TECHNOLOGY INTEGRATED FORMATIVE ASSESSMENT: EFFECTS ON STUDENTS' CONCEPTUAL KNOWLEDGE AND MOTIVATION IN CHEMICAL EQUILIBRIUM

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Abstract. *The main objective of this study was to evaluate the impact of technology integrated formative assessment strategies on students' conceptual knowledge and their motivation in chemical equilibrium. Quasi-experimental control group interrupted time series design was employed. Data were collected from 132 students which were selected using multistage random sampling technique from three governmental secondary schools. Two experimental (Technology Integrated Formative Assessment (TIFA) and Formative Assessment (FA) alone and one comparison groups were involved in the study. A series of chemical equilibrium conceptual tests and motivation questionnaire were used to collect data. One-way ANOVA and Mixed model ANOVA were used to analyze the test scores. There was a statistically significant difference between groups in posttest on conceptual plus remembering ($F(2,129) = 3.52, p=.033$), understanding ($F(2,129) = 4.70, p=.033$), applying ($F(2, 129) = 20.35, p<.001$) and their motivation ($F(2, 129) = 12.375, p< .001$). However, there were no statistically significant differences among groups in posttest on conceptual plus analysis ($F(2, 129) = 1.10, p = .335$) and evaluating ($F(2,129) = 3.03, p = .052$). There was also an interaction effect between treatment and time point on the conceptual test scores. It was concluded that TIFA more effective in facilitating students' conceptual knowledge and motivation in learning chemical equilibrium than the two other groups. The researchers recommended that chemistry teachers should adapt TIFA as a teaching strategy in chemistry classrooms and laboratories. They are also recommended that teachers should incorporate it into their classes to enhance students' motivation.*

Keywords: *Conceptual knowledge, Formative assessment, Motivation, Technology*

INTRODUCTION

In today's age of science and technology when scientific knowledge has grown exponentially, technological innovations have advanced at a fast pace, and the effects of science and technology are clearly observed in all parts of our lives. It is obvious that science education and technology plays a key role for the futures of civilizations. Because of its importance, all the world and particularly developed countries have continuously needed to improve the quality of science education [1]. Science is generally considered as the study of facts related to natural and material world. Modern era; however, has brought a shift in the views about science education from objective fact based knowledge to practical activity which caters to the learners' skills, attitude, and values along with understanding and it becomes meaningless and incomprehensible for learners, if the learners are unable to relate it with their lives [2].

The field of educational psychology has much to contribute to science education. There have been many significant recent developments in the study of young cognition and motivation, and this new knowledge has much to add to the improvement of science education. Learning about science needs the organization of a complex set of cognitive, affective, and motivational strategies and skills [3][4]. Specifically, research from educational psychology can contribute greatly to our understanding of how learners acquire and process scientific knowledge; overcome misconceptions; learn the discourse of scientists; learn to think and reason like scientists; evaluate sources of scientific information; and put to rights personal beliefs with science content [5]. Science education should therefore develop the ability of the students to reason, understand and bring out their ability to use resourcefully and originally the theoretical knowledge and skills acquired.

The ultimate goal of teaching science subjects in worldwide including in Ethiopia is, to develop members of society that are sufficiently literate and that possess relevant skills needed for technological innovations as well as meet the manpower requirements for the development of a country [6][7]. As a result, the curriculum of Ethiopia is formulated based on the needs of the nation as well as global scientific requirements. Therefore, the main focus of chemistry education as one part of science education is to understand how students learn chemistry, how best to teach chemistry and how to improve learning outcomes by changing teaching methods and assessment techniques in order to move students beyond memorizing facts and toward understanding and applying core principles of chemistry [8]. As a consequence, the learning of chemistry as one field of study of science is widely offered at secondary and higher education as mandatory requirement for further higher education in medicine, biochemistry, microbiology, pharmacy, textile industry, engineering, petroleum and agriculture [9]. It has also a greater contribution in generating the accomplishment of the aims of education and specifically helps individuals to develop effective process skills, critical thinking and competences [10]. Hereafter, to understand the ideas of chemical concepts in chemistry considerable higher order cognitive knowledge and process is needed.

According to Prokša, Drozdíková, and Halakova [11], to develop higher cognitive knowledge and process in chemistry requires students need to learn the macroscopic, sub-microscopic, and symbolic levels of chemical knowledge. It is pertinent that chemistry students at all levels of education have adequate knowledge of scientific concepts at the three levels and should be able to integrate the knowledge across the levels [12][13]. These three levels must be linked in order to understand the application of chemical knowledge in everyday life. But, if at one of these levels, students possess difficulties, it affects the other levels [14]. It has been observed that most students fear chemistry and hence they see chemistry as difficult to understand because of the abstract nature of many chemical concepts, teaching styles applied in class, lack of teaching aids and the difficulty of the language of chemistry [15]. All these cause students, from primary level to the university, to develop poor understanding and misunderstandings.

A number of studies have been conducted to identify students misconception on different topics in chemistry such as *particulate nature, physical state* and *change of*; *chemical bonding* [16]; *chemical thermodynamic* [17]; *acid-base*; *structure of matter*; *chemical kinetics* and *equilibrium* [18]; *redox reaction* [19]. Chemical equilibrium, in this regard, is found to be the most difficult fundamental concept [20][16][18]. Diagnostic studies on learning chemical equilibrium has recognized a number of students' misunderstandings on the concept of chemical equilibrium related to dynamism, reversibility and completeness of reaction [9]. For instance, students lack of awareness of dynamic nature of chemically equilibrated state; students associate chemical equilibrium with static balance [21]; students believe that the forward reaction goes to completion before the backward reaction starts [22].

