THE IMPACT OF SIMULATION-SUPPORTED CONTEXT-BASED LEARNING APPROACH ON THE SIX DIMENSIONS OF STUDENTS' MOTIVATION IN CHEMISTRY

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ABSTRACT

The efficacy of the simulation-integrated context-based approach (SICBA) on each of the six motivational dimensions of grade 10 students was compared to the efficacy of the context-based approach (CBA), simulation-integrated conventional teaching approach (SICTA), and conventional teaching approach (CTA) using the 7E learning model. The study employed a quasi-experimental pretest-posttest non-equivalent control group design. A six-dimensional chemistry motivation scale was utilized to collect data from 229 students. Descriptive and inferential statistics were used to analyse the data. The results showed that the motivation of SICBA-treated group was significantly different from CBA-treated group regarding intrinsic motivation. Although the SICBA group had higher mean scores, there were no significant differences from the CBA group in external motivation, self-determination, self-efficacy, personal relevance, and career motivation. Likewise**,** SICBA significantly enhances all six dimensions of student motivation compared to SICTA and CTA. The study suggests that similar to SICBA, CBA can also effectively improve students' motivation to learn chemistry. Chemistry teachers can then employ CBA (with or without simulation) via the 7E model to increase student motivation. *[African Journal of Chemical Education—AJCE 15(1), January 2025]*

INTRODUCTION

Studies in science education and chemistry in particular claim that students' motivation has been recognized as an important construct in the field of science education [1]. Scholars generally agree on the definition of motivation as the impetus that arouses, directs, and sustains students' behaviour and is important as they cannot learn unless they are motivated [1] [2]. It is, therefore, an essential prerequisite and co-requisite for learning science/chemistry. It is a complicated construct that it can be conceptualized in multiple dimensions (e.g., achievement goal, self-efficacy, self-determination, career motivation, intrinsic and extrinsic motivation, and many) as well as a wide range of theories (e.g., expectancy-value theory, goal theory, and self-determination theory) [3]. Later in the paper, we shall use the terms motivational dimensions, motivational dimensions, motivational factors, motivational components, and motivational elements interchangeably.

Although most motivational dimensions in chemistry education have not been widely measured as a function of instructional approaches [4], we chose only six dimensions—intrinsic motivation, extrinsic motivation, self-efficacy, self-determination, career motivation, and personal relevance. They were chosen because strengthening students' motivation with respect to these six dimensions is one of the focal areas of Ethiopian new National Education and Training Policy, and Education Sector Development Plan for secondary school students [5].

Intrinsic motivation, according to Self-Determination Theory (SDT), is the desire to engage in behaviours for no other reason than sheer delight, pleasure, or interest [6] [7]. Extrinsic motivation (according to STD) is the need to engage in activities to impress others, earn good grades or money, and so on [8]. Based on this theory, extrinsically motivated behaviours extend the spectrum between amotivation and intrinsic motivation, ranging in the degree to which their regulation is autonomous. Self-determination is the degree to which the motivation is autonomous-feels free [7] [9]. Also, self-efficacy, according to Bandura's Social Cognitive Theory, is a belief that addresses one's ability to perform a task [10]. Students who have low self-efficacy may struggle to complete learning activities while high self-efficacy students engage in more challenging tasks, work harder, persist longer in the face of difficulties [11] [12].

Career motivation is a motivation that arises from students' perception of their future career which is crucial for students to achieve their expected professions and develop skills required for their jobs [13]. Personal relevance is a motivation of students to learn chemistry as a result of its relevance to their goals. Students motivated with personal relevance may feel that learning chemistry makes my life more meaningful [6] [14]. Even though students' motivation is an essential element, research findings indicate students' level of motivational dimensions to learn chemistry (or science in general) is declining from primary to secondary schools [15].

LITERATURE REVIEW

A number of factors can have an impact on students' motivation to learn chemistry. For instance, decontextualized mode of chemical discourses and limited use of educational technology which dominate classroom instructions in schools could be some of the factors that makes chemistry boring for students and makes them less motivated to learn in secondary school [16] [17] [18]. According to SDT, these instructions may be less effective in addressing basic human needs such as autonomy, competence, and relatedness to boost, for example, intrinsic motivation and self-determination [9]. Additionally, because these instructions may lack social constructivist learning environment, students may not have as much opportunity to observe others while mastering tasks and gaining social persuasion from others to develop, for example, self-efficacy and extrinsic motivation [12].

