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Technology integrated guided inquiry-based learning approach and pre-service mathematics teachers' attitude towards learning geometry

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ABSTRACT

The study investigated the effects of technology-integrated guided inquiry (TGIBL), guided inquiry (GIBL), and traditional (TRAD) strategies on pre-service mathematics teachers' attitudes towards geometry in college of teacher educations. The study employed nonequivalent quasi-experimental design with two experimental groups and control group. A three-stage sampling method was used. The experimental groups were exposed to TGIBL (n=48) and GIBL (n=38), while comparison group (n=30) with TRAD approach. The geometry attitude scale (GAS) questionnaire was the instrument employed to collect data from 116 PSMT. A one-way analysis of covariance, multiple comparison test and paired sample t-test were used to analyze data. The results of the study revealed that pre-service mathematics teachers who were exposed to the TGIBL had gained positive attitudes towards learning geometry than their counterparts exposed to the GIBL and TRAD, respectively. Moreover, the group taught with GIBL also shown to have a statistically significant difference with TRAD on attitude. Similarly, paired sample t-test also favored post-test score. Based on the results, TGIBL and GIBL approach should be embraced in the college of teacher educations to reinforce favorable attitudes towards learning geometry among pre-service mathematics teachers.

Keywords: technology-integrated guided inquiry, guided inquiry, attitude, geometry

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INTRODUCTION

Throughout history, geometry has been an important subject in the mathematics curriculum. It is a subject that provides skills such as logic, deductive reasoning, analytical reasoning, and problem-solving skills. In addition, geometry is a mathematical concept associated with other fields of mathematics such as measurement, algebra, calculus, trigonometry, etc. and is also employed by architects, engineers, physicists, and many other professionals. According to Fyfe et al. (2015), the lack of geometric ideas is the primary reason why students have trouble understanding mathematics. As a result, researchers stated that learners' mathematical learning abilities are highly correlated with geometric understanding (Atebe & Schafer, 2008, 2011; Clements et al., 2018; Hannafin et al., 2008).

The learning competency of mathematics and geometry is determined by factors such as attitude, instructional approaches, and teachers' content knowledge (Kilpatrick et al., 2001; Mazana et al., 2019; MOE, 2013). Attitude is considered to be a crucial contributor to higher or lower mathematics and geometry performance (Mohamed & Waheed, 2011; Ngussa & Mbuti, 2017). An attitude is a positive or negative disposition towards an object, circumstance, concept, and/or event (Mensah et al., 2013). As a result, attitude must be assessed in order to explain variability in learners' mathematics and geometry understanding. According to Mohamed and Waheed (2011), the PSMTs' attitude toward geometry is a well-established factor that determines their geometry achievement and their future career in schools. In addition, Guner (2012) and Tapia and Marsh (2004) revealed that attitude towards geometry plays an important role in determining achievement in geometry. PSMTs' thoughts about the nature of mathematics learning and attitudes have a significant impact on their future teaching practices (Cooke, 2015).

From multiple viewpoints, researchers have suggested the existence of different components of attitudes. Davadas and Lay (2017), for example, suggested motivation, enjoyment, self-confidence, and value as components of attitudes. Likewise, Mullis et al. (2020) used enjoyment, confidence, and like as components of attitude. Similarly, attitude and its dimensions of attitude towards geometry, such as self-confidence, value, enjoyment, and motivation, have been examined and considered in this study (Syyeda, 2016; Tapia, 1996). According to

Atanasova-Pachemska et al. (2015), a positive attitude toward geometry shows positive confidence, enjoyment, value, and emotional disposition, while a negative attitude toward geometry reflects negative confidence, value, enjoyment, and emotional disposition. Therefore, PSMTs' attitudes toward geometry can be defined as their inclusive evaluation of geometry.

Self-concept (SCG) is PSMTs' confidence and self-concept of their performance in mathematics (Tapia, 1996). Self-confidence of PSMTs in geometry learning is defined by views that include beliefs about one's own ability to learn and perform well in subject matter (Adelson & McCoach, 2011). In a study by Gresham (2017), it was revealed that a lack of confidence is the main obstacle to PSMTs advancing in their courses.

Value or usefulness (VG) is PSMTs' beliefs about the usefulness, relevance, and worth of mathematics in their lives now and in the future (Tapia, 1996). PSMTs' attitudes towards geometry depend on their perceived usefulness or value. According to Syyeda (2016), PSMTs will be driven to study, practice, and master geometry if they see its importance in real-life.

Enjoyment (EG) is the degree to which PSMTs enjoy working with geometry and how much PSMTs enjoy geometry classes in general (Tapia, 1996). Enjoyment in geometry is the extent to which PSMTs like doing and learning geometry (Kupari & Nissinen, 2013). PSMTs' enjoyment while learning can influence their behavior or cognitive aspect of attitude (Syyeda, 2016).

