Effective Instruction for Calculus Learning Outcomes through Blending co-operative Learning and Geogebra

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Abstract: Most mathematics education research literatures reported that the use of teacher-centered instruction lacks active-collaborative learning environment and hands-on practices that could minimize learners' concept learning and affective aspects challenges towards calculus meaningfully. The motivation of this study was the understanding that the learning and teaching of calculus can benefit a lot if the delivering models are enriched by blending technology in the process and being able to go beyond the teacher-centered instruction. This study was aimed to examine the effect of the blended learning (BL) on learners' cognitive (CLO), psychomotor (PLO) and affective (ALO) learning outcomes. The mixed methods were used in a quasi-experimental design. Samples of size 298 for pilot and 248 for main study in both experimental groups were utilized. The data collection instruments were the closed and open-ended conceptual and procedural knowledge tests and the five points Likert-scale attitude questionnaire. A descriptive, paired-samples t-test and Two-Way ANOVA were employed for data analysis. The results of the study revealed that the levels of learners' CLO and ALO attainments were significantly boosted up, and PLO was reasonable.

Keywords: blended learning; calculus; instruction; learning outcomes

Introduction

These days technology has played a central role improving the learning and teaching environments and practices of higher education mathematics (Bozkurt, 2020). Blending technology in mathematics instruction can be effective in a learning environment in which learners are allowed to make active- collaborative participation. The academic and scientific community that, the virtual/online learning, a typical BL has been highly supporting higher education scientific yet, not completely discontinue their professional duties during COVID-19 pandemic era, where undertaking face-to-face classroom instruction is a difficulty worldwide. It has been found essential to comply with the rule of social distancing, a protective mechanism of the pandemic. Prior this incident, a limited use of it was realized by Ethiopian public universities.

According to Stein and Sim (2020), PhD candidates had limited knowledge about the importance of educational technology (ET), an umbrella term for many technology tools, for conducting research in higher education worldwide. As Saal, Graham, and van Ryneveld (2020) reported, even using ET in primary mathematics education can enhance learners' mathematics achievement. But, possessing and using digital media such as mobile phone and computer/tablet on a personal basis at home, school and other places cannot meaningfully assist them. However, collaborative and interactive use of computer/tablet and internet connection by learners would impact their mathematics performance positively. This bears us to mind, the use of technology could be significant for effective mathematics teaching if both instructors and learners use it interactively in an active, collaborative and social learning environment. They suggested to both teachers and students need to be competent of manipulating ET by the year 2021.

A lesson design and re-design approach through pilot to main study of this research project was undertaken to take advantage of the use of BL at addressing learners' conceptual understanding, procedural fluency and productive disposition problems (Kilpatrick, Swafford, & Findell, 2001, p. 5). More attention was paid to calculus concept learning and attitude aspects as learners are mostly challenged with them. According to Corrêa and Haslam (2020), learners' engagement on mathematical proficiency tasks can significantly be developed by the extent of the effort that instructors could make a suitable preparation of the subject-content assessment. Kilpatrick's et al. (2001) theory had played an important role in the construction of learners' assessment tools of this study.

Most educators' and researchers' had limited knowledge and competence to the meaning, use, and purpose of technologies for mathematics education. Selecting the appropriate technology for the desired instruction was also a challenge for them. In this regard, Lakhana (2014) assessed their perceptions and found that almost all perceived ET as hard ET while there is also soft ET aspect related to human communications. To this end, Lakhana suggested that the knowledge of soft ET is the most vital for them in the design of course instruction. On the other hand, Bond (2020) reported that to define the concept learners' engagement was also a challenge for their research work as the essences involved in it are too comprehensive. Despite these facts, BL was proposed, enormously influence learners' engagement in calculus concept learning, requiring a higher order cognitive thinking and their affective aspects to fill this knowledge gap.

The BL was devised as it is very helpful in enhancing the passive and boring classroom instructional setting in the prevailing teacher-centred instruction in Ethiopia and worldwide public universities into active-collaborative, interactive, and innovative learning environment. All the time speculating innovative learning strategy blended with emerging technology by instructors is essential to foster learners' engagement in calculus instruction. BL needs to be properly implemented in this postmodern era in which a number of active teaching philosophies overwhelmed mathematics education (Gweshe & Dhlamini, 2015). The assumption of using BL emanated from the researcher learning focused epistemological stance aiming at upgrading calculus concept learning attainment (Krikwood & Price, 2013).

Learners' engagement was measured by their absorption of formative and summative assessment tasks in class work, individual assignment, group assignment, quizzes, mid-term test and final examination. Along with this, their affective learning aspects towards calculus/mathematics through pre-test to post-test were examined.

Research Questions

This study responded to the following:
➢ To what extent BL influenced experimental group (EG) CLO,
➢ To what extent BL influenced EG PLO,
➢ To what extent BL influenced EG CLO as compared to their PLO,
➢ To what extent BL influenced EG ALO.