Researchers still debate how to improve school students' motivation toward chemistry to tackle this problem [17] [18]. As mentioned in the preceding paragraphs, these studies also claimed that utilizing a traditional / non-participatory approach may be at fault for students' lack of motivation for chemistry. The conventional approach in this regard is a content-based approach that uses linearly ordered content and isolated facts [19] [20]. In this approach, contexts may be offered as illustrations within educational materials.

These researchers proposed that CBA [18] [21] and technology-integrated instruction, TII, [22] [23] [24] might increase students' motivation for chemistry. CBA, according to this research, helps students connect chemical concepts to their daily lives, while TII (such as computer simulations) may help them grasp abstract chemistry concepts. However, most CBA and TII chemistry investigations focused on overall motivation rather than individual motivational components [4].

Under the context-based approach, the current study employed the 7E learning model as an instructional strategy. The 7E learning model [25] is a context-based instructional strategy that includes seven learning stages: Engage, Explore, Explain, Elaborate, Extend, Exchange, and Evaluate. This learning model was chosen for this study because it is supposed to coincide with CBA and the participatory teaching methods employed in the study. CBA is defined in this study as a teaching approach that begins with a context and emphasizes both the context and the content of chemistry.

There is also little chemistry education research that includes computer simulations into CBA to improve students' learning motivational factors. As a result, we used computer simulation in the 7E learning model to see how it affected the six dimensions of students' learning of the chemistry of oxides, acids, bases, and salts (OABS). In Ethiopian secondary school chemistry curricula, these four compounds are organized and taught as a single chapter in a chemical course for grade 10. They are closely related which allows them to connect with common contexts. Furthermore, the efficacy of SICBA was compared to that of a non-integrated CBA, simulation-integrated conventional teaching approach (SICTA), and conventional teaching approach (CTA). The present study is therefore guided by the following research questions:

RQ1. Which motivational factor has a greater (or lesser) impact on overall motivation across groups?

RQ2. Is there a statistically significant mean difference (or not) between the groups on each motivating factor?

RQ3. Would SICBA recipients have considerably higher (or lower) mean scores for each of the motivating components than CBIA, SICTA, and CTA?

METHODS

The present study used a quantitative research approach employing a non-equivalent control group pretest-posttest quasi-experimental design. 229 students from four different high schools in the Borena Zone, Ethiopia, were chosen for the current research after receiving informed consent via a letter from the education office. Students in these schools come from similar socio-cultural backgrounds and educational environments. We picked four intact groups (one from every school) since random allocation of groups was not methodologically viable in an educational setting [26]. These intact groups were chosen at random from a pool of 229 consenting students. Then, each group was assigned at random to one of four research groups: SICBA (60 students), CBA (58 students), SICTA (56 students), and CTA (55 students).

The research participants indicated a higher rate of involvement, which could be due to a variety of reasons. One possibility could be that all intervention group students consented and were excited to participate in the study. The second reason could be that the treatments were implemented during the second and third months of the first semester when dropout rates are typically low. Students in the SICBA, CBA, SICTA, and CTA administered the pretest-posttests at a rate of 60, 58, 56, and 55, correspondingly. As a result, the final analysis comprised data from 229 students.

The chemistry motivation questionnaire (CMQ) was utilized in the study to collect the data from students. Twenty-six-CMQ items were adapted from [1] [14] [27]. We checked the items' veracity with experienced professors from the chemistry and psychology Departments at our university. Following that, we did an exploratory factor analysis to categorize items into components.

We next identified six components with eigenvalues greater than 1.0 [28] that explained 65.75% of the total variation (intrinsic motivation, extrinsic motivation, self-determination, self-efficacy, personal relevance, and career motivation). Furthermore, the scree-plot validated these six components. All factor loadings exceed 0.33 on their major factor, and a KMO of 0.91 indicates distinct and reliable components [14]. All of the diagonal components of the anti-image Matrix are bigger than 0.70, and the majority of the off-diagonal elements (0.41) are small. The Barlett test was significant ($p < .001$), indicating that correlations between items are significantly different from zero and that there are enough correlations to proceed with the analysis [29]. We opted to include all 26 items and six factors for further investigation.

