BLENDING FORMATIVE ASSESSMENT WITH METACOGNITIVE SCAFFOLDING STRATEGIES: ITS EFFECT ON STUDENTS' ACHIEVEMENT AND SELF-REGULATION SKILLS IN CHEMISTRY

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ABSTRACT

The study was undertaken to examine the effect of blended formative assessment with metacognitive scaffolding strategies on students' achievement and self-regulation skills in learning Chemistry with focus to secondary schools in Addis Ababa City, Ethiopia. The study adopted pretest posttest quasi-experimental design. Three groups were involved in the study, two experimental and one comparison groups. The experimental groups practiced the formative assessment and blended formative assessment with metacognitive scaffolding strategies respectively, whereas for the comparison group the existing instruction were implemented. The sample, consisting of 132 eleven grade students, was taken by using the multistage random sampling technique from three secondary schools. The Chemistry Achievement Tests (CAT) and the Chemistry Self-Regulation Skills Questionnaire (CSRSQ) were the instruments for data collection. The internal consistency of the CAT was obtained using Kudder Richardson formula 20(KR-20) and the reliability index obtained was 0.79. The reliability coefficient for CSRSQ was estimated using Cronbach alpha and its value was found to be 0.76. For the pre- and post-tests' data analysis, descriptive statistics (mean and standard deviation) and inferential statistics (One-way ANOVA) tests were implemented to compare the scores obtained from the experimental and comparison groups. The main finding of one-way ANOVA indicated that there was a significant effect on students' achievement [F (2,129) = 13.32; $p<0.001$] and their self-regulation skills [F (2,129) = 12.38; $p<0.001$]. Moreover, effect size estimate was used to provide a strong validation on the variation between the three groups for the measure of students' achievement and self-regulation skills in learning chemistry. Recommendations were made to promote the use of blended formative assessment with metacognitive scaffolding strategies aiming at the improvement of student achievement and self-regulation skills in learning Chemistry at secondary schools. *[African Journal of Chemical Education—AJCE 11(2), July 2021]*

INTRODUCTION

Over the years, many efforts have been made in developing the Science Education program that would serve the aspirations of students and meet the global societal goals of education. The ideal science program is one which keeps pace with the modern modifications and challenges in the society with a view to addressing them in order to make this world better place to live in [1]. Because of this, the instructional design has moved through a series of improvement phases. The move from behaviorism through cognitivist to constructivism represents shifts in emphasis away from an external view to an internal view of learning [2]. This turning point of learning processes asks for designing of instruction that deals with students as constructors not receivers of knowledge, students who construct knowledge through interaction and connecting their experiences and their prior knowledge with the current situations, and students who have learning strategies to help in constructing their knowledge and understanding. Thus, fruitful and effective instruction gives emphasis to the teaching of strategies that support students to learn with understanding. To this end, ranges of instructional methods that support learning have been developed and their effectiveness in enhancing science learning has been proven with research findings.

Student-centered learning situations are needed that encourage and inspire secondary-level students to strengthen and establish a broad range of learning outcomes [3-4]. There are wide ranges of indications to support the view that a student-centered approach has positive consequences to learning science. Student-centered teaching produces deeper understanding, higher order thinking skills, responsibility in their learning and the ability to apply complex ideas in real-life situations and more positive attitudes towards the subject being taught [5-7]. Moreover, research finding indicated that student-centered approach resulted in significantly better understandings of scientific conception and elimination of misconceptions [8-9].

However, science teachers in general, and chemistry teachers in particular mainly adopt instructional strategies that are mostly teacher directed and do not encourage deeper students' participation and self-regulation [10] [11]. Self-regulated learners are independent learners, who possess relevant skills which enhance their ability to construct knowledge, assume accountability for their own learning and realizes that learning is a personal experience that requires active and enthusiastic participation [12] [13]. This perception of the role of the learners in the learning process is changing the views of educational researchers on the role of the teacher in the learning process. Instead of viewing teaching as teacher explanation followed by students practice, effective teaching may be achieved by integrating a self-regulating strategy such as metacognitive strategy. Metacognitive strategies have been reported to have influence on academic achievement. Some researchers contend that metacognition correlates significantly with students' academic achievement [14-17] while others view that explicit metacognitive training can enhance students' metacognition [18] [19] and as well support students' academic achievement [20] [21] [22]. They believe that students, who possess metacognitive knowledge and demonstrate a wide range of metacognitive skills tend to be more successful as they can self-regulate their learning, retain information longer, and perform better.