Literature Review
Educational Technology

The advancement of mathematics education has brought ET into existence and contributes a lot to its development. In turn, ET has an advantage by its virtue of tremendously facilitated and enhanced mathematics education activities at large. This means mathematics education and ET have been developing in a symbiotic mode. Generally, digital technology has played a great role for the growth of world economy and uplifted world civilization astonishingly. This implies that the benefits of technology are far reaching economically, socially and politically even though the level of investment can significant. Especially, digital media would greatly support mathematics to be learnable and teachable effectively if both teachers and students use it properly (Saal et al., 2020).

However, ET has found to be a very deep and versatile concept in a great number of literatures. Educators and researchers have not contributed a lot on the practice of using ET due to their limited knowledge. Bozkurt (2020) and Lakhana (2014) defined the two major components of ET as hard ET refers to material resources like computers and software while soft ET refers to resources like processes, practices, methods and theories. Ng'ambi and Bozalek (2013) also indicated that it encompasses a number of expensive material resources, technical tools and innovative human ideas other than these.

As to the benefit of ET, Lee, Waxman, Michko, and Lin (2013) examined the effect of ET on learners' CLO and ALO using meta-analysis techniques. Data were gathered using selection criterion and review methods. The present meta-analysis effect size values indicate that the effectiveness of ET on CLO and ALO was positive. The effect size value on CLO is larger than the past while nearly the same to current meta-analysis. The increment of effect size values goes along with the progress of technology and pedagogy. They recommended professional development for pre-and in-service teachers on the innovative pedagogies and collaborative learning strategies involving ET. Bhatti, Laigo, GebreYohannes, and Kameswari (2016); Bond (2020) also discovered that the flipped learning approach is recently introduced as one potential tools of ET in the contemporary education. It has been playing an important role in positively influencing learners' engagement in higher education mathematics. Bond suggested further research as to how ET facilitates CLO and ALO in different subjects and education levels. Sebsibe and Feza (2019) suggested that learners can overcome calculus concept learning difficulties through ET. However, Saal et al. (2020) found inconsistent result that using ET in mathematics education influenced learners' achievement positively or negatively in different contexts.

Learners Engagement

Learners' engagement is the other a very deep and challenging concept in the study of mathematics education. As Bond (2020) reviewed, there is no clear evidence showing the precise meaning of it. Researchers defined it in the context and purpose of their research study. Bond (2020) defined it as learners' energy and effort applicable to accomplish the expected learning outcomes appropriately and meaningfully, which is measured in terms of behavioural, cognitive, and affective indicators in which their present success also enable them to generate more power for later better learning. Furthermore, Bond indicated that very limited studies were conducted as to the influence of ET on learners' engagement in mathematics. Applying appropriate guiding theory in exploring the association and relationship between ET and learners' engagement in other courses was a challenge for researchers (Bond & Bedenlier, 2019). Seakhoa-King, Nehme, and Ali (2015) studied the relationship between learners' engagement measured by the amount of time learners' spent and MyMathLab (MML). The findings revealed that MML has contributed a lot for reduction of grade inflation and resulted in with fair grading. The normal expected time for problem-solving practices increased 12% to 35%. The total hour learners spent employing MML had a modest positive correlation with quiz, midterm tests, final examination and overall unit grade scores, and moderate positive correlation with homework grades.

Blended Learning

The BL used as intervention in this study emerged in the 21st century (Grover, 2013; Ojaleye and Awofala, 2018; Zhang and Zhu, 2017). It was used by educators and researchers due to the traditional face-to-face/lecture method (TLM) deficits for effective mathematics teaching. TLM is a theory based model of teaching that lacks active-collaborative environment and hands-on practices to grasp the complex topics and concepts of mathematics (Bhatti et al., 2016; Yimer, 2019). BL/hybrid learning refers often to virtual or e-learning integrated with face-to-face traditional teaching (Bhatti et al., 2016; Grover, 2013; Lin, Tseng, & Chiang, 2016). It also refers

to that combines mathematical software package used for teaching and learning and TLM. Bhatti et al. (2016) examined the impact of flipped and MATLAB on learning of numerical methods of differentiation and integration. They have improved concept learning which is not often likely by TLM. However, Krishnan (2018) found inconsistent result that learners preferred the TLM to online learning in mathematics learning for which the subject matter and type of learners are the favouring factors. This implies that the problem can be compromised by using BL. As with Bhatti, the BL was conducted in this study in the mathematics laboratory. BL was conducted to upgrade the pillars of Bloom's taxonomy of educational learning objectives, named CLO, PLO and ALO (Yimer, 2019).