Intrinsic motivation (#4), extrinsic motivation (#4), self-determination (#4), self-efficacy (#4), personal relevance (#5), and professional motivation (#5) all have almost the same number of items. [1] [13] [27] [30] obtained similar results. Experts in the field translated the scale's English version into Afaan Oromo (regional language). The linguist backtranslated it into English form.

Another English expert confirmed that the revised and original English versions were comparable. Table 1 shows a sample item for each dimension/construct.

According to the pilot study, Cronbach's reliability coefficients for intrinsic motivation were .85, .70 for extrinsic motivation, .80 for self-determination, .87 for self-efficacy, .73 for personal motivation, and .73 for career motivation. The overall CMQ had a total stratified alpha (s) of .88. All of these demonstrated that they were within acceptable limits for administering pre-and post-tests [20].

Table 1. Sample of Items for Every Motivational Construct

Dimension	Sample item
Intrinsic Motivation	I enjoy learning chemistry.
Extrinsic Motivation	I like to do better than other students on chemistry tests.
Self-Determination	I study hard to learn chemistry.
Self-Efficacy	I am confident I will do well or can answer most of the questions on chemistry tests.
Personal Relevance	I enjoy chemistry because it relates to my personal goal.
Career Motivation	Learning chemistry will give me a career advantage in my future.

Interventions

SICBA Group

We carefully administered a CMQ pretest alongside chemistry teachers before implementation. During the intervention, 'engage' stage, the teacher was able to elicit students' prior knowledge by asking questions related to their daily lives. The teacher then drew students by describing the context and encouraging them to find connections between prior and new knowledge.

Students can then answer the questions in small groups. According to the social constructivist approach [31], these group discussions can help students construct shared knowledge. Students next ‘explore’ through in-class and take-home practical tasks, and the teacher gave the opportunity to observe, record, and analyse results to provide answers to the questions posed during the engage stage.

The teacher introduced and explained concepts in the third (‘explain’) step by connecting contexts to concepts and concepts to concepts based on the textbook utilizing PhET interactive simulations, after which students ended their observations and presented the results from the second stage. Following that, during the ‘elaborate’ stage, the teacher lets students link previously developed ideas (stages 1–3) to other pertinent topics by asking questions or conducting real-life tasks. Learners intended to obtain a deeper understanding of OABS chemistry through new experiences, which would improve the six dimensions of their motivation [32].

Following the 'extend' stage, knowledge and lessons learned are linked and applied to similar contexts. At this stage, learners were given real-world examples from their surroundings and encouraged to hold group discussions based on these examples. In addition, the teacher may conduct extra in-class experiments to apply concepts in new settings. During the 'exchange' stage, a learning environment was created in which students may discuss their newly acquired knowledge with their peers. Finally, students were given a chance to evaluate their progress. Teachers posed open-ended questions. After a six-week intervention, students were given a posttest with similar care that they had during the pretest.

CBA Group

The instructional approach, instructional strategy, and participatory teaching methods employed in this group were identical to those used in the SICBA-treated group. The main distinction was that this group had not been taught via the PhET interactive simulation (Table 2).

SICTA Group

The teacher followed a similar teaching approach and instructional strategy as the comparison group. The utilization of computer simulations during the presentation stage was the only difference between this group and the comparison group (Table 2). The CMQ posttest was then given to the group in the same manner as the other groups.

Comparison Group

After the pretest, the study group received curriculum-based teaching. The teacher then utilized the conventional teaching approach (CTA) without any adjustment (Table 2). Students took the CMQ posttest following the six weeks of instruction.

