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The impact of blended learning on chemistry laboratory activities in Bonga College of education, Ethiopia

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Abstract

Science education focuses on connecting knowledge with process, developing students' research skill, knowledge construction skill, problem solving skill. Science courses are given coupled with practical laboratory activities. Most students consider science courses as difficult, irrelevant and boring. So that students are not motivated and encouraged for science courses. This study is intended to motivate chemistry teachers of Bonga College of education to design and implement a blended method and cultivate a passion for chemistry laboratory activities among students in the College. In this study descriptive survey and quasi-experimental design were used, and the research was conducted at Bonga College of education and the participants of this study were all chemistry teachers and all third year general science and environmental science department students of the College. Questionnaires, interviews, observations and test-results were used to collect data. The quantitative data gathered was analyzed using SPSS and qualitative data obtained from direct observation and interview was analyzed. The result of the study showed that students engaged in a blended learning laboratory were more motivated and achieved higher results in comparison with those learned in conventional laboratory methods. The results of the study were taken as evidence to design blended laboratories in the college and other universities and secondary schools.

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INTRODUCTION

An objective of teaching science is to provide students with science education that focuses on connecting knowledge with process, developing students' research skill, knowledge construction skill, problem solving skill, and encouraging their participation in class with suitable activities for each age group (Bokolo, 2019; Fitriani, 2023; Noor et al., 2025; Wulansari &Dewi,2022).

But, in many of the higher education disciplines, the majority of students view learning science and particularly chemistry as difficult, irrelevant, and boring. This leads to scoring lower grades, minimum competency, minimal student-teacher communication, very low critical thinking ability. As a result students are less motivated towards science subjects (Fitriani, 2023; Okono et al., 2023).

According to Al-Duhani et al (2023), one of the main barriers to students' understanding of scientific concepts is that most of the concepts of science redeem at the most microscopic (symbolic) level, where students may not understand how to interpret the symbols or translate them into the other levels of representations. So the need to strengthen our higher education infrastructure, especially in science, is crucial in order to be competitive in the world. This is because; science courses are coupled with laboratory practical activities to improve the cognitive thinking level as well as achievements of the students (Chaetsunnajah & Dewi, 2023; Noor et al., 2025).

In chemical laboratories theoretical concepts are integrated with practical activities. Many students consider science lab activities as manipulating equipment but not manipulating ideas. But Science Laboratories are rooms equipped with benches and student work stations and incorporate several types of indoor or outdoor science activities (Mihret et al., 2023).

As further explained by Mihret et al (2023), appropriately implemented practical work improves students' science experience, problem solving abilities, conceptual understanding, and scientific attitudes. Amuda (2019) also revealed that the use of laboratory equipment in teaching and learning processes makes learning effective and helps to sustain students' attention throughout the lesson. Moreover, most scientists and science educators have a deeply rooted, intuitive feeling that laboratory experience is essential to learning and understanding of science courses like chemistry, physics and biology (Rasmitadila et al, 2020). Laboratory experiments play a critical role in furthering scientists' understandings about how the universe works, so that scientists have historically placed high value on laboratory experiences in science classrooms. They are also fighting hard for maintaining such instructional approach in the face of frequently expressed doubts and critical oppositions like laboratory instruction is costly, and, since its effectiveness has been difficult to substantiate compellingly, some administrators have viewed it as luxury and cannot be afforded (Aliyu & Talib, 2019).

Due to the inadequate facilities in the laboratory, limitations of tools and chemicals, limited understanding of the essential chemical concepts, complicated procedures, inadequate working rooms, weak performance of laboratory facilitators and other related problems, the learning process in the laboratory practical activities haven't been effective (Wijayanti et al., 2019). Besides, different reports and studies revealed that currently students in higher institutions in most developing countries of the world like Ethiopia are struggling with several challenges in learning chemistry laboratory courses (Aliyu & Talib, 2019). The most significant of which is the need to keep up with technological changes and development of new educational methods emerged by the modern global economy (Al-Duhani et al., 2023). That means, as the world becomes connected all around the globe and becomes globally competitive in all aspects, the way of teaching science education has also changed.

