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Gender Differences in Students' Motivation and Conceptual Knowledge in Chemistry Using Technology-Integrated Formative Assessment

Tadesse Hagos[1] & Dereje Andargie[2*]
[1]PhD Candidate of Chemistry Education, College of Education and Behavioral Studies, Addis Ababa University, ETHIOPIA
[2]Institute of Education, Debre Berhan University, ETHIOPIA
derejefanaye@gmail.com

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Abstract

This study examines the impact of gender and technology-integrated formative assessment on learning chemistry in general and chemical equilibrium in particular from the perspective of learning and motivation. To achieve the aforementioned objective, a quasi-experimental, non-equivalent, non-randomized pre-test and post-test research design was adopted. There were three groups in the study: two experimental and one comparative. The experimental groups implemented formative assessment (FA) and technology-integrated formative assessment (TIFA) strategies, whereas the comparison group used lecture style method. Two intact classes were chosen for treatment and one intact class was chosen for comparison groups using a random sampling technique. The Chemical Equilibrium Conceptual Test (CECT) and the Chemistry Motivational Questionnaire (CMQ), both adapted from the literature, were used to gather data. The reliability coefficient for CMQ was calculated using Cronbach's alpha. The Kudder Richardson formula 20 was used to check the CECT's internal consistency (KR-20). Two-way ANOVA statistics were used to analyze the data. Gender has no effect on students' motivation or conceptual knowledge when learning chemical equilibrium. There was no interaction impact of treatment and gender on the conceptual and motivational test scores. TIFA was shown to be more successful than the other two groups in promoting students' conceptions and motivation in learning chemical equilibrium, regardless of gender. Chemistry teachers should implement TIFA as a teaching method in their classes, according to the study. It is also recommended that teachers use it into their classes to help motivate students.

Keywords: conceptual knowledge, gender, formative assessment, motivation, technology

INTRODUCTION

Learning in the digital age makes use of modern technologies to encourage students to learn new skills and improve their performance. Technical functionality and pedagogy are intricately intertwined in the effective use of digital technology (Bellman et al., 2014; Shirley et al., 2011). Although digital technology may assist in the facilitation or mediation of learning processes, the relationship between the teacher, the student, and the technology is critical in creating an enjoyable learning environment (Manca & Ranieri, 2013). The benefits of technology as a digital tool are important, but how it is used defines what purpose it performs and if it can be employed in the classroom (Beatty & Gerace, 2009).

In general, while there is evidence that using technology has benefits, it is difficult to draw definitive judgments about its use in schools. While some research support the premise that technology may help students learn more deeply and provide evidence of learning benefits (Higgins, 2016), others (Haßler et al., 2016) are less conclusive. Some of the differences in effect may be due to differences in how technology is used (Higgins, 2016) or in teacher pedagogy (Karp & Fletcher, 2014), while others may be related to changes in how technology is used (Higgins, 2016). Incorporating technology into the classroom, according to educational scholars, may assist both students and teachers. Technology, for example, may help learners become more motivated and equip them with essential tools to help them reinforce their learning (Serrano et al., 2019). As a consequence of technology improvements, the environments and ways in which students learn and interact, teachers instruct, and assessments are planned and executed have also altered. These technologies are beginning to have an influence on assessment science, giving students with greater environmental validity and feedback on their breadth and depth of knowledge as well as complex talents.

Researchers recognize the usefulness of technology in supporting formative assessment strategies (Bhagat & Spector 2017). Since technology such as mobile devices, computers, tablets, and online resources is becoming more widely used in classrooms, researchers are interested in examining and analyzing the effectiveness of using digital technologies for formative assessment (Kaware & Sain 2015). As a result, the use of technology to help formative assessment has yielded a wide range of results (García et al., 2017).

According to Aldon and Panero (2020), technology may help students and facilitators greatly by providing for formative assessment of skills, knowledge, and comprehension. Computers might be used to aid in the study of the subject and issue, with the facilitator connecting to LCD projectors to convey information to the students. Because computers make it easy to provide mark lists via spreadsheets, information, and activities, assessment and feedback should no longer be a problem. Students can utilize technology to perform assessment activities like as problem-solving, giving presentations, writing reports, searching the internet for information, and receiving tutorials (Barkley & Major, 2020).