Table 2. The Difference Between the Four Research Groups with Respect to Instructional Approach, Instructional Strategy, and Active Teaching Methods

Pedagogy	Treatments			
	Intervention			Comparison
	SICBA	CBA	SICTA	CTA
Approach	Context-based	Context-based	Content-based (conventional)	Content-based (conventional)
Strategy	7E learning model	7E learning model	Conventional (introduction-chalk/talk-summary-evaluation)	Conventional (introduction-chalk/talk-summary-evaluation)
Teaching methods	Q&A, in-class & take-home experiments, student presentation, small group discussion	Q&A, in-class & take-home experiments, student presentation, small group discussion	Existing teaching methods Q&A	Existing teaching methods Q&A
Supported with	PhET interactive simulation	None	PhET interactive simulation	None

Data Analysis

The data acquired from the CMQ were analysed using descriptive and inferential statistics (ANOVA, MANCOVA, follow-up DFA-discriminant function analysis, follow-up ANCOVA, and Bonferroni procedure) in IBM SPSS version 20. The major purpose of using follow-up DFA was to determine how much each motivational component contributed to overall motivation across groups. Most previous science education studies did not utilize follow-up DFA [32] [33]. We hope that our research paper can pave the way for future education researchers to use this cutting-edge statistical technique. Because ANCOVA is a univariate statistic that cannot account for the interaction between many dimensions, follow-up DFA is more crucial for supporting the findings and providing relevant data information [29] [34]. The significance level was set at .05. When their assumptions were met, the difference in posttest scores was examined using MANCOVA and follow-up ANCOVA.

RESULTS

ANOVA Results

Following the verification of its assumptions, ANOVA was performed to determine whether there was already a difference between the groups in terms of the pretest mean scores for each factor. According to the results, the pretest mean differences between the groups in three of the dimensions—self-efficacy ($F(3, 225) = 3.252$, $p = .023$), personal relevance ($F(3, 225) = 2.788$, $p = .041$), and career motivation ($F(3, 225) = 4.377$, $p = .005$)— were statistically significant. This indicated that students differ significantly in these motivational factors for chemistry from the outset. To isolate their effects, all preCMQ factor scores were used as covariates. This would allow for a more thorough investigation of the effect of instruction on postCMQ factors [30].

MANCOVA Results

Following the verification of its assumptions, a one-way MANCOVA with the omnibus Pillai trace test (Table 3) was used to test the null hypothesis of equality of group means. Pillai trace was chosen as a trustworthy test for any minor assumption violation. As indicated in the table, the pretest scores had no significant effect on the posttest scores; the sole effect on the posttest scores was the treatment, $V = 1.18$, $F_{(18, 645)} = 23.09$, $p = .000$, partial $\eta^2 = .39$.

Table 3**.** Results of One-way MANCOVA for the Linear Combination of PostCMQ Factors

Source	Pillai's Trace	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Treatment	1.176	23.093	18.000	645.000	.000	.392
PreCMQ_I	.005	.189	6.000	213.000	.980	.005
PreCMQ_E	.037	1.355	6.000	213.000	.234	.037
PreCMQ_Sd	.027	1.003	6.000	213.000	.424	.027
PreCMQ_Se	.018	.635	6.000	213.000	.702	.018
PreCMQ_P	.004	.131	6.000	213.000	.992	.004
PreCMQ_C	.024	.881	6.000	213.000	.510	.024

Note. I: intrinsic motivation, E: extrinsic motivation, Sd: self-determination, Se: self-efficacy, P: personal relevance, C: career motivation

DFA Results

The relative weights of the six motivational elements in the composite variable were explored using the follow-up DFA to answer RQ1. DFA generates three main discriminant functions (Table 4). The first function (R^2 =.96) explained 99% of the variation, while the second (R^2 =.22) and third (R^2 =.01) explained only 1.1% and 0.0%, respectively. A combined-group plot (Figure A1) was evaluated to identify which group had the greatest mean scores (centroids) of the discriminant functions. By inspecting the signs and placements of centroids, the SICBA and CBA-treated groups were segregated to the right-most (positive) and the other two groups to the left-most (negative) ends of the plot. This indicated that SICBA and CBA-treated groups scored better than those who received SICTA and CTA treatments with respect to the linear combination of postCMQ factors.

Table 4**.** Eigenvalues for the Three Canonical Discriminant Functions of PostCMQ Factor Scores

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation, R
1	23.94	98.8	98.8	.98
2	.28	1.1	100.0	.46
3	.01	.0	100.0	.08

The subsequent examination looks at the postCMQ factor scores standardized canonical discriminant function coefficients (β) and structure matrix coefficients (rs) to see which motivational factor contributed the most/least to the combined variable (Table 5). All six components were loaded and associated differently into the first discriminant function. But, post-career motivation (β = 1.67, rs =.52) was substantially loaded when post-self-efficacy (β = 1.09, rs =.48) and post-personal relevance (β = 1.07, rs =.46) were loaded second and third, respectively. Furthermore, post-self-determination and post-intrinsic motivations were loaded fourth and fifth, respectively, while post-extrinsic motivation was loaded last. These findings indicated that there was enough evidence to reject the null hypothesis; hence the alternative hypothesis was accepted. With these results, RQ1 had been answered.