Motivation (MG) is PSMTs' interest in geometry and the desire to pursue further studies in mathematics and geometry (Tapia, 1996). Motivation in this study is related to both interest and the desire to learn geometry (Guy et al., 2015). PSMTs are motivated to learn geometry if they have the desire to do so after finding learning geometry interesting. Motivation is assumed to be the driving factor behind learning (Yunus & Ali, 2009).

According to Russo and Russo (2019), PSMTs can learn geometry more effectively if they are self-directed and use an inquiry-based method to analyze or explore geometry conceptual understanding. In addition, Tsao (2018) found that using a constructivist instructional strategy increased PSTs' attitudes towards geometry (with subscales of usefulness, confidence, and enjoyment). Moreover, PSMTs' attitude towards geometry learning will be improved by using innovative teaching and learning techniques that use technology and inquiry aspects (Gambari, 2010; MOE, 2013).

To this effect, instructional methods have a considerable impact on PSMTs' attitudes towards learning geometry and mathematics. The technology-supported approach to teaching geometry enhances PSMTs' attitude towards their learning. Using technology-integrated guided inquiry-based learning (TGIBL) and guided inquiry-based learning (GIBL) approaches to improve PSMTs' attitude toward geometry is one method.

Technology (such as Geometric Sketchpad (GSP), GeoGebra, Cabri, etc.) integrated with a GIBL approach has an implication for improvement in mathematics education (Getenet, 2020; Pfeiffer, 2017; Saha et al., 2010). In addition, GIBL is a student-centered teaching strategy that addresses low motivation for learning via providing meaningful learning opportunities (Maaß & Artigue, 2013). GIBL, in particular, is a more effective learning strategy than unguided inquiry (Lazonder & Harmsen, 2016; Minner et al., 2010).

Statement of the Problems

Ethiopia has had alarming rates of underachievement in mathematics and geometry among learners at all levels of schools (Kasa, 2015; MOE, 2017, 2018). For instance, the Ethiopian National Learning Assessment (ENLA) stated that learners' mathematics and geometry performance remained constantly poor, with mean scores far below the national average (50%) (MOE, 2012, 2017, 2018).

According to MOE (2015), teaching strategies that give PSMTs with multiple representations have the ability to change their attitude towards geometry learning. As a consequence, the MOE (2018) curriculum framework for primary pre-service mathematics teachers (PSMTs) has been recommended as an active student-centered approach with technology-supported classrooms. However, research indicates that teachers in Ethiopian teacher education colleges (CTEs) continue to use traditional teacher-centered approaches (Bekele, 2018; MOE, 2015; Semela, 2014). Thus, it appears that the way mathematics, particularly geometry, is learned and taught in Ethiopian classrooms determines their attitudes. Furthermore, according to Clements and Sarama (2011), PSMTs are influenced by a lack of an appropriate instructional approach and an attitude towards geometry.

In line with this, technology-integrated teaching methods can influence mathematics education and promote student-centered learning approaches and improve learners' attitudes (Saha et al., 2010; Tsao, 2018; Usman et al., 2019). However, in Ethiopia, technology-integrated instructional approaches are rarely applied in geometry and mathematics teaching in CTEs, and it remains an open question (MOE, 2012, 2015, 2018).

Currently, there are nott many technology-based instructions to support PSMTs in the transfer or discovery of knowledge in geometry (Hathaway & Norton, 2018). Therefore, the educational value of such technology-integrated instruction and teacher-directed inquiry approaches has been neglected, and its impact on PSMTs' attitudes has yet to be addressed (Simegn & Asfaw, 2018).

In Ethiopia, since CTE prepares PSTs in mathematics for primary schools, it's significant to look into their attitude towards geometry learning in terms of self-concept, motivation, enjoyment, and value. Therefore, in this study, the researchers investigated the effects of the GIBL approach and the TGIBL approach on PSMTs' attitudes towards learning geometry in Oromiya CTEs.

Objectives of the Study

The objective of the study was to investigate the effect of GIBL approach and TGIBL approach on PSMTs' attitude towards learning geometry. The specific objectives of the study are:

1. To explore whether there is a significant difference in PSTs' attitude toward geometry by using TGIBL approach and GIBL approach.
2. To examine the attitude and components of attitude of those students taught with TGIBL approach and GIBL approach.

The research questions that directed the research are, as follows:

1. Are there significant mean differences of post-attitude (with its dimension of attitude) between the groups?
2. Are there significant mean differences between pre- and post-attitude (with its dimensions) of the group?