One of the key limitations to improving formative assessment in the past, according to Redecker and Johannessen (2013) and others, was that the vast majority of courses were delivered face-to-face, preventing the capture of learning interactions and outcomes into a system for identifying and analyzing formative feedback and assessment. Frequent formative assessments and comments for a large group of students can be time consuming for teachers, which can make it unpleasant in practice (Burns et al., 2010). This is one area where technology may be really useful. In both face-to-face and online classrooms, students benefit from technology-integrated formative assessment since it provides them with meaningful feedback and personalizes their learning experience (Jeffrey et al., 2014).

The primary purpose of technology-enhanced formative assessment in the classroom is to provide students with timely and relevant feedback, and the secondary goal is to help students personalize their learning. As a result, improving the quality of feedback and the way it is delivered are critical components of learning and technology may help with both of these objectives (Barksdale, 2018; Timmis et al., 2016). In the twenty-first century, there are several options to record and analyze both performance and assessment data using modern technology to understand how students grow with various sorts of activities and then decide what adaptations might be made to assist different learners (McKenney, 2018).

According to research, technology-integrated formative assessment is critical for motivating students to learn and ensuring that all students have a positive learning experience and become competent learners (Faber et al., 2017; Leenknecht et al., 2021). Competent students have a deep understanding, evaluate their own and others' progress, and have control over their own learning (Irons & Elkington, 2021), all of which are required to meet the challenges of the twenty-first century. Emotional reactions to assessment outcomes impact students' moods and motivation to learn (Mega et al., 2014). Furthermore, whether or whether learners are motivated to study is heavily influenced by their teachers (Cauley & Mcmillan, 2010).

Underachievement among Ethiopian secondary school students has been a strongly disputed educational concern. Before attempting to remedy an issue, it's necessary to first understand what's causing it. Many elements have been researched and pushed as etiological beginning points for researching student failure and success. These concerns are studied from a range of perspectives, including student engagement, teacher involvement, parent involvement, and school environment, society, and government involvement (Mitchell, 2015). One factor that has been identified as having a substantial influence on students' learning outcomes, particularly in science courses like chemistry, is gender (Veloo et al., 2015).

On standardized scientific assessments that focus on the human application of research, such as life science, females outperform males (Amelink, 2009). In contrast to the findings above, Olayinka (2016) revealed that there was no statistically significant variation in students' scientific achievement based on gender. Gender has little effect on academic achievement, according to Lamb et al. (2018), yet it may interact with other variables to alter learning results. Treatment interaction, according to Ajayi and Ogbeba (2017), means that different learners with different characteristics may benefit more from one type of instructional method than another, and that finding the best match between a learner's characteristics and instructional method to maximize learning outcomes may be possible. According to research, chemistry teachers' classroom teaching tactics may interact with students' gender to influence their learning outcomes (Estawul et al., 2016).

Despite the fact that the mode of presentation is meant to be activity-based, most chemistry teachers in the study area still employ the lecture technique to convey knowledge (Filgona & Sababa, 2017). Students' capacity to participate in the teaching and learning process is harmed as a result of this. As a result, to address the learning outcomes gap between male and female chemistry students, a fresh and inventive learner-friendly teaching strategy is required. One such innovative, learner-friendly teaching technique that may help both male and female secondary school chemistry students enhance their learning outcomes is technology-integrated formative assessment. As a result, the objective of this research is to see the effect of gender and technology-integrated formative assessment on students' motivation and conceptual knowledge in learning chemical equilibrium, with a focus on secondary schools in Addis Ababa. To address the above objective, the researchers came up with two specific research questions:

1. How does the interaction of intervention groups and gender affect students' conceptual knowledge exam scores?
2. Is there a significant difference in student motivation to learn chemistry across intervention groups and gender?

RESEARCH DESIGN AND METHODS

Research Design

This study used a quasi-experimental research design with a non-equivalent pretest, numerous treatments, and a posttest control group. As a result, the design includes a comparison group and two treatment groups, each with their own pretest and posttest designs. Students in experimental group one were exposed to technology-integrated formative assessment, according to the studies design (E_1). Students in the experimental group two (E_2) were subjected to formative assessment alone, whereas students in the comparison group (X) were exposed to lecture style instruction.