As different investigators explained that, metacognition can be developed through formative assessment activities [23-25]. Furthermore, [26] found that Scaffolding is an essential instructional element to facilitate metacognition. Scaffolding anticipates construction of some sort and supports immediate knowledge construction and extension of existing knowledge [27]. Combining scaffolding and formative feedback results in a powerful construct for improvement of the individual's and peer ability [28] [29]. Additionally, in attempting to maximize teacher effectiveness in meeting the student need, formative assessment is a well-known approach to improve student learning involving activities undertaken by teachers and students to assess themselves in order to provide feedback for modifying the activities in which they are engaged [30] [31]. Research has established both a strong theoretical foundation and empirical evidence to support the use of formative assessment to improve science performance [32] [33]. Formative assessment activities are embedded within instructions to monitor learning and assess learners understanding for the purposes of modifying instruction and informing further learning through ongoing and timely feedback until the desired level of knowledge has been achieved.

[34] Clearly explained how formative assessment and feedback have the potential to help students become self-regulated learners. On the one hand, the way in which students self-regulates their learning to achieve learning development parallels with the learning processes that are encouraged in formative assessment activities [35]. More specifically, self-regulation is established in learner active involvement in monitoring and regulating a number of learning processes, including setting learning goals, adopting strategies to achieve goals, managing resources, making efforts, responding to feedback, and constructing learning outcome [36]. On the other hand, formative assessment studies recommend that improving students' ability to regulate their own learning should be considered to be the crucial purpose of formative assessment [37] [38].

One key aspect of engaging formative assessment to support self-regulated learning is providing students with chances to decide on their learning goals, self-evaluate performance against their goals, and make improvement [37] [39]. [38] Identified various formative assessment strategies and activities that promote self-regulation among students. These strategies include setting learning goals, adopting activities that elicit evidence of learning, dialogical interaction, peer evaluation, and feedback on the current understanding and task-related processes [40]. Another critical aspect in formative assessment that supports self-regulation is the provision of feedback, which offers information on how effectively something has been done and what can be done to improve it [39]. Feedback and self-regulation are two complexly interrelated aspects of a broader learning process. A recurrent major theme in formative assessment research is the need to orient feedback provision towards developing students' ability to monitor and regulate their own learning [41] [39]. For the time being, self-regulation studies suggest that self-regulated learners are able to generate feedback, interpret self-generated and externally mediated feedback and use feedback to achieve their own learning goals [42] [43].

[44] Believe that feedback provided at four different levels may support self-regulation to a different extent. Feedback on tasks tells students of the correctness of their responses to tasks, looking for to build students' superficial knowledge. Feedback at the process level focuses on developing students' strategies for tackling tasks, thus potentially leading to deep knowledge. Feedback about self-regulation is aimed at developing students' ability to make and use internal feedback to self-assess and monitor their learning process. Feedback on the self focuses on students as persons rather than on their work and is therefore irrelevant to the enhancement of the quality of student learning. In the present study, this model of feedback is adopted to make analysis and interpretations of feedback arising from formative assessment.

Statement of the Problem

Even though the contributions of using formative assessment to improve students' learning, teachers' effectiveness, and school achievement have been understandable, the result of extensive researches have shown that formative assessment has been rarely adopted in classrooms in a worldwide including in Ethiopia [45] [46]. Moreover, based on findings in previous studies, we conclude that there is a need for more evidence how formative assessment affects students' achievement [47] [48]. In addition, researchers claim that for individuals to have the metacognitive skills, they must have a knowledge base that facilitates and help them in developing the cognitive skills. Some of the teaching strategies that teachers in many institutions use in teaching the students do not help the students in developing adequate cognitive skills that they require. For this reason, many students end up failing to achieve some of the fundamental skills that they need to succeed academically. In many cases, use of the metacognitive strategies is not applied correctly. As a result, this affects the academic achievement and future social studies among many students [49].