As part of science, chemistry cannot be separated from the scientific approach and practicum. Therefore it's necessary to have learning media in the form of interactive media so that students can do practical activities whenever and wherever (Wijayanti et al., 2019). A number of attempts had been done previously to alleviate the gaps observed in traditional chemistry laboratories. Therefore, to be progressive and successful in chemistry education, modern scholars tried to present a new model that integrates or blends conventional learning in physical laboratory with a virtual laboratory to facilitate students' learning to enhance their achievement (Bernard et al., 2017).

The idea of blended learning (BL) comes from two words such as blend and learning. The blend implies the combination or fusion of things, and learning is the assimilation of new information (Nduudee & Enebeli, 2024). The BL is a teaching method that combines internet-based and face-to-face learning or it is a combination of computer-generated and physical learning settings that promotes flexibility and adaptability of the course (Al-Qatawneh et al.,2020; Benzon et al., 2024; Bryan & Volchenkova, 2016; Fitriani,2023). In addition, BL is a program that utilizes multiple methods to transfer information to activate learning outcomes through teacher-student interaction (Dziuban et al., 2018). It differs slightly from conventional e-learning in that it combines face-to-face interaction with technologically oriented and computer-mediated approaches (O'Byrne & Pytash, 2015). Other terms have also been used to express this teaching method of instruction i.e., virtual learning, web-based learning, and online learning. In nutshell, the BL is an instructional technique that supports communication, self-motivation, proficiency, and technology in the everyday learning environment (Munawar et al., 2023). The BL environment includes a fully computerized smart classroom with amazingly fun visualizations and simulations that make learning pleasing and enjoyable and improve the overall school performance (Albeta et al., 2023; Brown, 2016; Cleveland-Innes & Wilton, 2018).

By considering this situation, Hofstein (2017) visualized that the development and increasingly widespread use of digital computing technologies provides blended learning, especially in supporting chemistry laboratories (Al-Fiky,2011; Astutic &Wusqo,2023; Hajar,2022; Hinampas et al.,2018). Blended laboratories are newly emerging approaches of teaching students by coupling face-to-face laboratory activities with technology. The blend or coupling could be between any forms of instructional technology with physical classroom teaching (Al Awamleh, 2020).

Several research findings demonstrate that students learning chemistry education through blended laboratories had good understandings of abstract ideas and scientific concepts compared to those utilizing physical or traditional laboratories (Al-Duhani, et al., 2023). Integrating virtual laboratories with physical laboratories enhanced achievements of expected results, easier to access learning materials, enhances students' understanding of real world and gives opportunity for students to learn by their pace of communication (Benzer & Yildiz, 2019; Latif et al., 2020; Wijayanti et al., 2019). According to Lucas et al (2018), blended laboratories also help lecturers to create internationally competent students. Blended laboratories are also alternative solutions for conducting practical activities that were previously not feasible due to a lack of equipment, the complication of procedures associated with certain experiments, or the inability to perform a physical version of the lab (Marble, 2017).

In universities and in colleges of education in Ethiopia, chemistry laboratory courses are given as independent courses and have their own credit hours and instructional materials. But the progress and achievement of students in science, particularly in chemistry is not as much as expected. This implies the problem mentioned is still severe and to be alleviated (Mihret et al,2023).

This study goes forward on the use of blended chemistry laboratory activities as a new pedagogy for promoting the science student's learning experience in Bonga College of education. The study analyses the impact of blended chemistry laboratories on students' achievement and thereby assessing the relationship between their cognitive and social presence in active learning. Moreover, the study is intended to motivate chemistry teachers of the College to understand the potential of blended strategies to increase the students' efficiency so as to design and implement methods that promote meaningful learning experiences and cultivate a passion for chemistry activities among students in Bonga College of education.

METHOD

Study Area

This study was conducted in Bonga College of education that is located in Bonga town of south west regional state of Ethiopia which has a distance about 450 km towards south west direction from the Capital Addis Ababa city.