Table 5**.** Standardized Canonical Discriminant Function Coefficients and Structure Matrix Coefficients of PostCMQ Factor Scores

Outcome variable	Standardized Coefficient (β)			Structure Matrix Coefficient (r_s)		
	F1	F2	F3	F1	F2	F3
PostCMQ_I	.852	1.51	1.49	.35	.39	.54
PostCMQ_E	.846	1.08	.67	.34	.27	.14
PostCMQ_Sd	.902	1.31	-1.97	.41	.44	-.72
PostCMQ_Se	1.09	-1.05	.70	.48	-.37	.22
PostCMQ_P	1.07	-1.38	-.87	.46	-.37	-.14
PostCMQ_C	1.67	-1.09	.13	.52	-.31	.08

ANCOVA Results

The descriptive statistics evidence (Table 6) and follow-up ANCOVA statistics (Table 7) were assessed to see if there was a statistically significant mean difference across groups for each motivational component. According to Table 7, the treatment had a statistically significant effect on each of the motivational elements. This demonstrated that, after controlling for covariates, the instructional strategy had significant effects on all posttest scores of motivational components to varied degrees, following the follow-up DFA results. This indicates that the treatment's impact on each component is different. With these results, RQ2 had been answered.

Table 6**.** Means and Standard Deviations for PostCMQ Factor Scores

Group	PostCMQ_I		PostCMQ_E		PostCMQ_Sd		PostCMQ_Se		PostCMQ_P		PostCMQ_C	
	M	SD	M	SD	M	SD	M	SD	M	SE	M	SD
SICBA	3.1	.34	3.1	.43	3.1	.29	3.2	.31	3.2	.32	3.1	.27
CBA	2.9	.38	2.9	.43	3.0	.30	3.2	.31	3.2	.33	3.1	.28
SICTA	2.4	.50	2.4	.55	2.4	.55	2.2	.50	2.2	.51	2.2	.37
CTA	1.3	.36	1.3	.31	1.2	.29	1.2	.26	1.3	.21	1.3	.23
Tot	2.4	.79	2.4	.84	2.4	.84	2.4	.90	2.5	.88	2.4	.80

Note. M: mean scores, SD: standard deviation

Table 7**.** Tests of Between-Subjects Effects for PostCMQ Factor Scores

Source	Dependent Variable	df1	F	Sig.	Partial Eta Squared	Power
Treatment	PostCMQ_I	3	204.20	.000	.74	1.00
	PostCMQ_E	3	183.46	.000	.72	1.00
	PostCMQ_Sd	3	292.16	.000	.80	1.00
	PostCMQ_Se	3	374.45	.000	.84	1.00
	PostCMQ_P	3	337.79	.000	.82	1.00
	PostCMQ_C	3	462.46	.000	.86	1.00

Following that, the results of the Bonferroni procedure of postCMQ factor scores (Table 8) along with descriptive statistics were analyzed to address RQ3. Based on the evidence presented, the

CBA-treated group was shown to be considerably as successful as the SICBA-treated group in all six motivational components. That is, SICBA was not statistically different from CBA in terms of increasing students' motivation across all factors. However, the SICBA-treated group had higher mean scores compared to the CBA-treated group, whilst the difference was not statistically significant. Then, with the exception of CBA, SICBA had significantly higher mean scores than SICTA and CTA groups for each of the motivational components. Similarly, in each motivational measure, the SICTA-treated group was significantly more motivated than the CTA-treated group.