Table 1. A nonequivalent control group quasi-experimental design

Group	Intervention		
EG1	Pre-test	X_1	Post-test
EG2	Pre-test	X_2	Post-test
CG	Pre-test	-	Post-test

Note. EG: Experimental group; CG: Control group; X1: Technology integrated guided inquiry approach; & X_2: Guided inquiry approach

Table 2. Reliability coefficients for the GAS towards geometry learning

Attitude & its dimension	Cronbach's alpha	Criteria
Self-concept (SCG) (eight items)	.76	Reliable
Value (VG) (seven items)	.89	Reliable
Enjoyment (EG) (seven items)	.71	Reliable
Motivation (MG) (six items)	.77	Reliable
Attitude (AG)	**.90**	**Reliable**

RESEARCH DESIGN

In this study, a pre-test-post-test nonequivalent quasi-experimental design was employed. According to Creswell and Plano Clark (2011), if random assignment of participants is not possible, a quasi-experimental design is preferable (**Table 1**). This occurs when participants are grouped into intact classes within schools and are expected to have comparable features. The pre-test provides a baseline against which the treatment's effects can be compared, as well as a way to check for group homogeneity (Edmonds & Kennedy, 2016).

Population, Sampling Procedure, and Samples

The population of the study consists of all second year PSMTs from CTEs in Oromiya Regional State (Department of Mathematics, 2019) who had been registered for Math-111 (plane geometry) during the 2019/2020 academic calendar. A total of 116 PSMTs, ranging in age from 19 to 26, were participated. The reason for choosing year two PSMTs is that Math-111 (plane geometry) is delivered at this level.

The study was employed a three-stage sampling method. To begin, two CTEs (i.e., Dambi Dollo CTE and Shambu CTE) were chosen using purposive sampling depending on equivalence in computer laboratories, academic and ICT facilities, candidate enrolment, and similarity in location. According to Fraenkel and Wallen (2006), the purposive sampling strategy is used to select participants who the researchers believe will provide the relevant data based on some reasonable conditions. Then, simple random sampling was used to assign these colleges into experimental and control groups. In this case, Dambi Dollo CTE was assigned into experimental site while Shambu CTE assigned into a comparison. Finally, the intact class from the Dambi Dollo CTE was assigned to one of the two experimental (TGIBL, and GIBL) using a simple random sampling procedure.

The first experimental group from Dambi Dollo CTE (EG1) (#TGIBL=48) used a TGIBL approach, while the second experimental group (EG2) (#GIBL=38) utilized a GIBL approach, and the comparison group from Shambu CTE (#Comp=30) used a traditional lecture approach.

Data Collection Instrument

The geometry attitude scale (GAS) was used as the major data collection instrument. The GAS questionnaire was adapted from Tapia and Marsha (2004) and Utley (2007). The GAS has a five-point Likert-scale with four sub-dimensions: SCG, VG, EG, and MG. It consists of a total of 28 items. All statements were rated, 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree, with negative items being assigned values in the reverse order.

Validity and Reliability

Validity and reliability are the two vital dimensions used to measure and assess instruments (Tavakol & Dennick, 2011). Validity describes how well an instrument captures the desired result. According to Tavakol and Dennick (2011), validity is the degree to which a tool, like a test or questionnaire, measures what it is designed to assess. Reliability is the consistency of scores or the degree to which participants' and/or raters' scores are error-free (McMillan, 2012). A pilot study was carried out to evaluate the validity and reliability of the instrument.

The validity of each instrument was checked using face validity and content validity. It was checked by supervisors from the college of teacher education and PhD candidate colleagues to ensure face and content validity. After experts' review, the original 40-item scale adapted was modified and reduced to 32-items.

Similarly, to estimate reliability, the GAT item was piloted with number of 60 PSMTs selected from Fitche CTE who were completed the course Math-111. The pilot study further found four items with low inter-item correlation, and they were deleted. Hence, a scale consisting of a total of 28 items was used to measure attitude towards geometry learning. It consists of four subscales: self-concept, value, enjoyment, and motivation. Therefore, for the actual study, 28 item were used with an acceptable reliability coefficient. The Cronbach's alphas for each dimension are at an acceptable level (Fraenkel & Wallen, 2006). **Table 2** shows the Cronbach's alpha coefficients of the instrument.

Procedure of Data Collection

GAS was administered as pre-tests to both experimental groups and comparison groups before to the implementations of the interventions. The PSMTs were given 15-20 minutes to complete the GAS items.

An initial instructor was assigned to the experimental groups to facilitate the intervention. The teacher educator has a master's degree in mathematics and has taught mathematics for 14 years in the college of teacher education. In addition, he has skills in how to use Geometric Sketchpad (GSP), GeoGebra, and YouTube video lessons, which are all free open source. For the purpose of the interventions, one-week training was given to mathematics teacher who was assigned for interventions on how to implement a TGIBL approach and GIBL approach based on 5E lesson.

After completing the training on intervention materials, implementation of the intervention was started. The intervention was lasted for ten weeks. The classes in the experimental groups and control group were used four hours to deliver the course. In addition, PSMTs in all groups were used the same course materials (plane geometry/Math-111), which had the same course description, course purpose, credit hour, and course outline. In the following, general explanations on the activities of intervention are given.

