathematics. Students' mathematics achievement improves if teachers are knowledgeable in the subject they teach [33, 34]. Grounded on data from previous research, the following question was set: Are there statistically significant differences in scores between the post-test and pre-test in students' achievement in algebraic expressions after using the think-pair-share learning method, as an intervention?

2. MATERIAL AND METHODS

Design

The study used the pre-test-post-test non-equivalent control group design. For this design, the participants were selected from two intact classes (already-formed groups) and received either an intervention (the treatment group) or not an intervention (the control group). The outcome of interest was measured twice, once before the treatment group received the intervention, the pre-test, and once after the post-test. The objective was to measure the effect of the intervention, by using the think-pair-share method in teaching algebraic expressions. This design had three major characteristics: The participants were not randomly assigned to either the treatment or the control group, and both groups were exposed to the same conditions except for the intervention: The treatment group received the intervention, whereas the control group did not, and the outcome was measured simultaneously for both groups at two points in time-the pre-test and post-test.

Chart 1 : Design framework



Participants

The participants were one hundred (100) form three (3) junior high school students of equal ability in mathematics (control group = 54 students; experimental group = 46 students) in a junior high school in the central region of Ghana. There were one hundred and sixty (160) form three students in the school. The average age of the participants was fifteen years and two months.

Intervention

Think-pair-share is a form of collaborative learning method, where students work together in pairs to achieve a common objective. With this approach, a lecturer poses a question during a lecture, asks students to think about the topic individually, and then has them discuss their conclusions in pairs. The use of think-pair-share results in increased participation, improved retention of information, and higher levels of student confidence [35]. Most people know from experience that a powerful way to learn the material at a deep level is to teach it to others [36].

When pairs of students work together to solve mathematical problems, they represent the most effective form of interaction [37]. When students work in pairs, one person listens while the other partner discusses the question under investigation. Both are developing valuable problem-solving skills by formulating their ideas, discussing them, receiving immediate feedback, and responding to questions and comments from their partner [37]. During instruction, students may or may not be involved by listening to the lecturer or taking

notes [38]. This practice falls within the larger domain of collaborative learning where students work together in small groups to achieve learning goals [39]. [39] emphasise five attributes of think-pair-share: a common task or learning opportunity suitable for group work, small-group learning, cooperative behaviour, interdependence, and, individual accountability and responsibility.

Think-pair-share provides many advantages to lecturers and students. Many of these advantages arise from the intrinsic motivational strengths of think-pair-share learning and the extent to which it fosters student interest, behavioural and attitudinal change, and opportunities for success. Cooperative learning, which includes think-share-pair, is an umbrella term for a variety of educational approaches involving a joint intellectual effort by students and lecturers together. Usually, students work in groups of two or more, mutually searching for understanding, solutions, or meanings in mathematics or creating a product. In this study, the lecturer met the students and advised them to participate actively in the learning process. Four important principles of active learning were demonstrated in the lecturer-student interactions. The students (1) constructed their learning (2) built new learning on their prior knowledge (3) enhanced learning through social interaction with their peers, and (4) developed learning by solving authentic tasks [40].

Pre-test and Post-test

The pre-test consisted of twenty (20) questions covering the entire syllabus. These questions were administered to the students to ascertain their performance before the intervention. Similarly, the post-test also contained twenty (20) questions, which were administered to the students after the intervention described previously, had taken place.

3. RESULTS

Table 1 Independent samples t-test for the pre-test scores.

		Levene's test for equality of variances		t-test for equality of means					95% C.I.	
		F	Sig.	t	df	Sig. (2 tailed)	Mean difference	Std. difference	Lower	Upper
Pre-test	Equal variances assumed	1.11	.30	-.20	98	.84	-.14	.71	-1.55	1.27
	Equal variances not assumed			-.20	91.40	.85	-.14	.72	-1.56	1.28

Table 1 shows the independent samples t-test for the pre-test scores. Levene's test for equality of variances shows that the equal variance assumption is upheld ($F= 1.11, p >.05$). The results of the independent samples t-test indicated non-statistically significant differences between the experimental and control pre-test scores ($t (98) = -.20, p > .05, C. I =$

[-1.55, 1.27]). Table 2 shows the ANOVA tests of between-subjects effects with their difference as the dependent variable

Table 2 ANOVA table of tests of between-subjects effects with their difference as the dependent variable

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Group	12232.02	1	12232.02	353.98	.000
Error	3386.49	98	34.56		
Total	15618.51	99			