Now a day, numerous studies on how to develop student learning and understanding in chemistry have been conducted. Student-centered learning situations are needed that encourage and inspire secondary-level students to strengthen and establish a broad range of conceptual, procedural, and meta-cognitive knowledge, and also a broader range of cognitive processes at school [23][24]. Consequently, different strategies were being suggested and applied to chemistry teaching with the aim of motivating students to learn chemistry at the macro, sub-micro and symbolic levels [9]. Besides, technology is being promoted as a potential means of providing an opportunity of multiple representations to illustrate the relation and interaction within these levels [25].

Among the strategies, formative assessment strategy is considered as a means to facilitate the learning of chemical equilibrium do not appear with sufficient importance in scientific literature [26]. In formative assessment, students are active participants with their teachers, sharing learning goals and understanding how their learning is progressing, what next steps they need to take, and how to take them. Meta-analyses and early studies have supported, with large amounts of evidence, that using formative assessment in the classroom had a large impact on student academic success especially for those students who were perennial low achievers [27]. However, teachers often feel they don't have time to assess students due to tight schedules for covering new content and to give individual feedback [28]. The demands and complexity of these types of assessment can be quite substantial, but technology makes them feasible. Technology can help teachers effectively to implement formative assessment by enabling more immediate feedback, displaying feedback in readily practical ways, and by providing new possibilities for assessing student understanding of scientific phenomena in dynamic and interactive ways [28].

Statement of the Problem

In many countries, there has been a decline in the motivation of students learning science from primary to university levels [29]. Numerous studies have tried to explain why students are not motivated in learning science in general and chemistry in particular from the primary to the tertiary levels. Unfortunately, these studies revealed that student's motivation towards science learning decline throughout their years at school, especially during secondary school levels [30]. In addition, motivation has been identified to have impacts on students' learning and influence students' performance in science [30]. Previous and current research has shown that students lacking motivation often encountered academic difficulties in science classes [31]. In line with this, it has recently been shown that decline in students' interest and academic achievements are becoming typical to science even at the level of general education [31].

In Ethiopia too, this undesired trend is reflected in the senior secondary examination results released by the national agency for examination for the past two years. These results reveal that the percentage of grade 12 students who passed chemistry at credit level over these years were below 50% as shown: 49.1% and 47.7% respectively. At this time, in order for students to be motivated to learn in any discipline, they must participate in activities that are personally meaningful and valuable [32]. For these reasons, many countries, including Ethiopia, are experiencing problems of engaging students in advanced study of natural science, especially chemistry [33][34]. Of many problems of engaging students, formative assessment represents a powerful means for meeting goals for high-performance, high-equity of student outcomes, and for providing students with knowledge and skills for lifelong learning.

In this regard, the education and training policy of Ethiopia launched in 1994, assessment as its major curriculum component helps to determine students' learning achievement, identify their learning difficulties for special supports, improve teacher's pedagogical practices, and improve quality of education in general. Regardless of the intention on the policy document, the practice of formative assessment is very low at the classroom level [35]. For several reasons such as lack of science resources, large class size, shortage of instructional time, lack of instructional materials, students' and teachers' negative perception on formative assessment, teachers' lack of knowledge and skill about formative assessment, and large content of courses as major factors for not implementing formative assessment in classrooms [35]. These all findings clearly indicated that the practice of formative assessment has been poorly practiced in classrooms.

Today's learning technological tools have been greatly improved, which makes it more feasible to embed formative assessment interventions in secondary classrooms and to provide different kinds of immediate feedback to students. However, most of the prior research on formative assessment has not focused on technology supported formative assessment strategies [36]. Consequently, Bhagat and

Spector [36] recommended that there is a need for further research on the use of technology in support of formative assessment. Therefore, this study aims at examining the effects of technology integrated planned formative assessment-strategy on improving students' conceptual knowledge and their motivation towards learning chemical equilibrium in particular and chemistry in general. To address the above objective, the researchers made three specific research questions:

1. Does technology integrated planned formative assessment affect students' conceptual knowledge on the dimension of cognitive process in learning chemical equilibrium?
2. What is the effect of technology integrated planned formative assessment on students' motivation towards chemistry in general and chemical equilibrium in particular?
3. Is there an interaction in students' conceptual test scores on the variation of time point by groups?

Theoretical Framework of the Study

Formative assessment is not necessarily associated with any particular theory of learning. However, current conceptualizations of formative assessment are typically rooted in a sociocultural constructivist view of learning [37]. This theory of learning is supported by investigation in most compatible with present goals of education, and best describes the processes of effective formative assessment [37]. From a sociocultural constructivist viewpoint, students are seen as actively constructing knowledge and understanding through cognitive processes within a social and cultural context [38]; as construction new knowledge on what they already know and as developing the metacognitive skills necessary to regulate their own learning [38]. These understandings about learning and development have implications for the practice of formative assessment in classroom instruction. The work of Vygotsky [38] forms much of the basis for current conceptualizations of the sociocultural aspects of constructivist learning theory and has been widely applied to models of formative assessment. Students are seen to improve knowledge and understanding in a domain over time, not only as individuals but in an interactive social context, guided by others with greater expertise [38].