Comparison group instruction

The researchers only discussed with the classroom teacher about how to deliver the pre- and post-test and how to gather and arrange the data. The teacher has a master's degree with 12 years of teaching experience in a teacher education college. Before the classroom started, PSMTs were given course outlines and modules. Teaching through presentation (direct instruction, which is the presentation of academic

Table 3. Mean, standard deviation (SD), skewness, and kurtosis, Levene's test on GAS pre-test score

Dependent variable	Group	n	Mean	SD	Skewness	Kurtosis	Levene's test	
							F	P
Pre-AG	EG1	48	2.98	.38	.797	-.455	1.32	.27
	EG2	38	3.06	.32	-.303	-.902		
	CG	30	2.74	.29	.014	-.666		
Pre-SCG	EG1	48	2.87	.49	-.104	-.243	1.03	.36
	EG2	38	2.95	.54	-.026	-1.340		
	CG	30	2.51	.49	-.495	-.600		
Pre- VG	EG1	48	3.14	.46	.546	.009	.91	.41
	EG2	38	3.08	.51	.434	.156		
	CG	30	2.77	.61	-.026	-.056		
Pre-EG	EG1	48	3.03	.56	.263	-.489	2.60	.08
	EG2	38	2.91	.53	-.010	-.515		
	CG	30	2.91	.41	1.006	1.658		
Pre-MG	EG1	48	2.91	.63	.500	-.263	2.11	.13
	EG2	38	3.10	.51	-.186	-.870		
	CG	30	2.78	.49	.490	-.264		

content to PSMTs by teachers, such as in a lecture or demonstration) was utilized. PSMTs were given notes, worksheets, quizzes, and a mid-term test on each chapter, which is a usual activity in most Ethiopian CTE classrooms. That is, PSMTs take only notes and follow the lecture passively.

Experimental groups instruction

The PSMTs in the experimental groups were divided into heterogeneous groups, each with five members depending on their diverse academic achievements. During the intervention, the teacher educator was to lead, facilitate, asks challenging questions, and motivate while PSMTs were cooperatively working on the activities given. The GIBL experimental group was taught in their classroom, while the TGIBL groups were taught in a computer lab.

1. *The TGIBL approach:* In this approach, PSMTs were taught geometry concepts using a technology-guided inquiry approach based on a 5E lesson plan. Accordingly, PSMTs in TGIBL used GSP-integrated geometric activities to explore and analyze geometric concepts by creating mathematical objects. In this case, PSMTs in a GSP environment can verify, explain, and discover the concepts in geometry. In addition, the teacher introduced the lesson via power point and video to provoke for opens a discussion on the lesson.
2. *The GIBL approach:* In this approach, PSMTs were taught geometry concepts using guided inquiry approach based on 5E lesson plan. The classroom teacher gives questions and facilitates working with the given questions. The PSMTs discussed and shared geometric concepts using their prior knowledge and understanding within and with members of the group by posing problems, analyzing examples, formulating conjectures, offering counterexamples, revising conjectures, and validating ideas that result in theorems. Sometimes manipulatives are used in the classroom.

Finally, the GAS, a post-test that is similar with pre-test, was given to all groups after the interventions were finished. Specific group-based activities for the groups are further explained (**Appendix A**).

Data Analysis Procedure

The analyses of data were conducted using parametric tests such as paired sample t-test and one-way analysis of covariance (ANCOVA) at alpha 0.05 using SPSS Version 20. The PSMTs' pre-test scores were used as covariates in ANCOVA to identify initial group differences. Finally, a post hoc comparison using Benforroni was performed to differentiate the places of statistically significant mean differences. Before testing the hypothesis, the assumptions of quantitative data were checked (i.e., independence of the observations, normality, homogeneity of variances and homogeneity of regression) checked.

RESULTS

The results are presented based on the research hypotheses. Before the analysis of data, the assumptions were checked. Descriptive statistics related to the pre-test (GAS) scores of PSMTs attitude towards geometry presented in **Table 3**.

From **Table 3**, since the value of skewness and kurtosis is between -2 and +2, the data on pre-attitude (its dimensions) score is normal (George & Mallery, 2010). The results of Levene's test also indicated pre-attitude and its dimensions are not significant. Therefore, the assumption of the homogeneity of the variances has been tenable (Field, 2009).

After reviewing the assumptions of parametric tests, a one-way ANOVA was employed to test the similarity between the groups before the interventions were administered. **Table 4** shows the result of the ANOVA comparison of the two experimental groups and control group on pre-test score. The analysis of ANOVA ($F[2, 113]=7.36$, $p<.05$), ($F[2, 113]=7.08$, $p<.05$); and ($F[2, 113]=5.11$, $p<.05$) were significant at the 0.05 alpha level for pre-attitude, pre-self-concept, and pre-values towards learning geometry, respectively. This implies that there was a significant mean difference among the EG1, EG2, and TRAD groups before the interventions. Thus, ANCOVA was employed in the analysis of the post-test score using the pre-test score as a covariate since the groups were not equivalent prior to the interventions.

H0[1]: There are no significant differences in AG (its dimensions) of PSMTs who were taught geometry using TGIBL, GIBL, and traditional teacher-centered (TRAD) approach.