Study Design

As adopted from Abdelmoneim (2022), a Quasi-Experimental study with a pre-test/post-test design and a survey design was applied on the study groups. Since the purpose of this study was to assess the impact of a blended learning approach in students' achievement of chemistry laboratory courses in Bonga College of education, it is assumed that the problem was approached using the above methods. These methods are appropriate research methods to get a description of the impact of using blended learning in teaching chemistry laboratory courses by examining and describing the major problems, opportunities and possible alternatives in Bonga College of education.

Population, Sample Size and Sampling Techniques

As indicated in table 1 and 2 below, the samples of the population of this study were11chemistry lecturers, 2 chemistry laboratory assistants and all currently existing 3rd year general science and environmental science under graduate students in Bonga College of education. Participation was entirely voluntary, with informed consent provided by the participants. The sampling technique was using Purposive or deliberate sampling technique, because all the participants mentioned above are responsible and their number is limited so as to be easy to control.

Table 1. Demographic data of participating students

Total number	Gender		Age limit			Department		Remarks
	M	F	21-25	26-30	Above 30	G.S	E.S	
33	24	9	32	-	1	11	22	

(Key: M=Male, F= Female, G.S= General Science, E.S=Environmental Science)

Table 2. Demographic data of teachers

Total No.	Gender		Age limit		Work Experience (in years)		Educational level	
	M	F	Age	No.				
13	10	3	20-25	1	below 10	3	Masters	12
			26-30	3	10-15	3	Others (PhD)	1
			31-35	-	16-20	3		
			36-40	2	Above 20	4		
			41-45	2				

46-50	3
Above 50	2

Instruments of Data Collection

In order to collect sufficient data, varieties of instruments were used. The instruments intended to be used to collect data for the study were direct class room observation, Semi-structured questionnaires, semi-structured interviews and pre-test and post-test review. The survey questionnaire for teachers contained 9 questions for their demographic information, 25 questions were composed of a Likert scale (1. Strongly Disagree 2. Disagree 3. Don't Know 4. Agree 5. Strongly Agree) aimed to determine the participants' existing insights and their attitudes regarding the traditional and blended chemistry laboratory activities and with 6 open-ended questions about the experiences of conducting chemistry laboratory activities which was adopted from Ramirez (2023).

On the other hand, the survey questionnaire for students was also containing 6 questions focusing on their demographic information, 26 questions were aimed to access the participants' existing insights regarding the traditional and blended chemistry laboratory experience and with 6 open-ended questions about their overall perceptions of chemistry laboratory activities. The semi-structured interview was focusing more on deepening participants' insights and experiences. The interview questions were framed based on the reflective and evaluative activity that determined the positive experiences of a chemistry laboratory in a blended learning setting, challenges encountered in chemistry blended learning, and new insights for improvement (Gonzales & Gonzales, 2024). Simple observation was also used to measure the performance of students and their perception during the laboratory activities. The instruments were pilot-tested by collecting data from 2 science teachers and 10 students of Bonga College of education who represent the population character but not the sample of the study using rule of thumb. The data collected for pilot-study purposes was measured for its internal consistency (reliability) and its coefficient (Cronbach alpha) which was α=.873 for teachers and α = .784 for students. After checking for the pilot test, the questionnaire was distributed to the target population and about 96% of the copies were returned back and analyzed accordingly.

Procedures of the Study and Data Collection

The researcher had successive meetings with the heads of both general science and environmental science departments, chemistry teachers and the participant students regarding the calendar of activities, class discussion flow, class characteristics, progress of the study, and other relevant information. In coordination with the chemistry teachers and participant students, a survey questionnaire was administered to gain preliminary information on the teachers' and students' experiences and attitudes (interest) in the chemistry laboratory activities that would provide important information for the researcher during the study. Consequently, the semi-structured interview was conducted with the selected participants wherein each session ranges from20 to 30 minutes. There was personal contact and support in the administration of the questionnaires to the students for any ambiguity. In this study, data were collected during the second College term of 2025 by the researcher. Since the participant students didn't have any experience about blended learning before, questionnaires were distributed and interviews were conducted for students after implementation of the selected laboratory activities.