Umoh and Akpan (2014) investigated to identify learners' perceptions of the challenges towards using the BL in mathematics. The findings show that the availability, accessibility and learners' information and communication technology (ICT) skills in the BL were not positively responded. This study recommended for institutions and instructors need to be responsible investing on the expansion of technology infrastructures and ICT. In the cohort study by Ghassani, Shamsi, Islam, Al-Salti, and Al-Hasni (2015) to improve teaching and learning of calculus through BL, the findings revealed that learning resources and activities incorporated in the Moodle benefited learners to improve their concept learning, which is often unattainable through TLM. Learners were not comfortable with the online quizzes as an assessment approach, which can be taken as limitation of the study and can be tackled using pencil and paper assessment. Learners positively responded to features of BL. Lin et al. (2016) examined the effect of Moodle on mathematics learning of grade seven. The results revealed that Moodle significantly supported EG better accomplish on achievement tests and changed attitude positively. The Moodle also influenced male and high-ability learners to be more motivated and interested. EG learners positively responded to the four qualitative questions. The study recommended that the BL needs to be extensively utilized giving due consideration to planning through implementing it.

Zhang and Zhu (2017) reviewed systematically 103 research articles on the status of BL research. It was undertaken based on six categories, namely design, strategy, factors, evaluation, methodology and review. Twelve key themes were identified. The following were the findings. Evaluation was the most frequently studied, and then follows design, methodology, strategy, factors and review. Authors suggested researchers need to effort a lot on review. Strategy was conducted on few medical sciences and mathematics. Further research was recommended on other courses. Researchers have shifted to Moodle research. The comparative and case studies were found the appropriate methodologies. Learners' factors were the most influencing factors. Teacher, administrator, policy and culture factors need further research. Many studies were conducted on online and TLM, separately. BL research was limited. BL would become the most effective learning model in the future. Ojaleye and Awofala (2018) explored the influence of BL, problem-based learning (PBL) and TLM on senior secondary school learners' cognitive engagement in algebra. The results revealed that CLO through BL was the highest and follows PBL and TLM. Curriculum developers and policy makers were advised to emphasize the teaching philosophy of BL in the pre-service teachers training programs.

Theoretical Framework

BL was designed to improve learners' engagement on CLO, PLO and ALO in calculus. The study was guided by Kilpatrick's mathematical proficiency and Vygotsky's social constructivism learning theories. At the outset, the researcher thought of access for free open source mathematics software packages used for teaching and learning calculus and desktop computers as they are scarce in developing countries, like Ethiopia. He found GeoGebra as the appropriate one, and looked for those instructors, who are proficient of manipulating in one of Ethiopian public universities. The ratio of the number of desktop computers to the number of students was found to be at most 1:5. Because of this, he speculated of an active-collaborative learning model, which is to be blended with GeoGebra. Co-operative learning was found suitable. This was intended to minimize scarce resource and large class size problems as Köhler (2020) suggested in the context of South Africa, large class size reduction is one means for cost-effective learning outcomes if qualities of school socio-economic factors are verified. He also developed calculus learning activities on four chapters of the course that best fit to BL so as to promote their basic proficiency of calculus and also adapted the five points Likert-scale attitude questionnaire, named Test of Science Related Attitude (TOSRA) (Khine, 2013) designed by a distinguished Professor Barry J. Fraser in Macquarie University, Australia. These ideas were theorised to enhance teacher-centered calculus instruction learning outcomes, by blending GeoGebra and Jigsaw method implemented in the mathematics laboratory and the TLM in the mainstream class. The aforementioned theories are analogous to the technology-enhanced learning environment framework used in Bond (2020) thesis. Technology-enhanced learning environment involves instructors, technology, learning activities, students, learning environment, and peers. The way this study utilized social constructivism paradigm is quite different from Bond's research. Social constructivism paradigm centres on the idea that collaborative learning precedes knowledge development (Orey, 2010).

Methodology

The post-positivism, critical realist ontology (objectivist and constructionist), and empiricist and interpretive epistemology were assumed as the appropriate philosophical perspectives for this study, based on the type of data collection instruments and analysis techniques used (Gelo, 2012). The deductive approach was employed to verify the formulated theory that the independent variable, BL can highly promote learners' engagement in absorbing the calculus CLO, PLO and ALO as dependent variables (Creswell & Creswell, 2019). The mixed methods were used as quantitative and qualitative data were collected (Johnson & Christensen, 2019).

Research Design

This study employed a non-equivalent pre-and post-test CG quasi experimental intervention design as depicted in Figure 1.
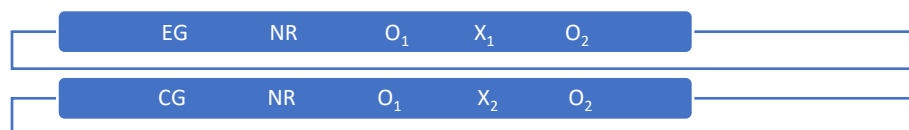

| EG | NR | O_1 | X_1 | O_2 |
| CG | NR | O_1 | X_2 | O_2 |

Figure 1: Non-equivalent Pre-and Post-test CG Quasi-experimental Design (Yimer, 2019)

Target Population

First year mathematics and science undergraduate program learners, who enrolled for calculus in two Ethiopian public universities, were the population of the study.