Table 2 shows the tests of between-subjects effects between the experimental and control groups. A one-way ANOVA indicated that the effect of the method of instruction was significant for student scores, $F(1, 98) = 353.98, p < .05$. The group statistics indicated that the experimental group ($M = 74.61, SD = 5.73$) performed better than the control group ($M = 52.28, SD = 3.71$). Table 3 indicates the paired-sample t-test for the pre-test and post-test scores

Table 3 Paired samples t-test for the pre-test and post-test scores

	Mean	Std. Deviation	Std. Error Mean	95% C.I.		t	df	Sig. (2 tailed)
				Lower	Upper			
Pre-test- Post-test	-10.93	12.56	1.27	-13.42	-8.44	-8.70	99	.000

Table 3 shows the paired-sample t-test for the pre-test and post-test scores. The results indicated that the students' post-test scores were statistically higher than their pre-test scores ($t(99) = -8.70, p < .05$), this follows from the difference between the post-test and pre-test means of -10.93. Table 4 shows the independent samples t-test for the post-test scores.

Table 4 Independent samples t-test for the post-test scores.

		Levene's test for equality of variances		t-test for equality of means				95% C.I.		
		F	Sig.	t	df	Sig. (2 tailed)	Mean difference	Std. difference	Lower	Upper
Post-test	Equal variances assumed	6.47	.01	-	98	.00	-22.33	.95	-24.22	-20.44
	Equal variances not assumed			-	74.80	.00	-22.33	.99	-24.29	-20.40

Table 4 shows the independent samples t-test for the post-test scores. Levene's test for equality of variances shows that the equal variance assumption is violated ($t(98) = -23.44, p < .05$). However, the independent samples t-test is robust to departure from normality and violation of the equality of variances assumption, hence equal variances is not assumed. The results of the independent samples t-test along this row, indicated statistically significant differences between the experimental and control post-test scores ($t = -22.68, p < .05, C. I = [-24.29, -20.40]$). Figure 1 shows the estimated marginal means of the difference between the post-test and pre-test scores.

Figure 1 Estimated marginal means of the difference between the post-test and pre-test scores

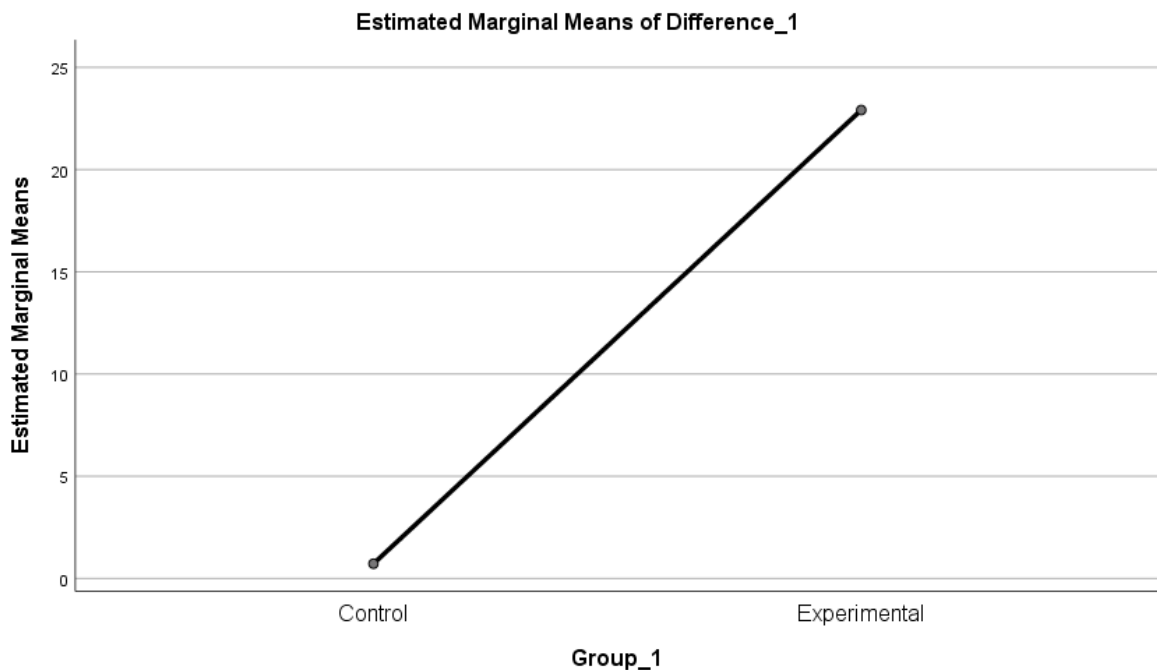


Figure 1 shows the estimated marginal means of the difference between the post-test and pre-test scores. The figure indicated that the estimated marginal mean for the experimental group ($M = 24.61$), was higher than the mean of the control group ($M = 1.22$).