Furthermore, some students do not have the metacognitive abilities that can help them in understanding complex issues. Research finding also shows that metacognitive scaffolding strategies help to develop metacognitive skills and facilitates students learning [50]. But, only a small number of studies have investigated the effects of metacognitive scaffolding strategies on improving students learning outcomes. To date, however, a few research studies have been conducted on the separate effects of metacognitive strategies or formative assessment on students' achievement and self-regulation skills in learning Chemistry. Yet, existing studies provide limited empirical evidence on the interconnection between formative assessment activities and metacognitive strategies on students' achievement and self-regulation skills of Chemistry learning. Therefore, the study specifically aimed to determine the combined effect of formative assessment with metacognition scaffolding strategies on 11th grade Natural Science students' achievement and self-regulation skills in learning Chemistry. And so, to address the above objective, the researchers made two specific research questions:

1. What is the combined effect of formative assessment with metacognition scaffolding strategies on students' achievement in learning Chemistry?
2. Does the blended of formative assessment with metacognitive scaffolding strategies affect students' self-regulation skills in learning Chemistry?

RESEARCH METHODOLOGY

Research Design

In this study, a non-equivalent multiple treatment pretest-posttest quasi- experimental comparison groups design was used. Quasi-experimental procedure is a useful method when it is not possible to use a true experiment [51]. In a true experiment, participants are randomly assigned to either the treatment or the control group, whereas they are not assigned randomly in a quasi-experiment. In a quasi-experiment, the control and treatment groups differ not only in terms of the experimental treatment they receive, but also in other, often unknown or unknowable, ways. Thus, the researcher must try to statistically control for as many of these differences as possible. Because control is lacking in quasi-experiments, there may be several rival hypotheses competing with the experimental manipulation as explanations for observed results [51]. According to this research design, experimental group one students were exposed to formative assessment integrated with metacognitive scaffolding strategies (E_1), Experimental group two students were exposed to formative assessment only(E_2) and the comparison group students were exposed to the existing instruction(X) which consists of one group. Table 1 below shows the diagrammatic representations of nonequivalent comparison group research design, the experimental group takes part in some types of treatments which are marked by E_1 and E_2 was used in this study.

Table 1: *The diagrammatic representations of nonequivalent comparison group research design*

Groups	Pre-test	Treatments	Post-test
Experimental group one	O_1	E_1	O_2
Experimental group two	O_1	E_2	O_2
Comparison group	O_1	X	O_2

Where: $\mathbf{O_1}$ is pre-test for the experimental and comparison groups
$\mathbf{O_2}$ is post-test for experimental and control groups
$\mathbf{E_1}$ is treatment for experimental group1 (received formative assessment with scaffolding metacognitive strategies)
$\mathbf{E_2}$ is treatment for experimental group2 (received formative assessment only)
X is treatment for comparison group (received the actual existing instruction)

The Sample and Sampling Techniques

Owing to the large number of secondary schools in Addis Ababa City, the researcher selected three secondary schools randomly by lottery method as a sample from three sub city of Addis Ababa. One Chemistry teacher relatively well qualified and experienced in teaching Chemistry was selected purposely for each school. Based on this, the study consisted of 132 eleven grade students (65 males and 67 females) in the selected governmental secondary schools. In the comparison group, 20 of the students were females and 24 were males. In the experimental groups, there were 47 females and 39 males (23 of students were female and 22 of students were male participated in E_1 and 19 of students were male and 24 of students were female participated in E_2).

Variables of the Study

The independent variables in this study were treatment. The treatment has three levels which are Formative Assessment with Metacognitive Scaffolding strategies (E_1), Formative Assessment without metacognitive strategies (E_2) and Comparison Method (CM) group. The dependent variables of the study were students' achievement which was measured using Chemistry

Achievement Test (CAT) and self-regulation skills to learn Chemistry which was measured by Chemistry Self-Regulation Skill Questionnaire (CSRSQ).

Data Collection Instruments

In the study, Chemistry achievement test and self-regulation skill questionnaire were used as data collection instruments.