Population and Sampling Technique

Using a convenience sample approach, the researcher chose Addis Ababa City as the research site based on simple accessibility, geographical closeness, and availability. The participants in this study were grade 11 students in public secondary schools. Then, out of 10 Addis Ababa sub-cities, three were chosen as the target population using basic random selection procedures. Following that, one secondary school was randomly picked as a sample from each of the three sub-cities. In addition, basic random selection procedures were used to choose three intact classes within the schools, and the three sections were simply allocated two for treatments and one for comparison at random. Then, one chemistry teacher was purposefully chosen, who was relatively well qualified and experienced in teaching chemistry.

Variables of the Study

Intervention groups and gender were the study's independent variables. Technology Integrated Formative Assessment (TIFA), Formative Assessment (FA) alone, and Comparison Method (CM) groups have three levels, while gender has two levels (male and female). Conceptual knowledge and motivation were the study's dependent variables.

Data Collecting Instruments

Data was obtained utilizing a conceptual knowledge exam and a chemistry motivation questionnaire to address the study's research topics (adapted from literature). As pre- and post-tests, the conceptual knowledge tests and motivation questionnaire were employed twice. The features of these devices are detailed in further depth below.

Chemical Equilibrium Conceptual Test (CECT)

There were 25 multiple-choice questions on this test. There is just one right answer and four distracters for each question. All of the questions were derived from the literature and modified to fit the study's needs. Before and after the treatment, the students were given a test to measure their general conceptual knowledge. The internal consistency of all conceptual test items had a reliability value of 0.75 or above (Mensah, 2017; Özmen, 2008).

Chemistry Motivation Questionnaire (CMQ)

Glynn and Koballa's Science Motivation Questionnaire II (SMQ-II) was revised in 2011 to gather information about students' motivation to learn chemistry. They allowed researchers to use SMQ in different versions, such as the Biology Motivation Questionnaire II (BMQ-II), Chemistry Motivation Questionnaire II (CMQ-II), and Physics Motivation Questionnaire II (PMQ-II), in which the words biology, chemistry, and physics replace the word science, respectively. Only the term "science" was substituted with the word "chemistry" in the version utilized in this investigation. As a result, for the total motivation score, the Chemistry Motivation Questionnaire II (CMQ-II) instrument was used. All of these variables were continuous and on an interval scale.

Validity and Reliability of the Instruments

Two experts in measurement and evaluation, two experts in chemistry education, and experienced senior secondary school chemistry teachers who had been teaching the subject for more than 20 years reviewed and examined the data collection instrument of the chemical equilibrium conceptual knowledge test for face and content validity. The instrument was re-evaluated in light of the feedback received. The instruments were evaluated in a single school that was not included in the study's sample of 40 12th-grade students. The conceptual chemical equilibrium pretest and posttest, as well as the motivation questionnaire, were all pilot tested with persons who volunteered to help. A dependability coefficient estimate of approximately 0.72 was calculated using the Kuder Richardson formula 20 (K-R20). Cronbach's alpha was used to calculate the reliability coefficient for the motivation questionnaire, which was determined to be 0.87.

Treatment Procedure

Three schools, three teachers, and three sections were randomly selected and divided into two treatment groups and one control group. At the time, teachers and students in treatment groups were provided training. We gave a quick overview of the study's goal, the treatment's methods of implementation, the activities to be completed throughout treatment, and the treatment schedule at the start. The ten-day training was conducted by the researchers (two hours per day for teachers and one hour per day for students).