Table 8**.** The Bonferroni Pairwise Comparison for SICBA-Treated Group with Other Groups

Factor	(I) Group	(J) Group	(I-J) $M_{adj}D$	Std. Error	Sig.	95% Confidence Interval	
						LB	UB
Intrinsic Motivation	SICBA	CBA	.197*	.073	.046	.002	.391
		SICTA	.660*	.073	.000	.464	.855
		CTA	.197*	.074	.000	1.589	1.984
Extrinsic Motivation	SICBA	CBA	.152	.082	.393	-.067	.370
		SICTA	.732*	.082	.000	.512	.951
		CTA	1.846*	.083	.000	1.624	2.067
Self-determination	SICBA	CBA	.105	.069	.780	-.079	.289
		SICTA	.667*	.069	.000	.482	.852
		CTA	1.911*	.070	.000	1.724	2.097
Self-efficacy	SICBA	CBA	.053	.067	1.000	-.124	.231
		SICTA	1.073*	.067	.000	.894	1.251
		CTA	2.031*	.068	.000	1.851	2.211
Personal Relevance	SICBA	CBA	.021	.068	1.000	-.161	.203
		SICTA	1.032*	.069	.000	.849	1.214
		CTA	1.949*	.069	.000	1.765	2.134
Career Motivation	SICBA	CBA	.051	.055	1.000	-.095	.196
		SICTA	.934*	.055	.000	.788	1.080
		CTA	1.836*	.055	.000	1.689	1.984

Note. LB: lower bound, UB: upper bound; $M_{adj}D$: Adjusted mean score difference; Std.: standard

*. The mean difference is significant at the .05 level.

a. Adjustment for Bonferroni multiple comparisons.

DISCUSSIONS

The purpose of this study is to determine the impact of a simulation-integrated context-based approach based on the 7E learning model on students' motivational components for learning OABS chemistry. The study also compares its effectiveness in enhancing student motivation to other interventions and the conventional teaching approach. The follow-up DFA results revealed that most of the motivational components contributed differently to the overall motivation scores as they loaded into (β =.846 to 1.67) and associated with (r =.34 to .52) the discriminant function to varying degrees. This demonstrated that the instructional strategy had a different effect on each motivational element. Similarly, the follow-up ANCOVA results indicated that the instructional strategy had a substantial effect on all motivational components, with large effect sizes (2 =.72 -.86). Career motivation has the greatest influence (2 =.86), whereas extrinsic motivation has the least (2 =.72).

Furthermore, the current study investigated whether or not the simulation-integrated context-based learning approach had the greatest impact (or not) on each of the students' motivational dimensions for OABS chemistry. SICBA showed no significant improvement over CBA in enhancing the five motivational dimensions: extrinsic motivation, self-determination, self-efficacy, personal relevance, and career motivation. However, SICBA outperformed CBA in boosting students' intrinsic motivation and surpassed SICTA and CTA across all six motivational components.

The increase in student motivation in the SICBA-treated group could be attributed to the use of interactive teaching methods such as the PhET interactive simulation, real experiments, group discussions, student presentations, and Q&A via the 7E instructional strategy. This study is consistent with self-determination theory, which states that fulfilling basic psychological needs (autonomy, competence, and relatedness) from both teachers and parents can improve student motivation like intrinsic motivation and self-determination [9]. Hands-on activities, small group discussions, challenging but achievable inquiries, and so on could help to foster the need for competence [9]. Similarly, one strategy used to meet students' demand for relatedness is to plan events in which students collaborate in mutually beneficial ways, limit competition among individuals, and highlight student variety through group discussions. This study supports the notion that intrinsic motivation and self-determination are socially generated rather than innate [35].

Likewise, the 7E strategy and teaching methods provide pupils with options rather than control. This may assist them in meeting their demand for autonomy. Our findings are congruent with those who discovered that students exposed to context-based learning had much higher intrinsic motivation than those subjected to conventional chemistry sessions [36] [37]. The findings for extrinsic motivation, on the other hand, contradicted [36] finding that extrinsic motivation wasn't different significantly across groups. In addition, as a result of the current study, one aspect that should be addressed is the comparison between extrinsic and intrinsic motivation.

Previously, it was thought that intrinsic and extrinsic motivations were antagonistic [38]. Extrinsic rewards, however, have been shown in the past to diminish intrinsic motivation. Our findings, on the other hand, corroborate the latter view that intrinsic and extrinsic motivations, as well as their sources, are not contradictory; rather, they may coexist and improve concurrently [35] [39]. Extrinsic motivation does not always reduce intrinsic motivation, according to [39], and students may learn for both intrinsic and extrinsic reasons.