One assumption of sociocultural theory is that learning is enhanced by what Vygotsky referred to as "joint productive activity" within a social setting, such as in a classroom where students and teachers collaborate as a community of learners. The "zone of proximal development" (ZPD), a concept taken from Vygotsky [38], has been invoked by formative assessment theorists as suitable for understanding the gap between a learner's actual understanding and the learner's targeted or possible learning. The ZPD is the developmental space between the level at which a learner can handle a problem or complete a task independently and the level at which the learner can handle or complete the same task with help from a more knowledgeable other, such as a teacher. Work within the ZPD is a specific example of joint productive activity, that is, teacher and learner are working jointly to ensure that the student reaches a learning goal [37].

In teaching, the teacher serves as a mediator between the student and the learning goal, providing scaffolding to aid attainment of the goal [39]. Formative assessment is part of this process whether implicitly or explicitly as the teacher uses information about how a student responds to instruction in order to give feedback to the student and/or adjust instruction so as to prompt learning or performance. In this case, formative assessment is almost indistinguishable from instruction, as the teacher introduces content; assesses how the student is responding; offers supports for understanding and modifies instruction as needed; re-assesses how the student's learning is progressing; continues with new con¬tent or returns in a new way to the same content, and so forth.

For the promoting of the conceptual and procedural knowledge of students on chemical equilibrium, this study will be based on the framework of formative assessment by Black and William [39] supported by socio-constructivist theory of learning by Vygotsky [38], and Heritage [37] model of formative assessment. From the theory of Vygotsky [38], the following will accordingly be adapted: Zone of Proximal Development (ZPD), context, scaffolding, social interaction and collaborative learning. From Heritage [37] model of formative assessment, the researcher adapted the following: learning progression, identifying the gap, teacher knowledge & skills and closing of the gap.

The formative assessment framework of Black and William [39], presents the five key formative assessment strategies including; clarifying and sharing learning intentions and criteria for success, engineering effective classroom discussions, questions and learning tasks, feedback that moves learners forward, self-assessment and peer-assessment. The three agents in the classroom are; teacher, learner and peer. The interaction of the three agents will be facilitated by using technological tools and software. Three questions to be answered during intervention; where the learner is going? Where the learner is now? And, how the learn gets there?

Self-determination theory established by Ryan and Deci [40] is the second framework used as a foundation for this study. Motivation is an integral aspect of self-determination theory. Ryan and Deci [40] identified distinct types of motivation that have direct influence on learning outcomes. Intrinsic motivation is the internal tendency to look for challenges, extend personal growth, explore and learn new concepts [40]. Extrinsic motivation is dependent on external rewards [40]. These rewards can also be called controls used to encourage desired behavior [41]. Fretz [41] recognizes that teachers have used external controls for a long time through the use of grade points and rewards. Motivation is something that comes from within the person and not from someone else [41]. Fretz [41] states that children are born with a natural tendency to explore, but schools have become more control-oriented leaving students with fewer choices. Three conditions are identified in self-determination theory as foundations for motivation. These conditions are autonomy of your own life, competence in dealing with your environment, and relatedness to something more than yourself [41]. Self-determination theory guided the treatment and interviews used for teachers administering formative assessment.

Conceptual Framework of the Study

The whole study was guided by social-constructivist learning theory and self-determination theory. The independent variables of the study were groups and time points. The intervening variables of the study were the interaction between self-learner, peer and teacher-learner with the five formative assessment strategies. For example, at the start of a lesson, the teacher is responsible for clarifying learning intentions and success criteria and communicating that to the students. While teaching, the teacher needs to create a learning environment involving discussions, questioning and other learning tasks to obtain evidence on student understanding. Moreover, he/she needs to provide formative feedback or comments to the students to enable them to achieve the success criteria and the learning intentions. Correspondingly, the students and peers are expected to understand learning intentions and criteria for success at the start of a lesson. Furthermore, the learning environment can be facilitated so that the students work together in their learning, evaluate each other's work, share feedback and comments to reach the success criteria and attain the learning targets. The dependent variables of the study were students' conceptual knowledge, procedural knowledge and their motivation towards learning chemistry.