Following the training, the three sections taught by the three teachers were given a pretest regarding the chemical equilibrium conceptual knowledge test and a chemistry motivation questionnaire, followed by the delivery of the intervention. The chemical equilibrium concepts were presented to all groups in the same way. The groups were taught in a classroom setting for three 45-minute sessions each week for a total of seven weeks. Both the experimental and comparison groups studied for the same amount of time. The experimental groups' lessons, on the other hand, focused on utilizing technology-integrated formative assessment and formative assessment alone to increase students' motivation to learn and conceptual knowledge of chemical equilibrium concepts (Anuar et al., 2021). To encourage discussion amongst the students, the lessons were usually performed through cooperative group work. The teacher established the groups in a diverse manner, taking into account aspects such as the students' gender, achievement level, emotional qualities, and so on. As a consequence, eight groups of four to five students were established, each consisting of four to five individuals. Throughout the class, students were asked questions that tested high-level thinking abilities and encouraged them to think, and they were given time to think before responding to the questions. Teachers used the concept map, conceptual diagnosis, observation, self-evaluation, quiz, oral questions, think-pair sharing, one question and one comment, three-minute pause, and one-minute essay as formative assessment strategies in the classroom.

An interactive whiteboard, a computer desktop, an LCD projector, a microphone, and a smart phone were some of the technology equipment employed in this research. Telegram, PowerPoint, and internet access were some of the tools utilized. In this study, the main goals of incorporating technology into formative assessment were to display open-ended formative assessment activities in the classroom and display scientific reasoning for these activities in real time, to create interactive learning, to easily access student work during the assessment process, to facilitate peer feedback and collaboration, and to enable students to receive feedback in faster and thus more frequent feedback cycles.

Before the lessons, the researchers verified the technological tools, and the researchers offered the student teaching materials for performing treatments at the start of the treatment. The teacher and researchers assessed the use of a technology-integrated formative assessment strategy after each class time. The method was followed by the other teacher as well. Researchers were always available to help teachers with any implementation challenges, as well as provide comments and recommendations for how to enhance the intervention. The conceptual knowledge exam and the students' motivation questionnaire were offered as a post-test after the research period was over, and their conceptual knowledge and motivation scores were compared.

Methods of Data Analysis

The researchers coded and examined the findings acquired from all of the instruments used. Two-way ANOVA was used to increase the validity and reliability of the studies. Descriptive statistics (mean and standard deviation) were used to describe the results between research variables. The effects of covariate variables (if any) were removed from the variables of interest using a pretest-posttest approach. For univariate, the Skewness-kurtosis coefficient was estimated in terms of normality for each group and variable. Normal skewness and kurtosis coefficients are between -1.96 and +1.96. The Statistical Package for Social Sciences (SPSS) computer package version 26 was used for this investigation. All statistical tests were run for significance at the 0.05 level in order to make valid conclusions from the data.

Consideration of Ethical Issues

During data collection, analysis, and dissemination, the researchers considered the following ethical issues: To begin, the researcher must first obtain permission from the school administration to perform the study. Second, the researchers told the research participants about the study's goals and received their informed permission. Teachers of chemistry and natural science students who took part in the study were given an informed consent form that explained the study's goal and procedures. Participation in the study was stated to be voluntary on the authorized permission form. Third, the researcher undertakes to keep the information gathered from research participants private.

MAIN FINDINGS

Effects of Treatment by Gender on Students' Conceptual Knowledge

The effects of the three groups' variations on the conceptual knowledge of female and male participants were evaluated using a two-factor (2x3) analysis of variance. The data exhibited a statistically close to normal distribution, according to the normality test, which looked at standardized skewness and the Shapiro-Wilks test (see Table 5). The Levene F (5, 126) = 1.17, p = 0.330, test for homogeneity of variance was not significant, suggesting that the assumption behind the use of the two-way ANOVA was met. For the preliminary studies, an alpha level of 0.05 was employed. Tables 1 and 2 provide descriptive statistics (mean and standard deviations) and two-way analysis of variance results for conceptual test scores as a function of the two variables

Table 1. Means and standard deviations for conceptual test scores as a function of a 2 (gender) x3 (groups)

Conceptual knowledge test scores												
	The three level group differences											
	TIFA group			FA only group			CM group			Total		
Gender	N	M	SD	N	M	SD	N	M	SD	N	M	SD
Male	22	18.45	3.20	19	17.21	3.66	24	14.88	4.01	65	16.77	3.91
Female	23	19.39	2.78	24	16.17	4.03	20	15.25	4.20	67	17.00	4.06
Total	45	18.93	2.30	43	16.63	3.86	44	15.05	4.06	132	16.89	3.97