Chemistry Achievement Test (CAT): For the development of the achievement test, 40 multiple choice questions were adapted from different literature review based on our curriculum. For the content validity of the questions, two chemistry teachers working in the school and two lecturers specializing in the field of chemistry education programs and teaching were consulted. The test was finalized for pilot implementation in line with the teacher and specialist opinions. The test was applied to the 12th grade students as they had studied the previous year. After the pilot implementation of the achievement test, Kuder Richardson formula 21 (K-R21) was used to establish a reliability coefficient estimate of approximately 0.79.

Chemistry Self-Regulation Skills Questionnaire (CSRSQ): CSRSQ was designed by [52] to determine the chemical equilibrium self-regulation skills (Metacognitive skills) of high school students. The response scale was based on a 5-point Likert scale with responses coded as follows: (1) never or rarely; (2) sometimes; (3) about half of the time; (4) frequently; and (5) always or almost always. The scale consists of 32 items and their Cronbach alpha value was .84. In this study, CSRSQ was adapted to measure the self-regulation skills of grade eleven students in learning Chemistry. The estimated Cronbach alpha reliability coefficient of the scale was .76.

Procedures of the treatment

The research was conducted in the 11th grade natural science classes at Addis Ababa three selected preparatory schools for 12 weeks. The three Chemistry teachers in both the control and experimental groups were participated. In this study, there were two treatment groups and one comparison group. One of the sections in the selected schools was assigned to receive formative assessment only and the second section was assigned to receive formative assessment with metacognitive scaffolding strategies and the third section in the remaining school which was considered as comparison group was assigned to receive the existing instruction. After assigned each group, training was conducted for teachers and students in treatment groups. At the beginning of the intervention, we gave brief information about the purpose of the study, the ways of the implementation of the intervention, the activities to be carried out during the intervention, and the time schedule. The training consisted of brief description of the formative assessment and metacognitive strategies. The training also consisted on how teachers can prepare a daily lesson plan using the formative and metacognitive strategies with practical examples.

Students in all the three groups filled Chemistry self-regulation skill questionnaires before treatment was administered to them. Then, a group each from comparison and experimental category sat the pre-test on Chemistry achievement followed by administration of the intervention. All groups were taught on the same content of the Chemistry concepts (chemical bonding and chemical kinetics). The language of the instruction was English. The classroom instruction of the groups was three 45-minute sessions per week and totally conducted for a total period of 36. The experimental and comparison groups spent equal time for studying. However, the lessons in the experimental groups focused on using the metacognitive scaffolding with formative assessment and formative assessment only that was designed to improve students' achievement and self-regulation skills in Chemistry subject.

For the treatment groups, the syllabus in which goals and sub-goals as well as the success criteria were explained in a detailed way and distributed to the students and students were informed about the goals and were explained the expectations. The three processes: self-assessment, peer-assessment and feedback were components of treatment. For each lesson planned for interactive individual and peer formative activities were prepared for students to take at the completion of the lesson. When students finished these planned for interactive individual and peer formative activities, the teacher was able to identify weaknesses and misconceptions that needed to be re-taught during the ensuring class period. The metacognitive strategies were also designed on the basis of the four steps: i) identifying teaching techniques, ii) identifying metacognitive dimensions, iii) process to develop metacognitive behaviors, and iv) validations.

The teacher scaffolds a student to bridge the gap between current abilities and intended goal using either tools or techniques. The scaffolding should be in what Vygotsky called the zone of proximal development (ZPD), where students can only proceed with appropriate scaffolding. As student competency increases, the scaffolding was gradually removed, allowing them to independently complete tasks that previously required assistance. Here teacher provides metacognitive instructional practice such as what information is important to remember? What do you need to do if you don't understand? Are you on the right way? How should you proceed?

When they are monitoring lesson they are guided to ask themselves the metacognitive questions. How am I doing? What information is important to remember? What do I need to do if I don't understand? How well did I do? Did my particular course of thinking produce more or less than I had expected? What could I have done differently? The strategy forces student to use metacognition to examine their thinking, analyze their position and explain their point of view. When the study period was completed, the achievement test and self-regulation skills questionnaire were administered as post-test after which their achievement and self-regulation skills scored were compared.