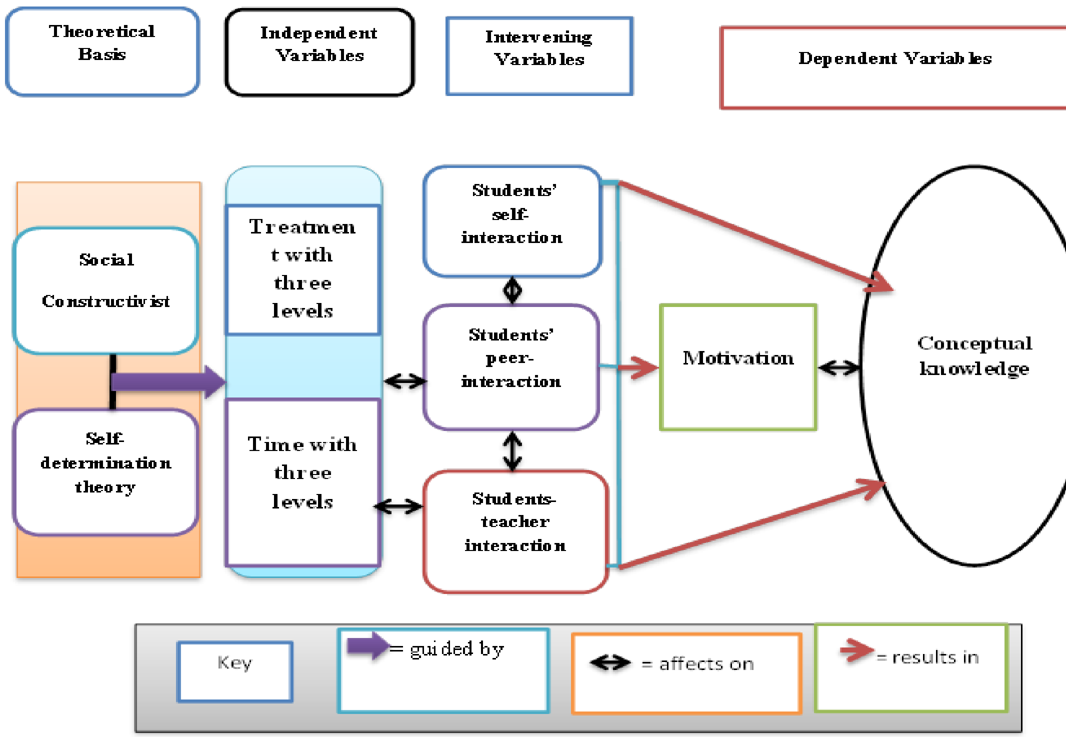

Figure 1. The conceptual framework model of the study

RESEARCH METHODOLOGY

Research Design

In educational research, it is difficult to conduct true experiment for the reason that variables cannot be controlled fully and randomization is not easy. As a result of this, quasi experiment developed as an alternative in experimental research. In this study, the non-equivalent pretest, multiple treatments, posttest control group quasi experimental research design was employed [42]. As a result, the design has one comparison group and two treatment groups with pretest, posttest and follow-up posttest design. According to this research design, experimental group one students were exposed to technology integrated formative assessment(E_1), Experimental group two students were exposed to formative assessment alone (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	Follow-up posttest
Experimental group one	O_1	E_1	O_2	O_3
Experimental group two	O_1	E_2	O_2	O_3
Comparison group	O_1	X	O_2	O_3

Where: **O_1** is pre-test for the experimental and comparison groups

O_2 is post-test for experimental and control groups

O_3 is follow-up post-test for experimental and control groups after a month of the intervention

E_1 is treatment for experimental group1 (received technology integrated formative assessment)

E_2 is treatment for experimental group2 (received formative assessment only)

X is treatment for comparison group (received the actual existing instruction)

Population and Sampling Technique

Considering easy accessibility, geographical proximity, and availability as criteria, the researcher was selected Addis Ababa City as research site using convenience sampling technique. The population of this study was grade 11 students in government secondary schools. Then, out of ten sub-cities of Addis Ababa, three sub-cities were selected using simple random sampling techniques as a target population. Next, from each three sub-cities, one secondary school was selected using lottery methods as a sample. Next to this, simple random sampling techniques was employed to select three intact classes within the schools and the three sections were just be randomly assigned two for treatments and one for comparison group. And then, 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.

Variables of the Study

The independent variables of this study were groups and time point. The groups, has three levels which are Technology Integrated Formative Assessment (TIFA), Formative Assessment (FA) alone and Comparison Method (CM) groups and time point has three level(pre-test, post-test, follow-up test). The dependent variables of this study were the conceptual knowledge and motivation.

Data Collecting Instruments

In order to answer the research questions of this study, data were collected using conceptual knowledge test and chemistry motivation questionnaire (adapted from literature). The conceptual knowledge tests were used three times as pre-test, post-test and follow-up posttest after two month of intervention. Chemistry motivation questionnaire were used two times as pre-test before intervention and post-test after immediate intervention. The characteristics of these instruments are described in detail below.

Chemical Equilibrium Conceptual Test

This test included 25 multiple-choice questions**.** Each question has only one correct answer and four distracters. All questions were adapted from literature and modified to make them suitable for the study. The adapted conceptual questions were distributed in terms of the cognitive process dimension based on the revised Blooms Taxonomy by the researcher and other specialists such as: remembering (6 learning outcomes), understanding (6 learning outcomes), applying (7 learning outcomes), analyzing (3 learning outcomes), and evaluation (2 learning outcomes). The test contained items to assess the students' general conceptual knowledge before the treatment, immediate after the treatment and also after two moth of the treatment. The reliability coefficient ca1culated for internal consistency of all conceptual test items was 0.74 and above**.**

Chemistry Motivation Questionnaire

Science Motivation Questionnaire II (SMQ-II) developed by Glynn and Koballa [32], in 2011 was adapted to gather information about students' motivation to learn chemistry. In their study they gave permission to researchers to extend the usage of SMQ to 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 are respectively substituted for the word science. In the version used in this study, only the word "science" was replaced with the word "chemistry". Therefore, the Chemistry Motivation Questionnaire II (CMQ-II) instrument was used for overall motivation score. All of these variables were in interval scale and continuous.

Validity and Reliability of the Instruments

Data collecting instrument of chemical equilibrium conceptual knowledge test was reviewed and examined for face and content validities by 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. The instrument was reviewed according to the comments obtained. The instruments were tested in one school which were not be part of the study sample on 40 respondents of 12th grade students. The conceptual chemical equilibrium pretest and posttest as well as the motivation questionnaire were pilot tested with those who volunteered to participate in piloting the instrument. Kuder Richardson formula 21 (K-R21) was used to establish a reliability coefficient estimate of approximately .72. Likewise, the reliability coefficient for motivation questionnaire estimated by Cronbach‟s alpha was found to be .87

Treatment Procedure

Three schools, three teachers and three sections were selected and assigned as two treatments and one comparison group randomly. At that moment, training was conducted for teachers and students in treatment groups. At the beginning of the treatment, I gave brief information about the purpose of the study, the ways of the implementation of the treatment, the activities to be carried out during the treatment, and the time schedule. The training was given by the researcher and lasted for two weeks.