Participants who were taught using traditional (physical) learning methods were checked for the availability of resources and laboratory materials and for those who were taught using blended learning were also checked for the availability of resources such as computers or laptops, LCD projector, internet access and electric power to do simulation experiments.

The total of 33 participant students from the two mentioned departments were mixed with equivalent ratio and grouped into two groups. These two groups were an experimental group (EG) containing 17 students with four sub groups and a controlled group (CG)containing 16 students with four sub groups (Mirmoghtadaie et al., 2023). The quasi-experimental study was conducted in two phases; a pre-test (pre-intervention) phase (where all the participant students were to be tested before the administration of both traditional and blended learning methods).

The structured achievement test (AT) questions were prepared from the selected chemistry laboratory activities by the selected teachers of the chemistry department. And five teachers from the education department were selected and checked in the light of six stages of Bloom's taxonomy of cognitive domain, clarity of questions and mark allocation. There were a total of 50 Questions with three items (True-false, multiple choice and short answer part focusing on operational activity part) in the AT having 100 marks in total at the rate of 2 marks for each question.

The pre-test was found helpful in gauging students' prior knowledge of chemistry lab courses. Then a total of six laboratory activities (Basic laboratory equipment and their functions, Operating Bunsen burner, Physical and Chemical properties of substances, Diffusion and movement of gases, Separating mixtures by simple distillation method and Properties of acids and bases respectively) were selected from basic chemistry laboratory courses by the appointed voluntary chemistry teachers. In the post-test (post-intervention) phase, blended laboratories and simulation applications were employed for the first three selected laboratory activities for the EG. In the meantime, traditional (face-to-face) laboratory activities were employed in the same three selected laboratory activities for the CG. Then the same test questions were prepared from the activities conducted and given to both groups and evaluated. In the next study, both EG and CG were interchanged. For this purpose, the first controlled group students that had already done the first three experiments using a traditional laboratory were allowed to perform the next three experiments through a blended laboratory and experimental group students that had done the experiment using a blended laboratory were allowed to perform the same three experiments using a traditional laboratory. The effect of post blended learning performance of students on blended learning was evaluated using the test questions prepared for this purpose (Abdelmoneim, 2022).

Many aspects such as laboratory activities, objectives, pre-laboratory questions, and post-laboratory questions, methods of instruction, and assessment and follow up schemes were similar. Moreover the participant students were not oriented (not to be careless) about the research and great follow ups, attendances and technical support were taken during the activities.

Method of Data Analysis

The data gathered from interview, questionnaire and test documents were coded appropriately and analyzed. For quantitative data, Statistical Package for Social Sciences (SPSS version 20) was utilized. Simple quantitative descriptive values such as Percentage, mean and median are important data analysis techniques to show the main constraint of impact of blended learning in students' achievement. The significant difference between the pre-test and the post-test achievements for both groups was determined. Similarly, the data collected from interview and direct class room observation were also qualitatively analyzed in words to develop an important idea which can support and emphasize the numerical data.

Ethical Considerations

A Plain Language Statement including purpose, benefits, possible risks and confidentiality agreement was given to the participants that indicate the details of the study. This indicates that the participants could freely decline and withdraw their participation at any point in the study if any inconvenience happens.

RESULT AND DISCUSSION

This part presents the analysis and interpretation of the main idea. To this end, both quantitative and qualitative data gathered from questionnaires, interviews, recorded test documents and observational checklists were subjected to both quantitative and qualitative analyses. Quantitative analysis was done using frequencies, percentages and mean scores. The actual respondents who responded to the questions were about 95.5% of the sampled population.

The pre-test and post-test results of the participant students were analyzed using Microsoft Excel because it was more appropriate due to the small number of the sample size.