Table 2. Two-way ANOVA showing the effects of gender and three groups on students' conceptual tests scores

Conceptual knowledge test scores						
Source	SS	Df	MS	F	P	η^2
Intercept	37364.54	1	37364.54	2759.96	0.000	0.956
Group	333.26	2	166.63	12.31	0.000	0.163
Gender	.26	1	.26	.019	0.890	0.01
Group * Gender	22.57	2	11.29	.834	0.437	0.013
Error	1705.80	126	13.54			
Total	39709.00	132				

The two-way ANOVA revealed that there was no significant main impact of gender on conceptual test scores (F (1, 126) = 0.019, p= 0.890, η^2 =0.001), with males (M = 16.77; SD = 3.99) and females (M = 17.00; SD = 4.06) achieving almost similar mean scores. The main impact of gender had an effect size of 0.01, suggesting that gender accounted for 1% of the variation in conceptual test results. The main effect of groups on conceptual test results was significant (F (2, 126) = 12.31, p<0.001). The main impact of three groups had an effect size of 0.163, suggesting that groupings explained 16.3 percent of the variation in conceptual test results. The TIFA group outperformed the FA group (M = 16.63, SD = 3.86) and the CM group (M = 15.05, SD = 4.06) by a large margin (M = 18.93, SD = 2.30). Furthermore, there was no significant interaction between gender and groups, with F (2, 126) = 0.834, p = 0.437, and η^2 = 0.013, showing that gender and the three groups had no combined influence on conceptual test results.

Because the lines didn't cross over to each other, the line graph Figure 1 revealed no significant interaction between gender and intervention groups, whereas the bar graph Figure 2 revealed a modest mean difference between males and females. The mean gain of female students in the TIFA and CM groups was somewhat larger than that of male students. Male students, on the other hand, gained somewhat more than female students in the FA-only group. As a result, these data imply that using technology in formative assessment increases students' conceptual knowledge understanding, and that this gain is nearly same for both males and females.

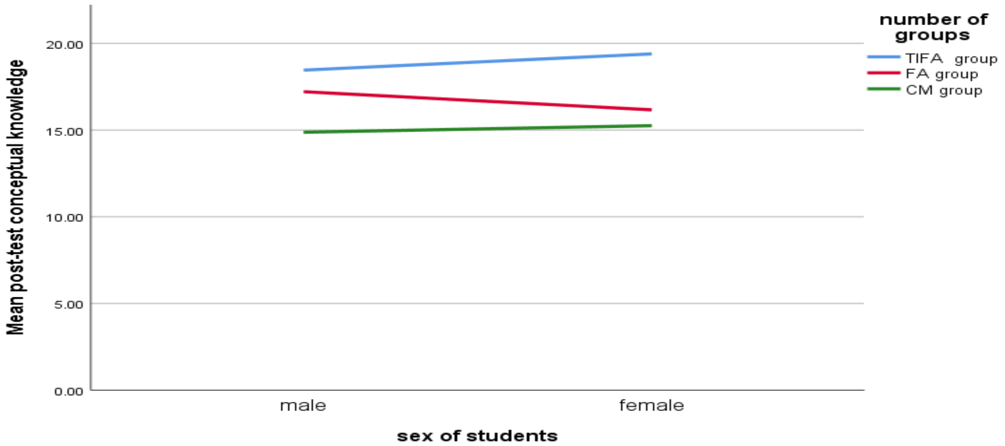

Figure 1: Line graph presentation of interaction effect of treatment and gender on mean gain in conceptual knowledge test scores