After training, pretest about the chemical equilibrium conceptual knowledge test and chemistry motivation questionnaire was given to the three sections taught by the three teachers followed by administration of the intervention. All groups were taught on the same content of the chemical equilibrium concepts. The classroom instruction of the groups was three 45-minute sessions per week and totally conducted for a period of 7 weeks. The experimental and comparison groups spent equal time for studying. However, the lessons in the experimental groups focused on using the technology-integrated formative assessment and formative assessment alone that was designed to improve students' conceptual knowledge on chemical equilibrium concepts.

The lessons were conducted mostly through cooperative group work in order to improve dialogue between the learners. The groups were formed in a heterogeneous way by the teacher considering such factors as the students' gender, achievement status, affective characteristics, etc. As a result, eight groups were formed and each group consisted of four and five students. Questions that measured high-level thinking skills and encouraged students to think were used often during the lesson and given time to think before they responded to the questions. To do this, teachers were practicing the following formative assessment techniques in the classroom: concept map, conceptual diagnosis, observation, self-assessment, quiz, oral questions, think-pair share, one question and one comment, 3-minute pause, and one minute essay.

Among the technological tools used in this study were interactive white board, computer desktop, LCD projector, microphone and smart phone. Among the software used in this study were telegram, power point, and internet access. The main purpose of integrating technology in formative assessment in this study was to display open ended formative assessment activities in the classroom and to display scientific reasoning of these activities in timely, to create interactive learning, to easily access student work during the assessment process, to facilitate peer feedback and collaboration, and enables students to receive feedback in faster and hence more frequent feedback cycles.

The technological tools were checked before the lessons and the student teaching materials for performing treatments were provided by the researcher at the beginning of the treatment. After each class time, the teacher and researcher evaluated the implementation of a technology integrated formative assessment strategies. The same procedure applied with the other teacher too. Researcher always supported the teachers in any problem about the implementations, as well as giving feedbacks and suggestion to make intervention more proper. When the study period was completed, the conceptual knowledge test and students' motivation questionnaire were administered as post-test after which their conceptual knowledge and motivation scored were compared. Finally, follow-up posttest was administered for all groups to evaluate the time point effects of each group.

Methods of Data Analysis

The results obtained from all the instruments administered were coded and analyzed by the researchers. To make the analyses more valid and reliable One-way ANOVA and Mixed model ANOVA was conducted. To summarize results between study variables, descriptive statistics (mean and standard deviation) was applied. To remove the effects of covariate variables (if any), in pretest-post test results from the variables of interest ANCOVA was done. Before the analysis, the needed assumptions were investigated for testing. In this way, univariate and multivariate normality, homogeneity of variances, sphericity and variance-covariance homogeneity assumptions were analyzed [43]. Skewness-kurtosis coefficient was calculated for each group and variables in terms of normality for univariate. The criterion that skewness and kurtosis coefficients are between -1.96 and +1.96 is accepted as normal distribution [44]. This analysis was done with the help of Statistical Package for Social Sciences (SPSS) computer package version 26. To make reliable inferences from the data, all statistical tests were tested for significance at alpha (α) level of 0.05.

Consideration of Ethical Issues

In this study, the researchers considered the following ethical issues during data collection, interpretation and dissemination. First, the researchers seek permission from the school administration to allow the researchers to conduct the study. Second, the researchers were discussed the objectives of the study with the research participants and obtained their informed consent. Chemistry teachers and natural science students participating in the study received an informed consent form describing the study purpose and procedures. The approved consent form indicated that participation in the study was voluntary. Third, the researchers promise to behave confidentially regarding the data collected from research participants.

RESULTS AND DISCUSSION

Analysis of Pre-test Results among Groups

Based on the data obtained from the pre-administration of pre-conceptual knowledge test and pre-motivation test; pretest mean scores for the two experimental and one comparison groups were compared using One-way ANOVA as there were three groups. The statistical results of each group were analyzed and presented in Table 2 and 3.

Table 2. Summary on students' pre-test scores in conceptual test in the dimension of cognitive process and their motivation among the three groups

Dependent variable	Group level	N	Mean	Std. deviation
pre-test conceptual knowledge plus remembering	TIFA group	45	2.64	1.33
	FA group	43	2.70	1.32
	CM group	44	2.75	1.43
	Total	132	2.70	1.35
pre-test conceptual knowledge plus understanding	TIFA group	45	2.04	1.21
	FA group	43	1.91	1.11
	CM group	44	2.25	1.22
	Total	132	2.07	1.18
pre-test conceptual knowledge plus applying	TIFA group	45	1.87	1.16
	FA group	43	1.51	1.35
	CM group	44	1.72	1.11
	Total	132	1.70	1.21
pre-test conceptual knowledge plus analyzing	TIFA group	45	.93	.72
	FA group	43	1.00	.87
	CM group	44	1.00	.78
	Total	132	.98	.79
pre-test conceptual knowledge plus evaluation	TIFA group	45	.38	.65
	FA group	43	.33	.52
	CM group	44	.55	.59
	Total	132	.42	.59
pre-test motivation	TIFA group	45	59.69	2.56
	FA group	43	60.35	2.58
	CM group	44	60.57	2.82
	Total	132	60.19	2.66

Table 3. One-way analysis of variance summary table comparing the three groups on scores of pre-test of conceptual test in the dimension of cognitive process and their motivation