Table 4. ANOVA on pre-test of attitude (its components) on EG1, EG2, and TRAD groups

Dependent variable	Sources	SS	df	MS	F	p
Pre-AG	Between groups	1.73	2	.87	7.36	.00
	Within groups	13.32	113	.12		
	Total	15.05	115			
Pre-SCG	Between groups	3.70	2	1.85	7.08	.00
	Within groups	29.49	113	.26		
	Total	33.18	115			
Pre-VG	Between groups	2.72	2	1.36	5.11	.01
	Within groups	30.03	113	.27		
	Total	32.74	115			
Pre-EG	Between groups	.41	2	.21	.77	.46
	Within groups	29.94	113	.27		
	Total	30.35	115			
Pre-MG	Between groups	1.81	2	.91	2.89	.06
	Within groups	35.41	113	.31		
	Total	37.22	115			

Table 5. The descriptive statistics and of skewness and kurtosis and Levene's test and linearity test on post-AG (its dimensions)

Dependent variable	Group	n	Mean	SD	Skewness	Kurtosis	Levene's test		Homogeneity of regression	
							F	p	F	p
Post-AG	EG1	48	3.73	.27	.442	.359	.079	.924	.059	.942
	EG2	38	3.42	.26	.417	-.019				
	CG	30	3.08	.29	-.873	.372				
Post-SCG	EG1	48	3.82	.55	.152	-.642	2.779	.066	.851	.430
	EG2	38	3.50	.63	.247	-.105				
	CG	30	2.77	.41	-.737	1.772				
Post- VG	EG1	48	3.80	.51	.513	- .753	.607	.547	1.254	.289
	EG2	38	3.39	.47	- .351	.507				
	CG	30	3.28	.55	-.473	.896				
Post-EG	EG1	48	3.65	.48	.058	-.506	.229	.796	1.873	.158
	EG2	38	3.34	.54	.626	.786				
	CG	30	3.32	.54	-.263	-.540				
Post-MG	EG1	48	3.67	.47	.029	-.420	1.559	.215	1.115	.319
	EG2	38	3.49	.37	.948	1.110				
	CG	30	2.96	.42	-.317	-.246				

Before the ANCOVA analysis on post-test score, assumptions of ANCOVA (i.e., normality, homogeneity of variance, homogeneity of regression) must be tested. Table presented below give information about the mean scores, standard deviations, the values of skewness and kurtosis, Levene's tests, and homogeneity of regression on post-AG (its dimensions).

From **Table 5**, the skewness and kurtosis ranged between -2 and +2, showing that GAS post-test scores are normally distributed (George & Mallery, 2010). Since p-values are not significant for Levene's and regression, it shows the assumption of homogeneity of the variance and homogeneity of regression were not violated (Field, 2009). A preliminary analysis evaluating the homogeneity-of-regression (slopes) assumption indicated that the relationship between the covariate and the dependent variable did not differ significantly as a function of the independent variable. As a result, the assumptions for ANCOVA were tenable in this particular study.

The estimated marginal means were statistically adjusted on post-test mean scores for all groups to enable comparison between the pre-test and post-test, among the groups in their post-test. **Table 6** presents the means, adjusted mean scores, and standard deviations for the geometry attitude scores. From **Table 6**, the adjusted means on attitude (its dimensions) towards learning geometry was different among the groups.

To determine whether there were significant differences between the three groups in post-attitude (its dimensions), ANCOVA is carried out and presented in the **Table 7**. In the **Table 7**, the ANCOVA test confirmed that there was significant mean difference between the groups in post-AG ($F[2, 112]=51.314$, $p=.000$), eta-squared (η^2) .48; post-SCG ($F[2, 112]=28.12$, $p=.000$), eta-squared (η^2) .33; post-VG ($F[2, 112]=11.69$, $p=.000$), eta-squared (η^2) .17; post-EG ($F[2, 112]=5.05$, $p=.008$), eta-squared (η^2) .08; and post-MG ($F[2, 112]=24.708$, $p=.000$), eta-square (η^2) .31.

The eta-squared (η^2) values .48, .33, .17, .8, and .31 for post-AG, post-SCG, post-VG, post-EG, and post-MG, respectively indicated that the interventions provided 48%, 33%, 17%, 8%, and 31% of variation, independent of the pre-test scores. The eta-squared (η^2) values are shown to have larger effect size for post-AG, post-SCG, post-VG, and post-MG while moderate effect size for post-MG (Cohen, 1988).

Follow-up tests were conducted to evaluate pairwise differences among the adjusted means for groups. To determine where the difference among the teaching approaches, Bonferroni's post-hoc multiple comparison test was used. The Bonferroni was used to control for type I error (Field, 2009). The post-hoc test for the teaching condition variable was tested at the pre-established alpha level of .05. **Table 8** shows the Bonferroni post-hoc multiple comparison tests.