Sample and Sampling Procedure

Pilot Study

Of the four calculus offering in one of the study areas, the statistics department was purposely drawn for pilot testing calculus conceptual and procedural tests. From the sample size of 80 intact class statistics learners sat for these tests, thirty samples were randomly drawn with equal proportion of slow, average and active learners. All 298 students in the four departments, of which 106 females and 192 males were purposely used as samples for pilot testing the five points Likert-scale attitude questionnaire.

Main Study

Two-stage random sampling method was used. Statistics and Chemistry departments were randomly drawn by cluster sampling technique from the study areas. Out of 145 Chemistry and Statistics intact students in one of the universities sat for the conceptual and procedural tests, 75 samples were randomly drawn for EG by lottery method. Seventy two EG samples responded to the attitude questionnaire. Out of 103 Chemistry and Statistics intact students in the other university, 75 samples of which 55 females and 95 males were randomly drawn for comparison group (CG).

Instruments

The calculus conceptual and procedural knowledge tests, and the five points Likert-scale attitude questionnaire were the instruments used to collect data.

Content/Face validity

According to Fraenkel and Wallen (2009), both instruments were validated using content/face validity. The instruments was assessed by three subject experts based on such aspects as whether they meet the objective of the study, the proposed definition of measurements, and the syllabus or not, the adequacy of sample questions/level of difficulty, appropriateness of language and the relative standard of format of the test/questionnaire.

Item Analysis of the Achievement Test for Ensuring Reliability

The four item analysis indices, named difficulty level (P), discrimination index (D), point-biserial coefficient (r_{pbi}) and reliability coefficient (r_{test}) were used to verify the quality and accuracy of the true-false and multiple-choice of this instrument (Ding & Beichner,2009; Kiliyanni & Sivaraman, 2016).

The item difficulty level (P) is defined as the ratio of the correct responses to the total number of responses and described as

$$P = \frac{N_1}{N} \qquad (1)$$

where N_1 is the number of correct responses, N is the total number of examinees taking the test (Ding & Beichner, 2009). It is measured in percentage (Boopathiraj & Challamani, 2013). The ideal value is one-half of chance and a perfect score for the true-false items. It is 0.75 for the true-false items of this achievement test. It is 0.6 for the multiple-choice items as five options are included in each stem. The P-value that ranges 0.3 to 0.9 is the acceptable value (Ding & Beichner, 2009).

Kiliyanni and Sivaraman (2016) defined the item discrimination index (D) as the ratio of the difference between the number of correct responses in the top quartile and the number of correct responses in the bottom quartile to one-fourth of the number of participants and given by the formula

$$D = \frac{N_H - N_L}{\frac{N}{4}} \qquad (2)$$

where N_H denotes the number of correct responses in the top quartile, N_L denotes the number of correct responses in the bottom quartile, N denotes the total number of participant. An acceptable D-value is greater than or equal to 0.3. The higher the value the better the item is.

The point-biserial coefficient (r_{pbi}) refers to the relationship between the item score and the total scores of all items in the test (Kiliyanni & Sivaraman, 2016) and expressed as

$$r_{pbi} = \frac{\overline{X_1} - \overline{X_0}}{\sigma_x} \sqrt{P(1 - P)} \qquad (3)$$

(Ghiselli, Cambell, & Zedeck, 1981) where $\overline{X_1}$ denotes the average total score for those who correctly answer the item, $\overline{X_0}$ denotes the average total score for those who incorrectly answer the item, σ_x denotes the standard deviation of total scores and P denotes the item difficulty index (Ding & Beichner, 2009). An acceptable r_{pbi}-value is greater than or equal to 0.2 (Kline, 2015). The higher the value the better the item is

According to Costa, Oliveira and Ferrão (2009); Ding, Chabay, Sherwood, and Beichner (2006), the reliability coefficient index (r_{test}) estimates the measure of the internal consistency of the entire test score. It is given by the Kuder-Richardson Formula 21 (KR-21) as

$$r_{test} = \frac{K}{K-1}\left(1 - \frac{\sum P_i(1 - P_i)}{\sigma_x^2}\right) \qquad (4)$$

where K is the number of test items, P_i is the difficulty index of item i, σ_x is the standard deviation of total scores (Kuder & Richardson, 1937). An acceptable r_{test}-value is greater than or equal to 0.7 (Kuder & Richardson, 1937).

As the work-out items in a calculus achievement test represent a continuous scale of measurement, the inter-rater reliability and inter-rater agreement were measured using two raters to ensure the

consistency and stability/agreement of it, respectively. The inter-rater reliability was measured by the Pearson Product Moment Correlation denoted by r and given by the formula

$$r = \sum_{i=1}^{n} \frac{(x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y} \qquad (5)$$

where $\bar{x}$ and $\bar{y}$ are the sample means, s_x and s_y are the sample standard deviation of the variables X and Y (Liao, Hunt, & Chen, 2010). The inter-rater agreement was measured by the intra-class correlation coefficient (ICC) (Graham, Milanowski, & Miller, 2012). Both indices can be generated using SPSS 23. The index r ranges -1 to 1 and the index ICC ranges 0 to1 (Graham et al., 2012; Liao et al., 2010).