Data analysis

In the data analysis, first it was examined whether the data obtained from the instruments corresponded with the assumptions of parametric tests. The Shapiro-Wilk normality test, central tendency measures, and skewness kurtosis coefficients were conducted to determine whether the data obtained from the control and experimental groups had a normal distribution. The Levine test was applied to determine whether the variances of the data obtained from the control and experimental groups were equal. After the data obtained from the data collection means showed normal distribution and the variances were equal, it was decided to use parametric tests in the data analysis. In this context, descriptive statistics (mean and standard deviation) and inferential statistics (One-way ANOVA Analysis) were used in the study. In the statistical analysis, the level of significance was accepted as .05.

RESULTS

Testing Statistical Assumptions

Here in this study, groups with 3 ordered levels are treated as ordinal for any analysis by SPSS. In such a case there is no need to check whether the data is normally distributed or not. Conditions in which normality is checked when the data is in the form of ratio/scale. The pre-test and posttest achievement test and self-regulation test are in scale levels skewness should be checked whether the data is normally distributed or not so as to choose parametric or nonparametric test for groups. Parametric methods assume that the dependent (outcome) variable is approximately normally distributed for every group to be compared.

Furthermore, the parametric test for comparing means of two or more groups assumes equal variances. The homogeneity of variances ensures that the samples are drawn from the populations having equal variance with respect to some criterion. The assumption for homogeneity is called homoscedasticity which is strongly influenced by non-normality. The departures from normality result in residuals, which account for the variances in sample data. The normality assumption ensures that distribution of data is symmetric, while the equality of variances complements the same assuming homogeneous deviations from averages in subgroups. Therefore, the normality and Levene's test of homogeneity of variances for students' Chemistry achievement and self-regulation skills tests scores among the three groups were analyzed and presented in the below Table 2 and 3.

Table 2: *Normal distribution analysis study for students' achievement and self-regulation skills tests among the three groups.*

DV	Group	Normality Test							
		N	Skewness	SE	z-value	Kurtosis	SE	z-value	Sig.
pre-achievement test	E_1	45	.06	.35	.02	-1.22	.70	-.85	.130
	E_2	43	-.59	.36	-.21	-.65	.71	-.46	.170
	CG	44	-.45	.36	-.16	-.52	.70	-.36	.120
post-achievement test	E_1	45	-.27	.35	-.09	-1.25	.70	-.88	.080
	E_2	43	-.07	.36	-.03	.20	.71	.14	.051
	CG	44	.13	.36	.05	-.96	.70	-.67	.060
pre-self-regulation skills test	E_1	45	-.28	.35	-.10	-.36	.70	-.25	.187
	E_2	43	-.32	.36	-.11	-.37	.71	-.26	.221
	CM	44	-.49	.36	-.18	.32	.70	.22	.428
Post-self-regulation skills	E_1	45	-.01	.35	-.01	-1.17	.69	-.81	.044
	E_2	43	-.68	.36	-.24	-.39	.71	-.28	.08
	CM	44	-.17	.36	-.06	-.42	.70	-.29	.105

Table 2 shows normal distribution analysis for study variables on pre-test and post-test of chemistry achievement and self-regulation skills among the three groups. A Shapiro-Wilk's test and a visual inspection of their histogram, Normal Q-Q plots and box plots showed that the exam scores approximately normally distributed, with a skewness of values are between 1and -1 this confirms variables with the ratio scales of achievement and self-regulation skills test normally distributed.

Table 3: *Levene's Test of homogeneity of variances for students' chemistry achievement and self-regulation skills test scores among the three groups*

Dependent variables	Levene Statistic	df1	df2	Sig.
pre-test chemistry achievement	.03	2	129	.969
pre-test self-regulation skill	1.94	2	129	.148
post-test chemistry achievement	1.07	2	129	.345
post-test self-regulation skill	.44	2	129	.646

Table 3 shows test of Levene's Test for pre-chemistry achievement test (p =.969), for pre-self-regulation test (p =.148), for post-chemistry achievement test (p =.345), and for post-self-regulation test (p =.646), respectively. The results of analysis shows that among all groups the Levene's test results of dependent variables were non-significant (p>.05 = Equal Variance) which fulfilled the assumption of homogeneity of variance.