Extrinsic motivation may be enhanced by intrinsic motivation because it develops when a student wants to appear competent and achieve well in the eyes of others during group discussion and question-answer activities [9] [11] [39]. However, according to STD, we expect this extrinsic motivation to be more autonomous; that is, identified and integrated regulation, as these two extrinsic motivations are associated with higher satisfaction [8] [9]. Discussions in groups can be used to meet the need for competence, autonomy, and relatedness to boost intrinsic motivation [8] [39].

Furthermore, the findings of personal relevance matched with [37] that found a simulation-integrated context-based approach improves students' relevance of chemistry to personal life better than the conventional approach. The findings are also similar to [40] which revealed that students who got computer-assisted instruction scored higher on self-efficacy than those who received conventional instruction. Self-efficacy would be increased not just through computer simulation, but also through social persuasion and vicarious experience during group discussions, Q&A, and student presentations [12].

However, there is a discrepancy in the study findings [36] who reported that students who received context-based instruction did not significantly exceed conventionally treated learners in terms of self-efficacy. The findings about self-determination appear to be in contrast with some studies [37]. The possible explanations for contradictory outcomes could be diverse. On the one hand, the previous study's approach to instruction and chemistry areas of study may differ from the current study. Turkish students may be more exposed to context-based approaches, with or without simulations, in their regular chemistry classes. This strategy may eventually bore the sample students. Ethiopian school pupils with no prior experience with such instructional methodologies may find it enjoyable.

CONCLUSIONS

The findings of this study indicate that the context-based learning approach using the 7E instructional strategy, with or without computer simulation, significantly enhances secondary school students' intrinsic and extrinsic motivation, self-determination, self-efficacy, personal relevance, and career motivation in learning chemistry. This most likely occurred because it could more effectively satisfy the three basic needs of students [9] than the controlled conventional approach. Based on the expectancy-value theory [9], our pedagogical packages may have contributed to an increase in motivational dimensions by supporting students in setting high (non-zero) expectations for success [12]. As a result, teachers can employ the 7E context-based instructional strategy, with or without simulation, to boost students' motivation for chemistry. As a result, to improve chemistry instruction, chemistry teachers may need to consider making a gradual move from the traditional approach to the use of context-based approaches.

Qualitative data from student and teacher sources have to be used to support the outcome. This can be done using various data-gathering means, including group discussions, open-ended questions, and interviews. Future studies in this area need to take into account these limitations. Furthermore, there may be a need to conduct this research on a macro level in order to get a clear picture of secondary school students' motivation toward chemistry.

ACKNOWLEDGEMENTS
We thank Addis Ababa University for funding and the Department of Science and Mathematics Education for supporting this research. We also thank our colleagues and friends for their valuable comments and insights throughout the development of this paper, drawing on their extensive experience in article review.

CONFLICTS OF INTEREST
The authors declare no conflict of interest.

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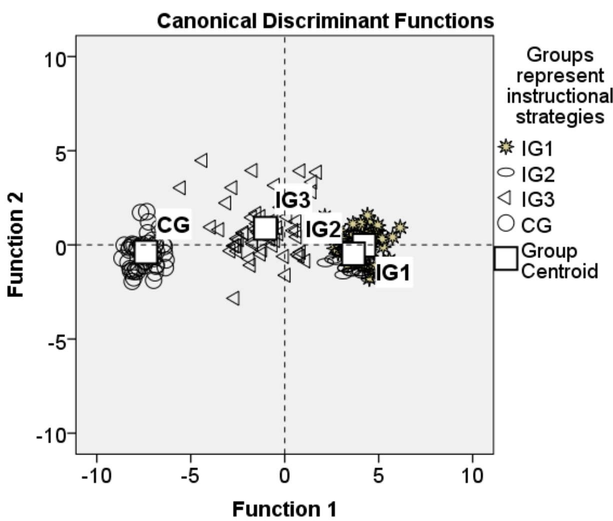
Appendix

Figure 1. Graphical Representation of Group Centroids on the Two Discriminant Functions Using a Combined-Group Plot of the PostCMQ Factor Scores (Source: Authors' own elaboration)



Note. IG1: intervention group 1 (SICBA), IG2: intervention group 2 (CBA), IG3: intervention group 3 (SICTA), CG: comparison group (CTA).