Table 1: Item Analysis Indices

Items	P	D	r_{pbi}	r_{test}	Remark
			Indices in Average		
True-false	0.72	0.38	0.26	0.7	All are acceptable.
Multiple-choice	0.45	0.61	0.46	0.9	All are acceptable.
	r		ICC		
Work-out	0.986		0.992		All are acceptable.

Correlation is significant at the 0.01 level (2-tailed). One way random effects model where people effects are random.

Construct Validity of Attitude Questionnaire

At the outset, the attitude questionnaire with 50 items was constructed by adaptation based on five factors/variables, namely normality of mathematics (N), mathematics inquiry (I), adoption of mathematics (A), enjoyment of calculus/mathematics lessons (E) and opinion towards calculus and GeoGebra (O). They were reduced to 28 items and three factors N, E and O by the construct validity method, particularly using the Principal Component Factor Analysis (PCFA) with varimax rotation as the variables are independent or uncorrelated (Demircioglu, Aslan, & Yadigaroglu, 2014). As this study used a medium-sized sample, the conformity of data for factor analysis was decided based on Kaiser-Mayer-Olkin (KMO) measure value found to be 0.85, which is greater than the standard value 0.6, and Bartlett Test of Sphericity as the p-value at the 0.05 or better level was found to be p=.000 (Demircioglu et al., 2014).

Table 2: Factors/Variables Reduction

Indices	N	I	A	E	O	N	E	O
	Variables for Pilot Testing					Variables for Main Study		
Eigen values	11.99	6.75	6.19	2.09	2.04	8.01	4.14	5.07
Percentage of variance (%)	23.98	13.51	12.38	4.18	4.08	16.03	8.3	10.1
Total percentage of variance (%)	58.13					34.43		
Cronbach's alpha (α)	.79	.78	.79	.81	.82	.81	.81	.82
Total Cronbach's Alpha (α)	.89					.84		

Data Collection

Data on learners' calculus cognitive/conceptual and psychomotor/procedural achievement were collected in line with the Ethiopian public universities harmonized modular curriculum marking and grading system as shown in Table 3. The positive/negative attitude data were collected based

on their responses to the five-points Likert-scale questionnaire with ratings, strongly disagree/SD=1, disagree/D=2, neutral/N=3, agree/A=4, and strongly agree/SA=5.

Table 3: Ethiopian Public Universities Marking and Grading system

Interval (100%)	Letter Grade	Fixed Number Grade	Status Description
[90, 100]	A^+	4.0	Excellent
[85, 90)	A	4.0	Excellent
[80, 85)	A^-	3.75	Excellent
[75, 80)	B^+	3.5	Very Good
[70, 75)	B	3.0	Very Good
[65, 70)	B^-	2.75	Good
[60, 65)	C^+	2.5	Good
[50, 60)	C	2.0	Satisfactory
[45,50)	C^-	1.75	Unsatisfactory
[40, 45)	D	1.0	Very Poor
[30,40)	F_x	0	Fail* (Re-exam)
[0,30)	F	0	Fail (Repeat course)

Data Analysis

The calculus CLO and PLO data were analyzed through descriptively, paired-samples t-test and Two-Way ANOVA statistical methods. The qualitative data on attitude were analyzed descriptively. The paired-samples t-test and Two-Way ANOVA had come to be applied for which assumptions underlying these two parametric tests such as two experimental conditions; two different independent groups were participated; each case in the sample was randomly drawn; and the data represented a ratio-scale and continuous in this study were met (Cohen, Manion, & Morrison, 2007; Green & Salkind, 2005; Saunders, Lewis, & Thornhill, 2009). As Field (2009); Kim (2013); Pallant and Manual (2009) suggested, the normality distribution of data was also tested using Shapiro-Wilk test, Kolmogorov-Smirnov test and z-test using skewness and kurtosis as shown in Table 4.

Table 4: Normality Test

	Variable	Group	n	Skewness	SE_s	Z_s	Kurtosis	SE_k	Z_k	Kolmogorov-Smirnov Statistics	Kolmogorov-Smirnov p-value	Shapiro-Wilk Statistics	Shapiro-Wilk p-value
Pre-test	CLO	EG	75	.10	.27	.37	-.58	.54	-1.07	.083	.200*	.98	.55
		CG	75	.62	.27	2.29	-.47	.54	-.87	.137	.001	.943	.002
	PLO	EG	75	.57	.27	2.1	.06	.54	.1	.136	.001	.949	.005
		CG	75	.6	.27	2.2	1.0	.54	1.8	.121	.008	.953	.008
Post-test	CLO	EG	75	-.03	.27	-.1	-.98	.54	-1.8	.075	.200*	.961	.021
		CG	75	.58	.27	2.1	.02	.54	.03	.070	.200*	.987	.627
	PLO	EG	75	.14	.27	.5	-1.2	.54	2.2	.110	.025	.952	.007
		CG	75	1.2	.27	4.4	1.6	.54	2.9	.133	.002	.959	.016

*. This is a lower bound of true significance. a. Lilliefors Significance Correction.
Note: Z_s=z-score due to skewness, Z_k=z-score due to kurtosis.