Analysis of the pre- test results

After assigning the students from the intact classes to the treatments and comparison groups, pre-test data were collected using achievement test and Chemistry self-regulation skills questionnaire. Before performing the analysis of pre-test scores, assumptions of ANOVA such as normality and homogeneity of variance were checked. The skewness and kurtosis of the pretest data was in an acceptable range in the two dependent variables (see in Table 2). This means the data were approximately normally distributed. Similarly, the other assumptions of ANOVA, the homogeneity of variance, were checked from the Levene test which was not significant for all dependent variables, pre- achievement and pre-Chemistry self-regulation skills questionnaire (see in Table 3). This means that the variance of scores on each variable for the population of the groups is equal. So, the assumptions for ANOVA were not violated.

Result from the ANOVA analysis revealed that there was no statistically significant mean difference between the comparison and treatment groups; F (2,129) = 2.63, p = .076 for achievement test and F (2,129) = 1.27, p = .283 for their Chemistry self-regulation skill questionnaire, suggesting that groups were similar in respect of their achievement test and self-regulation skill scores (see in Table 4). It should be noted that the results from the pretest from both the treatment groups and the comparison group are similar. This implies that before practicing of the treatment there is no significant difference in achievement and their self-regulation skills of the three groups. It could be concluded that results showed no significant differences among all study variables before the intervention. In addition, descriptive data showed the mean value for all dependent variables was almost similar to one another for each group. This implies that the groups used in this study exhibited similar characteristics and were therefore suitable for the study.

Table 4: *Summary on Students' pre-test scores in chemistry achievement and Chemistry self-regulation skills questionnaire among the three groups*

Dependent variable	Group	N	Mean	Std.deviation
pre-test chemistry achievement	E_1	45	7.87	2.64
	E_2	43	6.95	3.08
	CM	44	8.27	2.490
	Total	132	7.70	2.78
pre-test self-regulation skill	E_1	45	4.09	1.62
	E_2	43	3.40	2.52
	CM	44	3.84	1.96
	Total	132	3.78	2.07

Table 5: *One-way analysis of variance summary table comparing the three groups on scores of pre-test of Chemistry achievement and Chemistry self-regulation skills test scores*

Dependent variables	Source	SS	Df	MS	F	Sig.
pre-test chemistry achievement	Between Groups	39.64	2	19.82	2.63	.076
	Within Groups	971.83	129	7.53		
	Total	1011.48	131			
pre-test chemistry self-regulation skills	Between Groups	10.82	2	5.41	1.27	.283
	Within Groups	547.81	129	4.25		
	Total	558.63	131			

Analysis of Post-test Results

The effect of treatment on students' Chemistry achievement

One of the research questions for this study was to determine the combined effect of formative assessment with metacognitive scaffolding strategies son students' achievement in learning Chemistry as one subject of natural science. As there were no statistically significant differences between the pre-test scores of the groups (see in Table 5), the post-test scores were compared using One-way ANOVA. Prior to conducting the one-way ANOVA, the assumption of normality and homogeneity of variance was evaluated. The results of outcome variable was found to be approximately normal distributed and equal variances are assumed based upon results of Levene's Test ($F(2,129) = 1.07$, $p = .345$ (see in Table 2). The results of descriptive data and the summarized one-way ANOVA results are reported in Table 6, 7 and 8.