Dependent variable	Source	SS	Df	MS	F	Sig
pre-test conceptual knowledge plus remembering	Between Groups	.248	2	.124	.067	.935
	Within Groups	239.631	129	1.858		
	Total	239.879	131			
pre-test conceptual knowledge plus understanding	Between Groups	2.597	2	1.299	.932	.396
	Within Groups	179.789	129	1.394		
	Total	182.386	131			
pre-test conceptual knowledge plus applying	Between Groups	2.806	2	1.403	.959	.386
	Within Groups	188.671	129	1.463		
	Total	191.477	131			
pre-test conceptual knowledge plus analyzing	Between Groups	.132	2	.066	.105	.900
	Within Groups	80.800	129	.626		
	Total	80.932	131			
pre-test conceptual knowledge plus evaluation	Between Groups	1.155	2	.577	1.658	.195
	Within Groups	44.929	129	.348		
	Total	46.083	131			
pre-test motivation	Between Groups	18.67	2	9.34	1.32	.270
	Within Groups	910.21	129	7.06		
	Total	928.88	131			

The results in Table 2 show that before intervention, the mean and standard deviation for conceptual knowledge test in the dimension of cognitive process among the three groups. Table 3 further indicates that the One-way ANOVA results for pretest on conceptual knowledge test on the dimension of cognitive process among the groups. Results shows that there were no significant differences in pre-test on remembering ($F (2,129) = .067, p=.935$), understanding ($F (2,129) = .932, p=.396$), applying ($F (2,129) = .959, p=.386$), analysis ($F (2,129) = .105, p=.900$), evaluation ($F (2,129) = 1.658, p=.195$) and pre-motivation ($F (2,129) = 1.32, p = .270$). 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.

Analysis of Post- test Results

Effects of Treatment on Conceptual Test Scores in the Dimension of Cognitive Process

A one-way ANOVA was conducted in order to evaluate the mean differences among groups on the conceptual knowledge test scores in the dimension of cognitive process. The analysis of the conceptual post-test results are presented in the below Tables 4, 5 and 6.

Table 4. Means and standard deviations comparing the three intervention groups of conceptual knowledge on the dimension of cognitive process

Cognitive dimension	Groups	N	M	SD
Conceptual plus remembering	TIFA group	45	5.13	.94
	FA group	43	4.86	.94
	CM group	44	4.55	1.23
	Total	132	4.85	1.07
	TIFA group	45	5.44	1.22

Conceptual plus understanding	FA group	43	4.72	1.80
	CM group	44	4.39	1.91
	Total	132	4.86	1.71
Conceptual plus applying	TIFA group	45	5.49	1.24
	FA group	43	4.42	1.40
	CM group	44	3.73	1.30
	Total	132	4.55	1.49
Conceptual plus analyzing	TIFA group	45	2.20	.69
	FA group	43	1.98	.99
	CM group	44	1.95	.89
	Total	132	2.05	.86
Conceptual plus evaluating	TIFA group	45	.69	.51
	FA group	43	.65	.53
	CM group	44	.43	.55
	Total	132	.59	.54

Table 5. One-way ANOVA summary table comparing the three intervention groups on scores of conceptual knowledge in the dimension of cognitive process

Cognitive dimension	Source	SS	Df	MS	F	Sig.	η^2
Conceptual plus remembering	Between Groups	7.698	2	3.85	3.52	.033	.05
	Within Groups	141.272	129	1.10			
	Total	148.970	131				
Conceptual plus understanding	Between Groups	26.071	2	13.036	4.70	.011	.07
	Within Groups	358.194	129	2.78			
	Total	384.265	131				
Conceptual plus applying	Between Groups	70.192	2	35.10	20.35	.000	.24
	Within Groups	222.437	129	1.72			
	Total	292.629	131				
Conceptual plus analyzing	Between Groups	1.641	2	.82	1.10	.335	.02
	Within Groups	96.086	129	.75			
	Total	97.727	131				
Conceptual plus evaluating	Between Groups	1.702	2	.85	3.03	.052	.05
	Within Groups	36.207	129	.28			
	Total	37.909	131				

Descriptive statistics and one-way ANOVA results for intervention effects on students' conceptual knowledge in the dimension of cognitive process among groups were performed. There was a statistically significant difference between groups as determined by one-way ANOVA in posttest on conceptual plus remembering (F (2,129) = 3.52, p=.033, η^2 = .05), conceptual plus understanding (F (2,129) = 4.70, p=.033,η^2=.07), and conceptual plus applying(F(2, 129) = 20.35, p<.001, η^2 = .24). There were no statistically significant differences between group means as determined by one-way ANOVA in posttest on conceptual plus analysis (F (2, 129) = 1.10, p = .335, η^2 = .02) and conceptual plus evaluating (F (2,129) = 3.03, p = .052, η^2 = .05) (see in Table 26). It could be concluded that results showed significant differences in conceptual plus remembering, applying but the mean and standard deviation differences were too small and their effect sizes were small to medium according to Cohen's [45] guidelines except conceptual plus applying which was a large effect.

From the results so far, we know that there are statistically significant differences between the groups on conceptual plus remembering, understanding and applying. Recall from earlier that the ANOVA test tells us whether you have an overall difference between our groups, but it does not tell us which specific groups differed – post hoc tests do. Because post hoc tests are run to confirm where the differences occurred between groups, they should only be run when you have a shown an overall statistically significant difference in group means (i.e., a statistically significant one-way ANOVA result). So, post hoc using *Scheffé* test was conducted to see the significance differences for each individual group. The table below, multiple comparisons, shows which groups differed from each other.