All skewness and kurtosis values in Table 4 estimate normality distribution of data as these values are relatively close to zero, except the skewness value (1.2) for post-test PLO of CG, kurtosis value (1.0) for pre-test PLO of CG, kurtosis value (-1.2) for post-test PLO of EG and kurtosis value (1.6) for post-test PLO of CG. The values 1.2, 1.0, -1.2 and 1.6 cannot constrain using Two-Way ANOVA and paired-samples t-test for measuring intervention efficacy as the sample size was medium; it is greater than 30 due to the central limit theorem. The central limit theorem states that when the sample size gets larger (greater than 30), the distribution scores of the sample gets close to normality distribution (Field, 2009; Saunders et al., 2009). However, a relatively ideal alternative approach to Two-Way ANOVA to identify group differences and change in ability in learning and assessing intervention efficacy would be an item response theory approach (IRTA) if the requisite discussed before for the rationale of utilizing Two-Way ANOVA were not substantiated (McEldoon, Cho, & Rittle-Johnson, 2012).

Results

An overview idea about experimental groups' results on CLO and PLO in calculus in terms of descriptive statistics is given as in Table 5.

Table 5: Descriptive statistics for CLO and PLO

	Pre-test				Post-test			
Variable	CLO		PLO		CLO		PLO	
Group	EG	CG	EG	CG	EG	CG	EG	CG
Learners' Status	Fre(%)	Fre(%)	Fre(%)	Fre(%)	Fre(%)	Fre(%)	Fre(%)	Fre(%)
Excellent	0(0)	0(0)	0(0)	0(0)	20(26.6)	0(0)	9(11.9)	3(3.9)
Very Good	0(0)	0(0)	0(0)	0(0)	11(14.5)	0(0)	10(13.3)	3(4)
Good	0(0)	0(0)	0(0)	0(0)	15(19.8)	1(1.3)	9(11.9)	6(7.9)
Satisfactory	2(2.7)	2(2.7)	3(4)	2(2.6)	9(12)	8(10.6)	6(8)	4(5.3)
Unsatisfactory	4(5.3)	6(8)	2(2.7)	1(1.3)	4(5.3)	4(5.3)	3(4)	3(4)
Very Poor	8(10.7)	5(6.7)	1(1.3)	3(4)	6(8)	5(6.7)	1(1.3)	1(1.3)
Fail	61(81.3)	62(83.2)	69(91.9)	69(92)	10(13.3)	57(75.9)	37(49.3)	55(73.3)

It can be seen in Table 5, during pre-test 97.3% of both EG and CG CLO in calculus was below pass mark/grade (50%/C). This shows that almost all participants had poor background knowledge and low order cognitive thinking towards understanding calculus concepts. The same holds true for their PLO as 95.9% of EG and 97.3% of CG attained below pass mark/grade. During post-test, 72.9% of EG and 11.9% of CG accomplished above pass mark/grade on CLO in calculus. The reason for EG higher performance on CLO is the application of the intervention, BL in social learning environment allowed them to be highly engaged with the calculus learning activities in hands-on experiences with the aid of GeoGebra. In this same session, 45.1% of EG and 21.1% of CG achieved above pass mark/grade on PLO. As compared to the differences observed on CLO, the performance difference that EG and CG showed on PLO was not paramount.

These differences can be significant or not, was verified by the effect size values produced through the Two-Way ANOVA for repeated measures and paired-samples t-test.

Table 6: Two-Way ANOVA Results

Variable	Between Groups			Within Groups		
	Source of variance	η^2	p	Source of variance	η^2	p
CLO	Group	.313	.000*	Pre-Post Measure	.66	.000*
				Pre-Post Measure*Group	.57	.000*
PLO	Group	.037	.018*	Pre-Post Measure	.034	.000*
				Pre-Post Measure*Group	.054	.004*

*p<.05

As can be seen in Table 6, there was a statistically significant mean incremental difference between experimental groups on both CLO and PLO in calculus. However, according to Cohen et al. (2007); Pallant (2007); Morgan, Leech, Gloeckner, and Barrett (2012), the effect size value $\eta^2 = .57$ shows us the effectiveness of BL on learners CLO was very large while it affected little the PLO as the effect size value is $\eta^2 = .054$.