4. DISCUSSION

The improvement in the post-test scores in the experimental group over the post-test scores in the control group points to the effectiveness of the think-share method as an instructional method. Its versatility provided a systematic framework for the teacher to plan for his instruction [2]. The students retained more knowledge during the active engagement with the learning process, thus demonstrating extremely effective learning and teaching method [41]. Think-share-method provided a structured process for team members to work and accomplish a common goal, stress positive interdependence, individual accountability, and group accountability. The accountability rules made each member individually and

collectively responsible for the group's work [42]. Students who are taught using the think-pair-share method have longer information retention, better performance in examinations, stronger critical thinking, and problem-solving skills, more positive attitudes toward mathematics and greater motivation to learn it, better interpersonal and communication skills, and, higher self-esteem [37]. Teachers who use such effective instructional methods translate into high mathematics achievement among their students [1]. These teachers' mathematics knowledge and beliefs are dependent on their instructional choices [26, 27, 28, 29, 30, 31].

Think-pair-share method results in increased participation, improved retention of information, and higher levels of student confidence [35]. The benefits of collaborative learning activities tend to foster active learning. Information teachers give to their students must develop into communities that discuss, debate, and summarise ideas. Most people claim that an effective and constructive way to learn and grasp the content is to teach others [36]. When students work in pairs to solve mathematical problems, it represents the most effective form of interaction [37]. During such a situation, one student listens while the other explains or discusses or explains his/her viewpoint. Both develop valuable problem-solving skills by formulating their ideas, discussing them, and receiving immediate feedback from the other [37]. During the session, both students are engaged.

When students work in pairs, they focus and concentrate as a group. It allows them to review their viewpoint before presenting it to the whole class, thereby, reducing many mistakes and errors [37]. [43] contend that students who work in small groups tend to learn more content and retain it longer than when it is taught using other forms of instruction. Students who work using the think-pair-share method appear more contented working in their groups by placing them in groups and giving them tasks in effective ways to capitalise on their social needs. Collaboration and cooperation among students are integral components of the think-pair-share learning approach. By working as a team, [41] claim that such a relationship can create a positive interdependence and individual accountability among students as each member consciously contributes to the team's progress. Cooperation can also foster students' growth, develop social and learning skills and help them construct their knowledge through engaging in the exchange of ideas.

The use of an active classroom or constructive learning technique provided the students with a great opportunity to engage with the content since they explored ideas among themselves before arriving at conclusions [3]. They built consensus through dialogue and open debate when working in their respective groups. As they engaged with themselves, they nurtured confidence and expressed themselves competently. This learning method enabled the lecturer to elicit responses from the students based on their thinking and creativity, with the lecturer largely facilitating the learning process [3]. These strategies include but are not limited to, making mind maps and allowing the students to make presentations.

Implications to teaching and learning

Results indicate that cooperative learning experiences promote higher achievement and greater retention than individual learning experiences for all students [36]. Cooperative learning, in addition to impacting academic achievements, also positively influences the attitudes of students. The effects of cooperative learning on attitudes are evidenced by

increases in self-esteem, social acceptance, and lecturer ratings of students [44]. Cooperation is working together to accomplish shared goals. Within cooperative activities, individuals seek outcomes that are beneficial to themselves and beneficial to all other group members in mathematics education.

A carefully structured think-pair-share method during mathematics lessons involves students working in teams to accomplish a common goal, under conditions that involve both positive interdependence and individual and group accountability. To be successful, members must have confidence in each other, promote each other's learning, and hold others accountable to do their share of the work. From the findings of this study, the think-pair-share method appears to demonstrate positive effects on the learning of mathematics. Although the think-pair-share method may require more teacher preparation of lesson materials and monitoring of activities, the rewards and benefits teachers and students derive from this method are significant. Mathematics teachers should encourage positive interdependence by assigning their students very meaningful roles.

5. CONCLUSION

Think-share-pair, a collaborative learning method, provides many advantages to teachers and students. These advantages arise from the intrinsic motivational strengths of collaborative learning and the extent to which it fosters student interest, behavioural and attitudinal change, and opportunities for success. Cooperative learning represents a significant shift away from the typical lecture-centred learning method. In collaborative classrooms, the lecturing process may not disappear entirely, but it lives alongside other methods based on students' discussion and active work with the mathematics content. Teachers who use cooperative learning approaches think of themselves less as expert transmitters of knowledge to students and more as expert designers of intellectual experiences for students [44,45].

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