Table 6: *Means and standard deviations comparing the three groups on scores of achievement test*

Groups	achievement scores		
	N	M	SD
E_1	45	25.52	4.82
E_2	43	20.38	6.08
CM	44	19.98	6.57
Total	132	21.96	6.36

Table 7: *One-way analysis of variance summary table comparing the three groups on scores of achievement test*

Source	Df	SS	MS	F	Sig	η^2
Between Groups	2	917.54	458.77	13.32	.000	.16
Within Groups	129	4858.21	34.46			
Total	132	5775.75				

Table 8: *Multiple comparisons of three groups on students Achievement test*

Scheffé

(I) group of students	(J) group of students	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
E_1	E_2	5.15*	1.20	.000	2.31	7.98
	CM	5.54*	1.20	.000	2.70	8.38
E_2	E_1	-5.15*	1.20	.000	-7.98	-2.31
	CM	.39	1.20	.942	-2.44	3.23
CM	E_1	-5.54*	1.20	.000	-8.38	-2.70
	E_2	-.39	1.20	.942	-3.23	2.44

*. The mean difference is significant at the 0.05 level.

A one-way between groups analysis of variance was conducted to explore the effects of interventions on students' achievement. The analysis of variances showed that the effect of group significantly influenced the combined effect of formative assessment with metacognitive scaffolding strategies, F (2, 129) =13.32, p < .001, $\eta^2 = .16$. Thus, there is a significant result and concluded there is significant difference among students' levels of achievements between the three groups. The actual difference in the mean scores between groups and the effect size was large based on Cohen's (1992) conventions for interpreting effect size(see in Table 7). Post hoc analyses were conducted using Scheffé post-hoc test. Based on a Scheffé value the Achievement in the E_1 group (M = 25.52, SD = 4.82) was significantly less than in the E_2 group (M = 20.38, SD = 6.08) and the CM group (M = 19.98, SD = 6.57). The achievement in the E_2 group and the CM group did not differ significantly.

The effect of treatment on students' self-regulation skills in learning chemistry

To determine the possible effect of treatment on student self-regulation skill in learning chemistry as a subject, the researcher compared students' mean post-test scores of the three groups using a One-way ANOVA. The results of this analysis are displayed in the Table 9 10 and 11 below.

Table 9: *Means and standard deviations comparing the three intervention groups on scores of students' self-regulation skill questionnaire in learning Chemistry*

Groups	Self-regulation skill scores		
	N	M	SD
E1	45	72.60	16.71
E2	43	63.84	17.37
CM	44	54.73	16.76
Total	132	63.79	18.36

Table 10: *One-way ANOVA summary table comparing the three group levels on scores of students' self-regulation skill questionnaire in learning Chemistry*

Source	SS	Df	MS	F	Sig	η^2
Between Groups	7106.67	2	3553.34	12.38	.000	.16
Within Groups	37039.39	129	287.13			
Total	44146.06	131				

Table 11: *Multiple comparisons among the three groups on students' self-regulation skill scores Scheffé*

(I) group of students	(J) group of students	Mean Difference (I-J)	SE	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
E_1	E_2	8.76*	3.61	.044	.19	17.33
	CM	17.87*	3.59	.000	9.35	26.39
E_2	E_1	-8.76*	3.61	.044	-17.33	-.19
	CM	9.11*	3.63	.036	.49	17.73
CM	E_1	-17.87*	3.59	.000	-26.39	-9.35
	E_2	-9.11*	3.63	.036	-17.73	-.49

*. The mean difference is significant at the 0.05 level.

A one-wan between-subject ANOVA was run with number of groups as the independent variable, and student self-regulation skill as the dependent variable. The assumptions of homogeneity of variances was tested and found tenable using Levene's test, F (2, 129) = .44, p= .646 and the outcome variable was approximately normally distributed (see in Table 3). A significant difference was found between the three groups in their self-regulation skill, (F (2, 129) = 12.375, $p < .001, \eta^2 = .16$). After establishing that there was a significant difference between self-regulation skill of students taught the chemistry topics using formative assessment combined with metacognitive strategies, formative assessment only and those taught using Conventional Methods, it was important to carry out further tests to show where the difference occurred. This was done using Scheffé post-hoc analysis tests of multiple comparisons. Post-hoc analyses using Scheffé indicated that the chemistry self-regulation skill in the CM group ($M = 54.73$, $SD = 16.76$, $p < .001$) was significantly less than the chemistry self-regulation skill in the E_1 group ($M = 72.60$, $SD = 16.71$, $p = .044$) and E_2 group ($M = 8.10$, $SD = 1.69$, $p = .036$). Further, Cohen's effect size value ($\eta^2 = .16$) suggested a moderate to high practical significance (See in Table 10).

DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

Discussion related with students' achievement

The first sub-problem in the study was as to whether there was a significant difference in their achievement between the experimental groups, which were taught using formative assessment with metacognitive scaffolding strategies, formative assessment without metacognitive strategies and the control group, which was taught in accordance with the existing instruction. The analysis of the first sub-problem involved determining any possible difference between the two experimental and control groups in their scores in the achievement test of Chemistry.

The statistical analysis and findings suggest that there was a difference between the experimental groups, which were subject to formative assessment with metacognitive scaffolding strategies and formative assessment without metacognitive strategies, respectively, and the control group, which was taught with the existing instruction, in their achievement, with the difference being in favor of the experimental groups. This result coincides with the results of studies in the literature examining the effect of formative assessment and metacognitive strategies on academic achievement [42] [40] [53]. Also [54] agreed that an enhanced formative assessment and metacognitive strategies instruction improve the academic achievement of the students in any subject. Therefore, it can be argued that students need to use both the two strategies in order to understand the concept of Chemistry properly and make fewer mistakes in the process.

Discussion related with students' Self-regulation Skills

In the analysis of the second sub-problem, an attempt was made to identify whether there was a significant difference between the two experimental and control groups in their self-regulation skills. The statistical analysis and findings suggest that there were a significant difference between the two experimental groups and the control group, in their self-regulation skills, with the difference being in favor of the experimental groups. This finding is consistent with the findings in other study and supports the fact that when students are exposed to formative assessments and metacognitive strategies their self-regulation skill increases significantly [48]. [55] Evaluated the relationship between formative assessment and metacognitive strategies in a study and emphasized that the teachers who apply formative assessment strategies should understand the students' self-regulatory learning processes in order to make correct decisions. In addition, [55] advised that teachers should frequently use formative assessment in order to develop the students' self-regulation skills and increase their motivation.

There are also studies in the literature that have shown formative assessment and metacognitive strategies do not statistically significantly affect student self-regulation skills. For example, [56] concluded that even though the formative assessment had a positive effect, no significant difference was found between the experimental and control groups. Self-regulation skills require students to actively use their cognitive skills, make efforts to reach their learning goals, get help from their friends, teachers or parents when necessary, and most importantly, take responsibility for their own learning. Therefore, the nature of formative assessment based on learners' learning and the applications aiming at eliminating learning deficits are closely related to the self-regulation skills of the students. However, it can be interpreted that self-regulation skills can be developed over a long period of time through appropriate and consistent approaches.

Conclusion and Recommendations

The purpose of this study was to determine the effects of three separate groups on students' achievement and self-regulation skills in learning chemistry. An attempt was made in the study to determine whether the experimental groups, which were taught how to learn chemistry through formative assessment with metacognitive scaffolding strategies and formative assessment without metacognitive strategies, respectively, and the control group, which was taught through the existing instruction, significantly differed from each other in their achievement and self-regulation skills. There were clear differences between the groups in all the two dependent variables (achievement and self-regulation skills), with the differences being in favor of the experimental groups. Therefore, it can be concluded that Chemistry subjects should be taught in a learning environment with formative assessment activities that will support with metacognitive strategies so that students will be more successful in their academic achievement and, in particular, develop their self-regulation skills. It is therefore recommended that:

1. Students should be learning through formative assessment and metacognitive strategy as this has been found to improve their achievement and self-regulation skills.

2. Formative assessment and metacognitive strategies should be used in teaching chemistry in secondary school rather than the conventional methods.
3. In view of the importance of effectiveness of formative assessment and metacognitive learning strategies, teachers should be trained to acquire the skills needed for use of the formative assessment and metacognitive strategies.
4. Teachers should provide students with scaffolding throughout the implementation of planned for interactive individual and peer formative activities; they should try to enable them to fill any gaps. In this way, they can reveal and correct any mistakes or wrong learning in the use of metacognitive strategies.
5. Reflective teachers should be encouraged to use action research, a tool for innovation in education based on higher order thinking, more often in order to conduct studies on their own classroom or school practices.

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