Table 6. Adjusted and unadjusted means and variability on the three groups for pre-service mathematics teachers' geometry attitudes and its components using pretest as covariate

Variables	Groups	n	Unadjusted		Adjusted	
			Mean	SD	Mean	SE
Post-AG	EG1	48	3.73	.27	3.73	.040
	EG2	38	3.43	.26	3.42	.046
	CG	30	3.08	.29	3.09	.052
Post-SCG	EG1	48	3.82	.55	3.81	.079
	EG2	38	3.50	.63	3.44	.091
	CG	30	2.77	.41	2.84	.116
Post-VG	EG1	48	3.80	.51	3.78	.076
	EG2	38	3.39	.47	3.40	.083
	CG	30	3.28	.55	3.30	.101
Post-EG	EG1	48	3.65	.48	3.65	.074
	EG2	38	3.34	.54	3.33	.083
	CG	30	3.32	.54	3.36	.096
Post-MG	EG1	48	3.66	.47	3.67	.062
	EG2	38	3.49	.37	3.51	.073
	CG	30	2.96	.42	2.96	.083

Table 7. ANCOVA result for geometry attitudes (its dimensions) variable

Variable	Source	df	MS	F	p	Eta²
Post-AG	Pre-attitude	1	.211	2.848	.094	.025
	Groups	2	3.793	51.314	.000	.478
	Error	112	.074			
Post-SCG	Pre-self-confidence	1	1.66	5.62	.02	.032
	Groups	2	8.188	28.120	.000	.334
	Error	112	.291			
Post-VG	Pre-value	1	.05	.193	.661	.002
	Groups	2	3.056	11.69	.000	.173
	Error	112	.261			
Post-EG	Pre-enjoyment	1	.235	.887	.348	.008
	Groups	2	1.339	5.051	.008	.083
	Error	112	.265			
Post-MG	Pre-motivation	1	.023	.126	.724	.001
	Groups	2	4.579	24.708	.000	.308
	Error	112	.185			

From **Table 8**, the post hoc multiple comparison result revealed that there was statistically significant mean difference between EG1 and CG at (p=.000) in attitude, self-concept, value/usefulness, and motivation after the intervention with mean gain .638, .98, .534, and .702, respectively. This indicated that, PSMTs in EG1 (i.e., TGIBL approach) has improved attitude, self-concept, values, and motivation towards learning geometry than comparison group (i.e., traditional teacher-centered approach).

Similarly, there was statistically significant mean difference between EG1 and EG2 at (p<.05) in attitude, self-concept, value/usefulness, and enjoyment with mean gain of .315, .336, .419, and .306, respectively. This revealed that PSMTs in EG1 (i.e., TGIBL approach) has gained positive attitude, self-concept, value, and enjoyment towards learning geometry than EG2 (i.e., TGIBL approach). Furthermore, the post hoc multiple comparisons showed that there was no statistically significant mean difference between EG2 (i.e., GIBL approach) and TRAD (i.e., traditional teacher-centered approach) at (p>.05) in value and enjoyment towards learning geometry. Hence, it is evident to say that the intervention was successful in improving PSMTs' attitude towards learning geometry.

Thus, it can be concluded that technology integration into guided inquiry learning environment is more effective than both traditional approach and guided inquiry approach in improving PSMTs attitude, motivation, enjoyment, and values towards learning geometry. The key reason is that the use of technology provided PSMTs with an innovative, exciting, and visible way of learning. Technology such as dynamic geometric software (like GSP and Geogebra) and YouTube video used within guided inquiry approach was assisted PSMTs to understand geometric concepts with concrete real-life examples through visualization. Moreover, the instant and quick feedback offered in a technological learning environment might be another factor for improved attitudes.

H0[2]: There is no significant mean difference of pre-test and post-test attitude (its dimension) of each group.

In order to determine whether differences in the averages scores of each groups, a paired sample t-test was applied. **Table 9** summarizes the results of the paired sample t-test analysis for the pre-test and post-test of attitude score for all groups.

Table 8. Bonferroni's post-hoc multiple comparisons test

Variable	(I) group	(J) group	Mean difference (I-J)	p[b]
Post-AG	EG1	EG2	.315*	.000
		CG	.638*	.000
	EG2	CG	.323*	.000
Post-SCG	EG1	EG2	.336*	.015
		CG	.980*	.000
	EG2	CG	.643*	.000
Post-VG	EG1	EG2	.419*	.001
		CG	.534*	.000
	EG2	CG	.115	.990
Post-EG	EG1	EG2	.306*	.022
		CG	.313*	.032
	EG2	CG	.007	.990
Post-MG	EG1	EG2	.185	.160
		CG	.702*	.000
	EG2	CG	.517*	.000

Note. *p<.05 & [b]Adjustment for multiple comparisons: Bonferroni

Table 9. A paired sample t-test on the pretest and posttest comparison within groups on attitude variable