The effect size value generated through paired-sample t-test could ascertain whether the difference between CLO and PLO in calculus attained by the same EG is significant or not.

Table 7: Paired-Samples t-test Results

Variable	Group	n	M	SD	df	t	p	η^2
CLO	EG	75	65.5	20.3				
					74	9.4	.000*	.55
PLO	EG	75	46.9	24.3				

*p<.05

The effect size value $\eta^2 = .55$ in Table 7 implies that the effect of BL on EG CLO was very significant as compared to its effect on PLO (Cohen et al., 2007; Pallant, 2007; Morgan et al., 2012).

The descriptive results on EG ALO through pre-test to post-test towards calculus and BL are portrayed in Table 8.

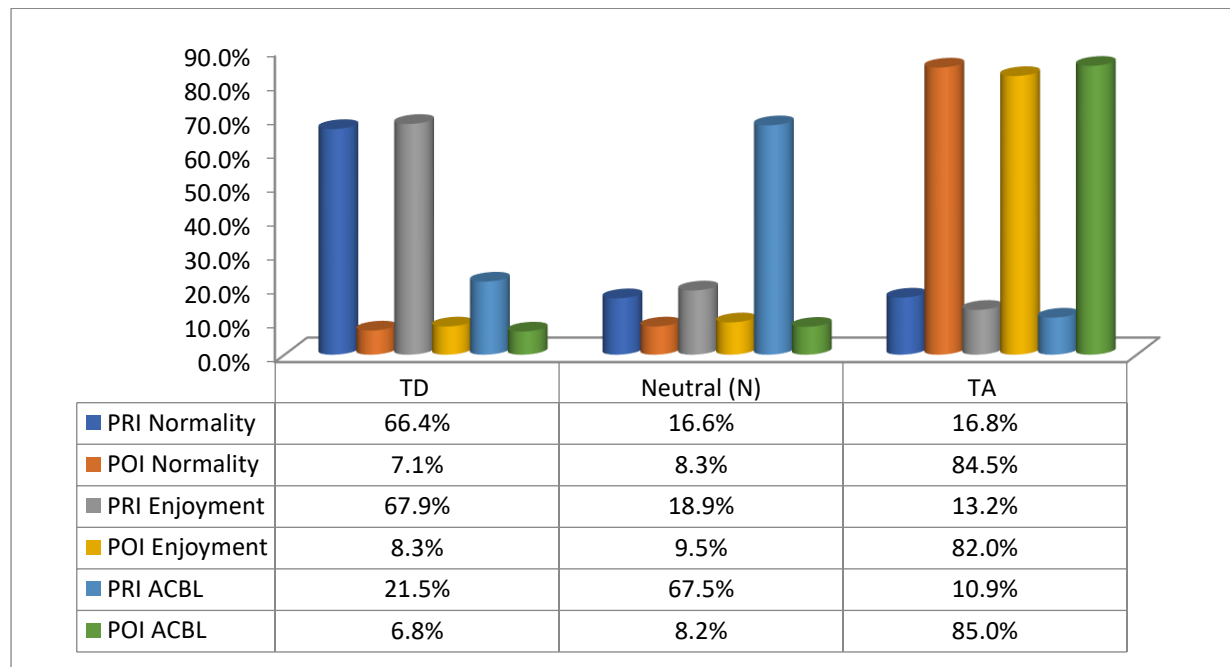**Table 8:** Descriptive Statistical Results on ALO

Construct	Pre-test (%)			Post-test (%)			Interpretation
	TD	N	TA	TD	N	TA	
Overall Normality Attitude towards Calculus/Mathematics (N)	66.4	16.6	16.8	7.1	8.3	84.5	VP
Overall Enjoyment Attitude (E)	67.9	18.9	13.2	8.3	9.5	82.0	VP
Overall Attitude towards Calculus and BL	21.5	67.5	10.9	6.8	8.2	85.0	VP

Note: TD=Total Disagreement (SD and D); TA=Total Agreement (A and SA), P=Positive, VP=Very Positive

It can be seen from Table 8 that the positive affect of BL on most learners calculus concept learning was immense as their opinions through pre- to post-test were changed very positively and vice-versa.

These same results are concisely depicted by chart in Figure 2.

	TD	Neutral (N)	TA
■ PRI Normality	66.4%	16.6%	16.8%
■ POI Normality	7.1%	8.3%	84.5%
■ PRI Enjoyment	67.9%	18.9%	13.2%
■ POI Enjoyment	8.3%	9.5%	82.0%
■ PRI ACBL	21.5%	67.5%	10.9%
■ POI ACBL	6.8%	8.2%	85.0%

Note: PRI=Pre-Intervention, POI=Post-Intervention, ACBL=Attitude towards Calculus and BL
Figure 2. Bar Graph of EG ALO