Students' achievement in Blended and physical laboratory classes in chemistry lab courses

Table 3. Analysis of pre-test and post- test result in blended and traditional learning method

NT=33	Pre-test Result		Post-test Result (Exp.1-Exp.3)		Post –test Result (Exp.4-Exp.6)	
Group	EG(Blended) N=17	CG(Physical) N=16	EG(Blended) N=17	CG(Physical) N=16	EG(Physical) N=17	CG(Blended) N=16
Mean(m)	39.29412	39	73.64706	53.23529	59.0625	65.9375
Range	68	52	40	60	88	71
SD	11.31371	11.45584	21.2132	14.14214	23.13351	31.81981

*(**Key:** NT= total number of students, N= number of students in the group Exp. = Experiment, EG=experimental group, CG= controlled group)*

In order to investigate the test scores of the participating students an independent sample t-test was employed to compare mean scores at the post-test level between blended learning group and traditional learning group. As shown in Table 3 above, there was no statistically significant difference on the mean scores of the chemistry laboratory achievements of pre-test between the Experimental group (EG) (m=39.29412, SD =11.31371) and the controlled group (m=39, SD= 11.45584). The findings of the independent sample t-test indicated that both groups were equivalent in terms of chemistry laboratory activity performance before implementing the treatment. This result helps to understand students' previous knowledge about the course.

As shown in Table 3 above, there was statistically significant difference on the mean scores of the first three chemistry laboratory activities performance post-test between EG in blended learning class (m=73.64706, SD =21.2132) and CG with traditional learning method (m=53.23529,SD=14.14214). The difference of mean's score at the post-test level between the blended learning and traditional learning group was 20.411770. This indicates that the participants in the blended learning group achieved higher scores in the first three chemistry laboratory activity performance at the post-test level than participants in the traditional learning group.

In the second research activities the participant groups were interchanged and performed the next three activities. As indicated in table 3 above, there was statistically significant difference on the mean scores of the second three chemistry laboratory activities performance post-test between the EG performed in traditional learning method (m=59.0625, SD =23.13351) and CG performed the laboratory activities by blended learning method (m=65.9375,SD=31.81981). The difference of mean's score at the post-test level between the blended learning and traditional learning group was 6.8750. This indicated that the participants in the blended learning group showed higher scores in the second three chemistry laboratory activity performance at the post-test level than respondents in the traditional learning group.

From the above two research results it can be said that students in the blended learning group showed higher scores in chemistry laboratory activities at the post-test level than pre-test level. This indicated that the level of students' performance in chemistry laboratory courses improved after performing activities using the blended learning method. The proposed reason for this finding is that students in blended laboratories are more engaged, motivated and highly interested in their learning. This finding is in strong agreement with the findings of several studies (Kiviniemi, 2014; Sarabadani & Berenjian ,2017; Bridges et al.,2014). The researchers reported that virtual laboratory learning had a positive impact on learners' understanding of scientific concepts at a microscopic level (as shown by their achievement) and stimulated interest in chemistry laboratory courses.

The findings of this research also confirm the theoretical understanding to promote learning by active participation and cooperating of knowledge. This is because independent learning can be promoted, and trial-and-error activities can be affected in the virtual platforms before students go into a traditional laboratory session. With this notion, chemistry teachers should consider using virtual laboratories for teaching abstract concepts in all school science subjects in general and chemistry in particular. Blended laboratories are capable of complementing students in learning abstract chemistry concepts and promoting higher achievement scores in content tests. Curriculum experts should also consider instituting the use of virtual laboratories in science curricula globally.

Furthermore, the standard deviation of the result scored by blended learning class students was also higher than that of the traditional method of learning, showing that the dataset for blended learning groups consisted of test scores that were more spread out away from the mean while those for traditional class learners showed a tendency to group around the mean. When applied to the teaching methods used, this could mean that there was more consistency in physical or traditional method learners, since the learners used a familiar teaching method which could not improve their levels of motivation. With blended class students the opposite happened, possibly because the learners were at different stages of Maslow's hierarchy of needs and the way blended teaching was implemented could have appealed to some learners more than others resulting in the manifestation of a wider range of levels of motivation. This result has a very good agreement with the result of other research studies (Seage &Türegün, 2020).