Table 6. Multiple comparisons of TIFA, FA and CM groups on students conceptual test scores on the dimension of cognitive process

Scheffé

Dependent Variable	(I) number of groups	(J) number of groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
post-test conceptual plus remembering	TIFA group	FA group	.27	.22	.442	-.26	.80
		CM group	.58*	.22	.024	.06	1.11
	FA group	TIFA group	-.27	.22	.442	-.80	.26
		CM group	.32	.22	.342	-.22	.85
	CM group	TIFA group	-.59*	.22	.024	-1.11	-.06
		FA group	-.32	.22	.342	-.84	.22
post-test conceptual plus understanding	TIFA group	FA group	.72	.36	.108	-.12	1.57
		CM group	1.06*	.35	.009	.22	1.90
	FA group	TIFA group	-.72	.35	.108	-1.57	.11
		CM group	.33	.36	.618	-.51	1.18
	CM group	TIFA group	-1.06*	.35	.009	-1.89	-.22
		FA group	-.33	.36	.618	-1.18	.51
post-test conceptual plus analyzing	TIFA group	FA group	.22	.18	.448	-.21	.66
		CM group	.25	.18	.375	-.19	.68
	FA group	TIFA group	-.22	.18	.448	-.66	.21
		CM group	.02	.19	.992	-.42	.46
	CM group	TIFA group	-.25	.18	.375	-.68	.19
		FA group	-.02	.19	.992	-.46	.42

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

A post hoc *Scheffé* test showed that the TIFA group and CM groups differed significantly at p < .05; the FA only group was not significantly different from the other two groups on the conceptual plus remembering and conceptual plus understanding learning outcome. There was no statistically significant difference on conceptual plus applying among the three groups ($p > .05$; see in Table 6).

Effect of Treatment on Students' Motivation towards Learning Chemistry

To determine the possible effect of technology integrated formative assessment on student motivation towards learning chemistry as a subject, the researchers 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 7, 8 and 9 below.

Table 7. Means and standard deviations comparing the three intervention groups on scores of students' motivation questionnaire towards learning chemistry

Groups	Motivation scores N	Motivation scores M	Motivation scores SD
TIFA group	45	72.60	16.71
FA group	43	63.84	17.37
CM group	44	54.73	16.76

Total	132	63.79	18.36

Table 8. One-way ANOVA summary table comparing the three group levels on scores of students' motivation questionnaire towards learning chemistry

Source	SS	Df	MS	F	Sig	η^2
Between Groups	7106.673	2	3553.336	12.375	.000	.16
Within Groups	37039.39	129	287.127			
Total	44146.06	131				

Table 9. Multiple comparisons of TIFA, FA and CM groups on students motivation scores

Scheffé

(I) group of students	(J) group of students	Mean Difference (I-J)	SE	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
TIFA group	FA group	8.76*	3.61	.044	.19	17.33
	CM group	17.87*	3.59	.000	9.35	26.39
FA group	TIFA group	-8.76*	3.61	.044	-17.33	-.19
	CM group	9.11*	3.63	.036	.49	17.73
CM group	TIFA group	-17.87*	3.59	.000	-26.39	-9.35
	FA group	-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 motivation as the dependent variable. The assumptions of homogeneity of variances was tested and found tenable using Levene's test, F (2, 129) = .028, p= .972 and the outcome variable was approximately normally distributed. A significant difference was found between the three groups in their motivation, (F (2, 129) = 12.375, p< .001,$\eta^2 = .16$). After establishing that there was a significant difference between motivation of students taught the topic of chemical equilibrium using TIFA, FA and those taught using CM, 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 motivation towards learning chemistry in the CM group (M = 54.73, SD = 16.76, p < .001) was significantly less than the motivation towards learning chemistry in the TIFA group (M = 72.60, SD = 16.71, p = .044) and FA alone group (M = 8.10, SD = 1.69, p = .036). Further, Cohen's effect size value ($\eta^2 = .16$) suggested a high practical significance.

Effects of Time Point by Groups on Conceptual Test Scores

A two-way 3 (time: pretest, posttest and follow-up test) × 3 (groups: TIFA, FA only and CM groups) mixed ANOVA with repeated measures on conceptual knowledge test scores was conducted. The main effect of time point for conceptual test was not significantly violate the sphericity assumption because the significance value is greater than .05, W= .847, χ^2 (2) = 2.83, p> .05. Therefore, the F-value for the main effect of time point (and its interaction with the between-group variable of groups) was not need to be corrected for violations of sphericity. The results of the descriptive and inferential statistics were presented in the below Tables 10 and 11.

Table 10. Means and standard deviations for the conceptual knowledge test scores as a function of a 3 (time) x 3 (groups)

Time	Group	M	SD	N
Pre-conceptual Knowledge test	TIFA	7.87	2.64	45
	FA only	6.95	3.08	43
	CM	8.27	2.49	44

	Total	7.70	2.78	132
Post-conceptual Knowledge test	TIFA	18.93	2.30	45
	FA only	16.63	3.86	43
	CM	15.05	4.06	44
	Total	16.89	3.97	132
Follow-up conceptual knowledge test	TIFA	17.27	2.74	45
	FA only	14.74	3.30	43
	CM	12.57	3.13	44
	Total	14.88	3.60	132

Table 11. Mixed model ANOVA results for time point by groups on conceptual test scores

Source	Type III MS	Df	MS	F	P	η^2
between-subject effective						
Group	524.068	2	262.034	16.732	.000	.206
Error	2020.225	129	15.661			
Within-subject effect						
Time	6133.429	2	3066.715	419.042	.000	.765
time*group	348.394	4	87.098	11.901	.000	.156
Error(time)	1888.147	258	7.318			