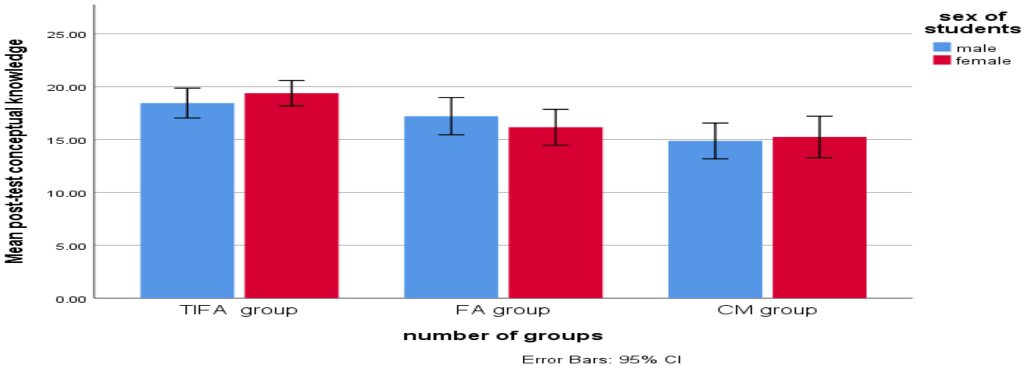

Figure 2: Bar graphs mean of conceptual test scores by three levels group by gender showing three types of interactions

Effects of Treatment by Gender on Students' Motivation

Similarly, a factorial ANOVA was used to assess the main effects of gender and groups on motivation test scores, as well as their interaction effects. The assumptions of normality and homogeneity of variance have to be satisfied in a two-way ANOVA. The Leven's test revealed that the groups' variances were equal (F (5,126) = 0.27, p = 0.929), and that the sample's normality and residuals were roughly normally distributed (see Table 5 in the Appendix). There were no violations of assumptions discovered. Tables 3 and 4 show the descriptive and two-way ANOVA findings, respectively.

Table 3. Means and standard deviations for motivation test scores as a function of a 2 (gender) x 3 (groups)

Motivation test scores												
	The three level group differences											
	TIFA group			FA only group			CM group			Total		
Gender	N	M	SD	N	M	SD	N	M	SD	N	M	SD
Male	22	73.77	16.41	19	64.68	17.41	24	53.13	15.68	65	63.49	18.41
Female	23	71.48	17.27	24	63.17	17.68	20	56.65	18.20	67	64.07	18.43
Total	45	72.60	16.71	43	63.84	17.37	44	54.73	16.76	132	63.79	18.36

Table 4. *Two-way ANOVA showing the effects of gender and three level groups on students' motivation test scores*

Motivation test scores						
Predictor	SS	Df	MS	F	P	η^2
Intercept	533269.96	1	533269.96	1824.867	.000	.935
Group	6968.75	2	3484.37	11.924	.000	.159
Gender	.30	1	.30	.001	.975	.001
Group * Gender	218.81	2	109.41	.374	.688	.006
Error	36820.22	126	292.22			
Total	581240.00	132	581240.00			

On the motivation to study chemistry test, there was no statistically significant difference in the mean between males and females, $F(1,126) = 0.001$, $p = 0.975$, $\eta^2 = 0.001$, with the eta partial squared yielding a small effect size. However, statistically significant differences between groups were found, with $F(2,126) = 11.924$, $p < 0.001$, and $\eta^2 = 0.159$, indicating that the mean change scores for the TIFA group (M = 72.60, SD = 16.71) were significantly higher than the FA only group (M = 63.84, SD = 17.37) and the CM group (M = 63.79, SD = 18.36). According to Cohen's (1992) guiding lines, it has a large effect size (see in Table 4).

$F(2,126) = 0.347$, $p = 0.688$, $\eta^2 = 0.006$; the findings of two-way ANOVA also revealed that there was no statistically significant interaction between the effects of gender and groups on motivation in studying chemistry. However, the main effect of intervention groups on students' motivation to learn chemistry results was significant ($F(2, 126) = 11.92$, $p<0.001$, $\eta^2 = 0.159$, with the eta partial squared yielding a large effect size. The line graph in figure 3 demonstrated that there was no significant interaction between groups or gender differences since the lines were not crossed. The mean motivation score between genders and the three groups was also shown in Figure 4's bar graph. In both the TIFA and FA alone groups, the mean gain of male students was somewhat larger than female students, as seen in the bar graph. Female students in the CM group, on the other hand, gained more than male students.