Dimensions	Group	n	Paired differences			t	df	p
			MD	SD	SEM			
Pre- & post-test AG	EG1	48	.75583	.42147	.06083	12.424	47	.000
	EG2	38	.37202	.39528	.06412	5.802	37	.000
	CG	30	.18311	.66523	.12145	1.508	29	.142

Note. MD: Mean difference; SD: Standard deviation; SEM: Standard error mean; & AG: Attitude

A paired samples t-test presented in **Table 9** depicted that PSMTs' attitude to learn geometry (t[47]=12.424, p<.05) have significantly improved for EG1 groups and not significantly improved for the comparison group (t[29]=1.508, p>.05). EG2 also made a significant improvement in attitude (t[37]=5.802, p<.05). The result highlight that PSMTs who were learned geometry with technology supported guided inquiry approach favored to attain positive attitude towards geometry. Therefore, this shows that there is a significant difference in pre-test and post-test results in favor of the post-test. Similarly, PSMTs in guided inquiry approach showed significant mean difference in favor of post-test score.

DISCUSSION

The current study was done to investigate the effects of the TGIBL approach, GIBL and the traditional teacher-centered approach on PSMTs' attitudes toward learning geometry in college of teacher education in Oromiya Regional State, Ethiopia. The results of the analysis of ANCOVA on the attitude of PSMTs taught geometry using a TGIBL approach, a GIBL approach, and those taught using a traditional teacher-centered method approach indicated a significant difference in favor of PSMTs taught with the TGIBL approach. The findings of the study showed that the TGIBL approach was more effective than the GIBL approach and the traditional teacher-centered approach in improving PSMTs' attitudes (motivation, self-concept, enjoyment, and value) towards learning geometry.

This finding is concurred with the findings of Abdi (2014), Cavus and Deniz (2021), Yudt (2019), and Zuiker and Whitaker (2014) who showed that technology complemented with an inquiry-based learning teaching environment improves the attitudes of PSMTs towards learning geometry. Furthermore, previous studies by Birgin and Topuz, (2021), Demir and Onal (2021), Deringol et al. (2021), Juandi et al. (2021), and Meng and Idris (2012) found that technology-rich teaching environments have positively influenced PSMTs' attitudes towards learning geometry and mathematics. Thus, using technology (such as GSP, GeoGebra, etc.) enhanced PSMTs' engagement and motivation in learning mathematics and geometry.

Moreover, the results of this study indicated that the attitudes of PSMTs taught with the GIBL approach are significantly better than those of traditional teacher-centered groups. This finding is supported by Audu et al. (2017), who determined that through guided inquiry, PSMTs increase their confidence and develop a deep understanding of concepts. Similarly, Abaniel (2021), Albay (2020), Bodner and Elmas (2020), Tsao (2018), and Tutal and Yazar (2022) found inquiry instructional approach improved PSMTs' attitudes toward geometry.

Furthermore, the paired sample t-test results showed post-test score of attitude of the pre-service teachers who were taught with TGIBL and GIBL approach were significantly higher at the end of the course than pre-intervention. Many studies (Abdullah & Zaharia, 2013; Kutluca, 2013) show that attitudes towards learning mathematics and geometry are changed in computer-based environments. In addition, studies indicate that using concrete materials and hands-on activities improved PSMTs' attitude and level of understanding in geometry (Siew & Abdullah, 2013; Siew et al., 2013).

CONCLUSION AND RECOMMENDATION

Based on the findings of this study, it can be concluded that both the TGIBL approach and the GIBL approach have a positive effect on PSMTs' attitudes toward learning geometry. In these approaches, abstract geometrical concepts are visualized, which motivates PSMTs to learn the subject matter. Hence, TGIBL and GIBL approaches are more effective for teaching geometry at CTEs. The findings implied that a GIBL approach is more effective in a technology-based environment for a positive attitude towards learning geometry.

Based on the findings of the study it can be recommended:

1. Mathematics teacher educators should use TGIBL, and guided inquiry approaches so as to promote collaborative, active learning, discovery learning and motivation among PSMTs towards the subject matter.
2. Technology-assisted instruction method should be practiced for teaching and learning of geometry (mathematics) in college of teacher education.
3. In this study, the research was limited to quantitative data analysis. Thus, qualitative approaches of study, such as interviews, are recommended in order to gain an in-depth understanding of the effects of the TGIBL approach on PSMTs' attitudes towards learning geometry (mathematics) in CTEs.

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APPENDIX A

Sample Lesson Plan

Previous Knowledge: PSMTs should recognize

- The characteristics of triangle by sides and angles.
- A straight angle is 180^0 in measure.
- Alternate interior angles of parallel lines are equal in measure.

Outlines of lesson: (summary of tasks/ activities)

1. Technology Guided Inquiry-Based Learning Approach

a) Measuring Angles (THINK-PAIR-SHARE)

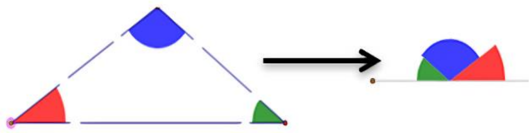
PSTs are to be arranged in group of 5 members. Each PST should draw different triangle (e.g., acute, right, obtuse, scalene, isosceles, and equilateral).