Students' perception on blended learning environment

With respect to the views of blended learning and its implementation, participants of this study perceived that presenting the course in a blended format made it easy to follow and enhanced their learning. The findings are consistent with the literature reporting that students show greater satisfaction in blended courses than in traditional lectures (Castle & McGuire, 2010; Mandina, 2019). As shown in table 4 below, the satisfaction of an individual's intellectual and personal needs is very critical and is fostered by providing an individual with a variety of educational opportunities that promote students' involvement. The mean difference of the perception of students is about 3.787846 out of 5, which is good acceptance of the blended format of learning. The blended learning environment created in this study was found to help deepen student interest in the subject matter and encourage them to learn. This finding is in agreement with Shantakumari & Sajith (2015) who reported that when learners are provided with multiple formats of learning materials in a blended learning environment it could sustain the students' interest and thereby promote their cognitive engagement. The results of the present study on the application of the blended learning method in a unit of the ordinary level chemistry laboratory courses was found to be a promising learning method to enhance the students' learning desire and improve their learning outcomes (Alvina & Mustofa, 2025). Moreover, the mean value on table 4 item 14 which is 4.049

indicates that students were more confident that blended learning courses improve the four language skills (reading, writing, listening, and speaking) of the students (Table 4, item 14).

On the other hand, students argued that there exists scarcity of resources like desk top computers, lab tops, LCD projectors and internet access in chemistry laboratories that are necessary for students to succeed in blended courses in the College (table 4, item 13).

Table 4. Analysis of students' views on blended learning environment

Items	t	Sig. (2-tailed)	Mean Difference
The things I am learning in this course will be useful to me	31.58	.000	4.152
I feel confident that I will do well in this course.	26.53	.000	4.000
The description of course objectives, learning activities and assignments in the blended class were excellent.	26.91	.000	3.970
The continuity between face-to-face class and online learning was good	28.60	.000	4.030
The pace of the course was user friendly	19.79	.000	3.636
Blended learning improved my time-management skills	36.14	.000	4.303
Blended learning improved my digital literacy	52.96	.000	4.303
Blended learning improved my performance in exam	32.50	.000	4.091
Blended learning enabled me to learn at any time and any pace, from anywhere, using any device	30.27	.000	3.939
I have trouble using the technologies in this course.	14.10	.000	3.091
The online teaching materials are designed to really try more topics interesting to students.	29.59	.000	4.061
The blended plat form makes me feel that I am a true member of the class	33.85	.000	4.030
There are sufficient resources necessary for students to succeed in blended courses in the College	9.454	.000	1.636
Blended learning courses improve the four language skills reading, writing, listening, and speaking of the students.	27.00	.000	4.049

CONCLUSION

This study determined the effectiveness of blended teaching on academic achievement focusing on students in Bonga College of education studying chemistry laboratory courses. The findings underscore the importance of addressing technological, infrastructural, and environmental factors to facilitate the effective implementation of blended learning in chemistry education. Collaboration between stakeholders, including educators, policymakers, and technology providers, is essential to ameliorate challenges and maximize the benefits of blended learning in the College's chemistry laboratory education. The effectiveness of blended teaching on academic achievement could have been largely due to active learning strategies utilized, meaningful and increased interactions (learner-to-learner and teacher-to-learner) that led to deeper learning and shared creation of knowledge.

So, the implementation of a highly promising blended learning platform for the College students has made a great contribution to alleviate the exacerbating motivation problem towards learning chemistry. The study also adds best opportunities for implementing the blended teaching method in Bonga College of education by providing possible ways of mitigating some of the challenges like students learning problems during conventional laboratories, interest towards science and innovation, acquaintance with upcoming technology and others through the use of the blended technology. Additionally, this study proposes some other basic benefits of using the blended learning environment in teaching chemistry laboratory courses in the College. This study, which was in response to challenges in teaching chemistry laboratory courses, has implications on how the discipline could be taught more effectively using blended teaching.

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