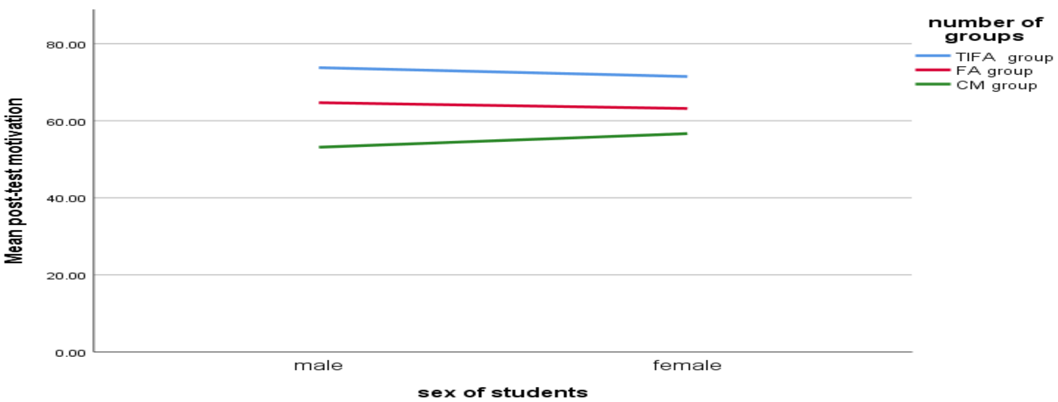

Figure 3: Line graph for gender versus groups on means of motivation test scores

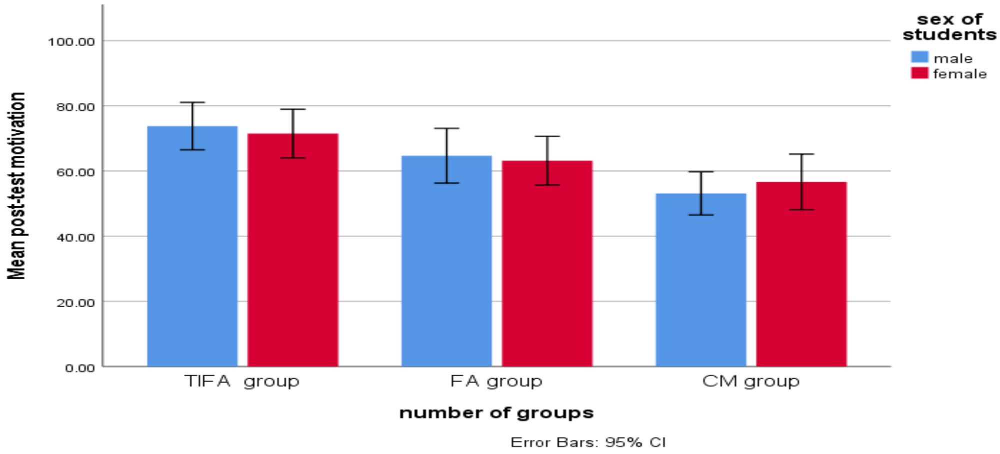

Figure 4: Bar graphs mean of conceptual test scores by three groups by gender showing three types of interactions

Statistical Assumption

Table 5. Normal distribution analysis study for students' post-motivation, and post-conceptual knowledge tests among the three groups

DV	Group	Normality Test							
		N	Skewness	SE	z-value	Kurtosis	SE	z-value	Sig.
post-conceptual knowledge test	TIFA	45	.06	.35	.17	-1.22	.70	-1.74	.130
	FA only	43	-.59	.36	-1.64	-.65	.71	-.92	.170
	CM	44	-.45	.36	-1.25	-.52	.70	-.74	.120
post-motivation test	TIFA	45	-.28	.35	-.80	-.36	.70	-.51	.187
	FA only	43	-.32	.36	-.88	-.37	.71	-.52	.221
	CM	44	-.49	.36	-1.36	.32	.70	.46	.428

DISCUSSION OF MAIN FINDINGS

In order to investigate the main and interaction effects of intervention groups by gender on conceptual and motivational test scores as distinct dependent variables, the researcher used a 2x3 factorial design. Gender (male and female) and the three intervention groups are the three independent factors in this research (TIFA group, FA-alone group, and CM group). The findings of the two-way ANOVA revealed that there was no significant main impact of gender on conceptual test scores, with males and females having almost similar mean scores. Furthermore, no significant interaction impact between gender and groups was identified, suggesting that gender and the three groups had no combined influence on conceptual knowledge. On the other hand, the major effect of groups on conceptual exam results was significant.