Did you get the same angle sum? If you do not get the same angle sum, discuss why?
What did you conclude about the angle sum of a triangle?

b) Discovering with hands-on activities/methods

Cutout and Foldup papers (THINK-PAIR-SHARE)

On the piece of plain white paper, draw a triangle and cut out. Label the interior of each angle. Now tear of each corner of the triangles and re-arrange the three "angles' so that their vertices meet at one point with no overlap.



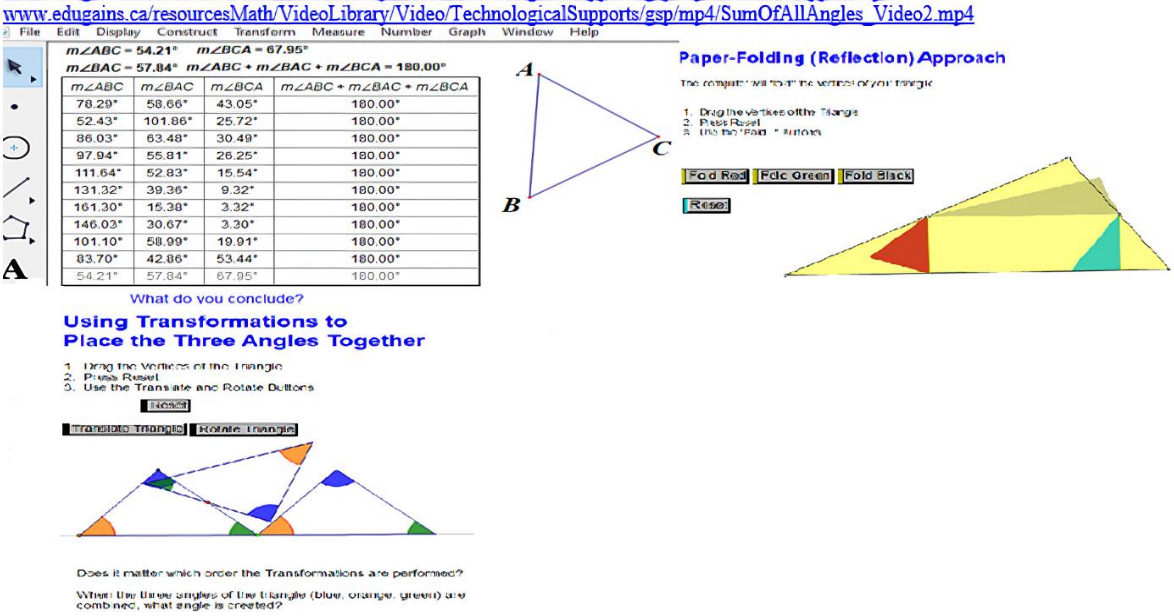
What does this tell you about the sum of the angles in the triangle?

c) Investigating with GSP and GeoGebra software (THINK-PAIR-SHARE)

GSP Applet On Plane Geometry of Angle Sum of Theorem:

Find the sum of the interior angle measures, and then drag one vertex to create a new triangle. Find the sum again. (Repeat)

YouTube Videos: https://www.youtube.com/watch?v=-sth6XeNUZY&t=258s
https://www.youtube.com/watch?v=_yRDwYYjgOY, https://www.youtube.com/watch?v=kajD-Wixcvo
https://www.youtube.com/watch?v=V81sAvmSY4M, https://www.youtube.com/watch?v=v5TJRunAaw4&t=339s
https://www.youtube.com/watch?v=3kx6HGO6gvM
The Geometer's Sketchpad™ (GSP) (edugains.ca),
www.edugains.ca/resourcesMath/VideoLibrary/Video/TechnologicalSupports/gsp/mp4/CirclePiSupport.mp4
www.edugains.ca/resourcesMath/VideoLibrary/Video/TechnologicalSupports/gsp/mp4/SumOfAllAngles_Video2.mp4



m∠ABC	m∠BAC	m∠BCA	m∠ABC + m∠BAC + m∠BCA
78.29°	58.66°	43.05°	180.00°
52.43°	101.86°	25.72°	180.00°
86.03°	63.48°	30.49°	180.00°
97.94°	55.81°	26.25°	180.00°
111.64°	52.83°	15.54°	180.00°
131.32°	39.36°	9.32°	180.00°
161.30°	15.38°	3.32°	180.00°
146.03°	30.67°	3.30°	180.00°
101.10°	58.99°	19.91°	180.00°
83.70°	42.86°	53.44°	180.00°
54.21°	57.84°	67.95°	180.00°

Evaluation

1. If a triangle has angle 30^0 and 50^0, find the third angle?
2. If a triangle has an angle measure x, 4x, 5x, find the value of x and each of the three angles?

❖❖❖