The results of the Two-way mixed ANOVA showed that there was significant main effect among groups (F (2, 129) = 16.73, p <. 001, η_p^2 = .206) on conceptual test scores with larger effect size. In addition, there was also significant main effect of time point on conceptual test scores (F (2, 258) = 419.04, p <. 001, η_p^2 = .765) which also has large effect size. Furthermore, there was a significant interaction between time point and groups (F (4, 258) = 11.59, p <. 001, *ηp2* = .156), on conceptual knowledge test scores (see in Table 11). Descriptive statistics showed that while TIFA group performed better on conceptual test scores (M= 27.60, SD = 2.30) compared to FA alone group (M = 25.95, SD = 2.68) and CM group (M = 25.95, SD = 2.68) (Table 10). The profile plots Figure 1 illustrate the trend across time for three intervention groups. There was an overall linear, increasing tread and the trends for the three groups were parallel. Overall, there was difference among three groups and the conventional method group was less effective than the other two groups. Furthermore, the mean gains of the three groups were higher in post-test than the other two time points.

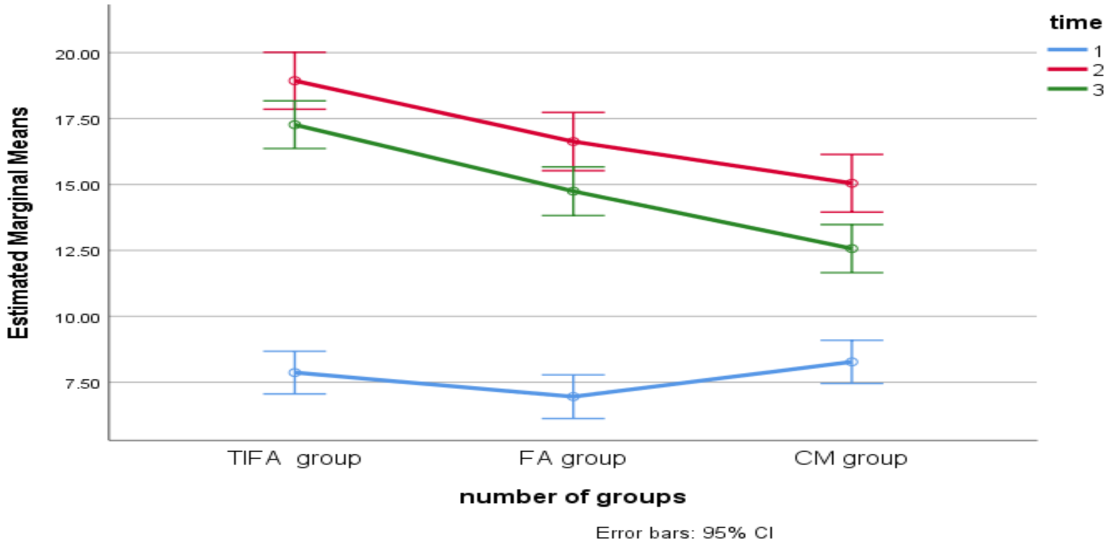

Figure 2. Line plot represents students' conceptual knowledge test scores across different time point among groups

Discussion

Conceptual knowledge is the understanding of concepts in the minds of students. In this study, Revised Bloom's Taxonomy was used to assess both pre-test and post-test conceptual knowledge test scores among groups. A one way ANOVA analysis for effect of treatment on outcome variables for three groups was applied. Results showed that there were statistically significant difference between groups in posttest on conceptual plus remembering (F (2,129) = 3.52, p=.033, η^2 = .05), conceptual plus understanding (F (2,129) = 4.70, p=.033,η^2=.07), and conceptual plus applying(F(2, 129) = 20.35, p<.001, η^2 = .24). There were no statistically significant differences between group in posttest on conceptual plus analysis (F (2, 129) = 1.10, p = .335, η^2 = .02) and conceptual plus evaluating (F (2,129) = 3.03, p = .052, η^2 = .05). The positive impact of using technology integrated formative assessment to improve learning as presented in the results of this study is in line with what a number of researchers have argued [46][47][48].

To determine the potential effect of technology integrated formative assessment on student motivation to learn chemistry, the researcher compared students' pre- and post-test scores using one-way ANOVA. A significant difference was found between the three groups in their motivation, (F (2, 129) = 12.375, p< .001,η^2 = .16). This shows significant shift towards increased student motivation following the intervention. This means that, based on this sample, there is significant difference between student motivation and the implementation of technology integrated formative assessment strategies. The results are in line with previous studies about technology-supported assessments where students were more favorable towards technology integrated instruction compared to those who used paper-based assessments [49].

CONCLUSION AND RECOMMENDATION

Based on the findings of this study, it could be concluded that when technology integrated planned for interactive formative assessment are used in classroom, it improve the conceptual knowledge and motivation of the students on the subject and also enable them to understand the contents of the subject more better than the use of formative assessment alone and conventional method. Also planned for interactive individual and peer formative activities serve as a basis for finding out the sources of difficulties on the contents of the subject. In this way, the teacher is able to give necessary feedback and correctives measure to improve the understanding of students on the contents of the subject in order to improve their conceptual knowledge and motivation towards the subject. The study has revealed that those students who are not exposing to formative assessment have no significance difference in their conceptual score in chemistry. In light of findings from this study, the following recommendations are being made:

- Frequent training on how to use technology integrated formative assessment effectively in teaching and learning chemistry
- Should be organized for chemistry teachers by the government and stakeholders in secondary schools. Such training should be supervised and evaluated to make sure that chemistry teachers have mastered the strategies for use in classrooms.
- Chemistry teachers should adapted technology integrated formative assessment strategies to improve students learning outcome in the learning process actively and make them take more responsible for their own learning.

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