The main and interaction effects of treatment by gender on students' motivation to learn chemistry were determined using the post-test mean scores of the Chemistry Motivation Questionnaire (CMQ). The difference in CMQ mean scores between male and female students was not statistically significant, according to the data analysis. This implies that males and females performed equally well in chemistry after being taught utilizing formative assessment methods. Furthermore, the results of the two-way ANOVA demonstrated that there was no statistically significant interaction between gender and group effects on students' motivation to learn chemistry. When the mean scores of female and male students were compared, it was observed that male students in the TIFA and FA alone receiving groups had somewhat higher mean scores than female students. In the CM group, however, female students got higher mean scores than male students.

This study's findings are in line with prior research on various sorts of gender groups in computer-assisted formative assessment, which found no gender differences in learning outcome scores (Obery, 2021; Okoye, 2015). Similarly, this conclusion is in line with Glory and Ihenko (2017) and Matilda and Helen (2019) studies, implying that gender has no impact on students' learning outcomes. Furthermore, the findings are consistent with the findings of several writers, who found no significant treatment-gender interaction effect on student learning outcomes (Adigun, 2015). Olayinka (2016) discovered that there was no statistically significant difference in students' science achievement depending on gender, similar to the findings above. In the formative assessment strategies, Gambrari (2015) found a non-significant difference in learning outcome test scores between male and female students. Furthermore, in a study of college students, Razavi (2021) found no significant gender differences in academic performance.

In contrast to the findings above, Godpower-Echie and Amadi (2013) discovered a favorable link between gender and students' chemistry achievement in a study involving 400 senior secondary (SS) 2 chemistry students. According to Ajayi and Ogbeba (2017), treatment interaction means that different learners with different characteristics may benefit more from one type of instructional method than another, and that it may be possible to find the best match between a learner's characteristics and instructional method to maximize learning outcomes. Furthermore, Ugwumaduka and Ogunyemi (2021) found that male students do better than female students in any classroom instructional activity. It also contradicts previous research that found a substantial treatment-gender interaction effect on students' learning results (Asamoah & Derkye, 2019; Filgona & Sababa, 2017). Motivation is a precondition for students' learning (Roslan et al., 2021). However, there is no empirical evidence to support the idea that technology-integrated formative assessment interventions have major impacts on students' motivation in terms of behavioral engagement in learning activities.

CONCUSSION AND RECOMMENDATION

The difficulties surrounding the use of technology-integrated formative assessment approaches combined with feedback to enhance students' learning results should be addressed as soon as possible. Formative assessment procedures with feedback have proven to be particularly helpful in assessing and improving students' learning outcomes without biasing gender differences, allowing students to build effective study habits and positive interpersonal interactions with their teachers and classmates.

As a result of this study, it is possible to infer that technology-integrated formative assessment strategies with feedback are effective in improving students' conceptual and procedural knowledge in studying chemistry in general, and chemical equilibrium in particular. Instead of the traditional assessments and take-home assignments, they allowed students to be exposed to alternative formative assessment strategies such as teacher-guided peer assessment, projects, and group tasks. Students were able to get rapid remedial actions by receiving immediate and frequent feedback, which allowed them to determine which areas they had learned and which they still needed to acquire. In the view of this, the study concluded that when teachers are committed to using formative classroom assessment with timely feedback mechanism, students’ learning outcomes will be positively impact.

According to the study, chemistry teachers should use TIFA as a teaching approach in their classrooms and laboratories. Workshops and seminars for in-service chemistry teachers should be organized. To assure the training of pre-service chemistry teachers, teacher education institutes should integrate the usage of TIFA in their chemistry method course curriculum. It is also suggested that teachers use it in their lessons to help motivate their students.

Declaration of Conflicting Interests

The authors state that there were no commercial or financial ties that may be considered as a possible conflict of interest during the research.

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