Discussion

This study was designed to utilize BL as intervention to minimize learners' calculus concept learning challenges and attitude problem as the most often and widely used teacher-centred approaches by instructors has not been addressing it. This is mostly likely because the teacher-centred instruction lacks active learning models, and hands-on practices and collaborative environments. In order to promote learners' engagement in the intervention, at the outset the researcher prepared calculus learning activities involving more conceptual aspects overall four chapters of the course that best fit to BL. The Jigsaw method in BL was applied for EG learners should demonstrate active participation in the calculus learning activities in their teammate. The GeoGebra in BL was allowed learners to experience hands-on practices through representing abstract concepts and complex notions of calculus numerically, symbolically algebraically, pictorially, geometrically, and graphically. GeoGebra also helped them to be creative and develop critical thinking skills through manipulating it. The use of the BL as a fallibilist philosophy of teaching mathematics approach had created conducive learning environment for learners' imagination and creativity. Generally, BL influenced learners' motivation, interest, attitude, behaviour, engagement and achievement, positively.

Accordingly, the findings of the study revealed that the influence of BL on EG CLO as compared to CG was paramount as it was verified through descriptive analysis and the generated big effect size value, $\eta^2 = .57$ through TWO-WAY ANOVA. Similarly, the effect size value, $\eta^2 = .55$ produced through paired-samples t-test implies that the efficacy of BL on EG CLO as compared to their PLO was of the most significant. In contrast, the effect of BL on EG PLO as compared to CG PLO was the least as the effect size value produced through TWO-WAY ANOVA was found as $\eta^2 = .054$. The influence of BL on EG ALO was also very meaningful as most of EG participants responded to attitude test on calculus learning via BL very positively. The findings of this study as to the efficacy of BL on CLO and ALO are completely in agreement with (Lee et al., 2013; Ghassani et al., 2015; Lin et al., 2016). Using just the same design as the current study, Ojaleye & Awofala (2018) verified BL is highly important for effective learners' engagement on CLO in algebra as compared to PBL and TLM. Umoh & Akpan (2014) findings recommend mathematics educators to engage into the use and expansion of blended e-learning infrastructure for effective mathematics teaching and learning. Seakhoa-Kimg et al. (2015) findings also in agreement with the current study findings that a satisfactory outcome was generated as to the relationship between BL and level of learners' engagement in the Foundation Mathematics Program content. The systematic literature review conducted by Zhang and Zhu (2017) was in support of the methodology of this study on BL and also anticipated that BL will become the dominant mode of delivery for mathematics instruction in the future. As with Bond (2020), this study verified that BL can facilitate learners' engagement in different CLO and ALO.

Conclusion

As all mathematics educators know, our world is ever advancing with digital technology and has reached to artificial intelligence (AI) as the result of technological revolutions. These all endeavours signify how much human intelligence has extremely flourished; and humans are looking for electronic brain formation. They have undertaken them as livelihood is to transform and simplify their life style. As a matter of fact, BL as a tool with active-collaborative learning models for the enhancement of mathematics instruction is essential; and it should be compulsory for educators applying it. Taking part in such circumstance could make updating themselves with the dynamic digital world and would also help to have an in-depth understanding of what learners of digital era are most interested in mathematics content. However, bear in mind that there are a number of implementation challenges of BL for which educators need to cope with. Some of the main ones are mentioned as the level of technology investment can significant, especially for developing and least developed countries like Ethiopia as it is not abundant and easily accessed (Umoh & Akpan, 2014); and learners' and instructors' knowledge gap on ICT skills due to insufficient pre-service and in-service professional development training program. Nevertheless, in higher education in which even some of technology packages are equipped and utilized in an active social learning environment, this study and the reviewed literatures are evident to that the teaching philosophy of BL in an active-collaborative learning environment as compared to teacher-centred instruction can significantly promote learners' CLO and their ALO positively. Overall, BL can make an important learning difference on learners' of digital era in mathematics if educators would make careful planning, designing, processing, evaluating and implementing it and being

able to go beyond the use of teacher-centred models of delivery which is not adequate in this dynamic world where digital technology is incredibly overwhelmed it (Sandanayake, 2019).

Recommendation

BL and learners' engagement/absorption of calculus learning activities reflected through their achievement on pencil and paper assessment were used as pillars of theoretical framework of the study. In the most reviewed literatures, they are discoursed as very philosophical terms and regarded as umbrellas for a number of educational constructs with which educators and researchers have been challenged in addressing them in their research work. It was also found that very limited studies have been conducted on the association and relationship between them. Bearing this in mind, this study has unravelled some of educators' misunderstanding and misconception towards both concepts and how to curb such attitude problems. It was also observed that the benefit of the BL on learners' engagement in CLO and ALO of calculus was very substantial and reasonable on PLO. Therefore, the results of this study inform mathematics educators and researchers should always be encouraged looking for appropriate BL that scale-up learners' calculus and advanced mathematics higher order thinking skills. The researcher would like to advise them to publish a paper on systematic literature review that discerns the current research trends of BL, for the sake of advocating the role it will play in mathematics education.

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