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Contribution of Conceptual Understanding, Creativity Skill and Motivation to Student's Problem-Solving Skill in Learning Plane Geometry Based on Visually Assisted with Guided Discovery Based Learning Model

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Abstract

The purpose of this study is to determine how students' conceptual understanding, creativity, and motivation relate to their problem-solving skill when learning plane geometry using a visually assisted with guided discovery-based learning model in grade 10 students in Woldia City, North Wollo, Ethiopia. 96 students were divided into three groups for this study: experimental group-1 (n = 29), experimental group-2 (n = 39), and comparison group (n = 28). Using a straightforward random sampling technique, three secondary schools were specifically chosen and allocated to experimental and control groups. A nonequivalent quasi-experimental pretest-posttest-control group design was used in this study. Multiple regression analysis was used to examine the data. The analysis's findings demonstrate that the relationship of conceptual understanding, creativity and motivation of the students has the greatest contribution to problem solving skills in the Visually Assisted with Guided Discovery Based Learning Model.

• Introduction

Mathematical problem-solving is not a single component, but an ability that involves simple calculations and reading comprehension as well as extensive reasoning skills (Kilpatrick, 1978). The level of students' learning interest in mathematics is often associated with success and failure in learning outcomes (Putra & Ikhsan, 2019). Students who have a high interest in learning always try to complete their assignments satisfactorily and solve mathematical problems (Rakhmawati & Alifia, 2018). In fact, research suggests that personal internal psychological factors, such as motivation, learning interest, and self-efficacy, are more significant in mathematical problem-solving performance. Some studies have found that increasing middle school students' mathematics interest and self-efficacy can effectively improve their mathematical problem-solving (Wieth &

Burns,2000; Fatimah et al., 2019; Xu & Qi, 2022). Al-Mutawah et al. (2019) revealed that there is a positive correlation between conceptual understanding and problem-solving abilities. In addition, Tyagi (2015) result suggests that significant predominant causal relationship was found between mathematical creativity and mathematical problem-solving. Further, Sharma (2014) claimed that the strategy for fostering mathematical creativity was found to be effective for developing mathematical creativity. In addition, Irhamna et al. (2020) demonstrated that the capacity to solve mathematical problems is influenced by mathematics anxiety, learning motivation, and self-confidence. It is supposed in this research those students were expressed positive emotions, when working with visually assisted guided discovery strategies in the classes. The value of these positive emotions was also added by employing student-centered group workings. Lai (2011) revealed that critical thinking activities could encourage students who are motivated to learn to be persistent when faced with a task; and that the challenge of a task may cause students who are less motivated to learn. To increase student motivation teachers should encourage focusing instruction on workable problem-based activities that are learner-centered and that involve the higher-order cognitive intellectual skills, such as critical thinking (Lai, 2011; Norman & Spohrer, 1996). Amabile (1989) considered that intrinsic motivation in children included important characteristics, such as love and dedication and that these attributes were important for the creative process to occur. The opposing argument will make that students' motivation levels, which they bring to the classroom affect their willingness in problem-solving, conceptual understanding and critical thinking activities. Therefore, systematically evaluate the conceptual understanding, motivation and creativity variables in the process of problem-solving must be valued.

2 Statement of the problem

In Ethiopia, evidence suggests that instructional program has traditionally depend upon teacher centered method of teaching, making students to become passive recipients of information rather than being active is adopted in most classrooms. Studies have shown that most secondary school students achieve very low in mathematics. Teacher Education System Overhaul (TESO) program was introduced in 2001 and emphasized the implementation of participatory, student center in the pre-service and in-service programs of teacher education within other major programs MoE (2002a), and the Ministry of Education MoE (2002b) stressed the importance of implementing student center approaches in teaching at various levels to encourage the development of problem-solving capacities and competencies of the students. Mathematics is one of the subjects offered in the secondary school curriculum in Ethiopia. However, in spite of this and though it has been acknowledged that the subject plays an important role in learners' future educational and career-related outcomes learners have continued poor results in the subject. Alemu (2022) year to year the numbers of Ethiopian General Secondary Education Certificate Examination exam sitters were increased, though students' who were taken the EGSECE exams 2001 to 2017 the relative numbers of passers were very low. Statistics show that student's achievement in mathematics in the Ethiopian grade 10 Secondary school examinations has been poor over the years and the majority of secondary school students scored below the average passing mark (50%); this showed that students lacked an adequate understanding of mathematical concepts and procedures across different domains of the mathematics curriculum as reported by the Ethiopian National Examination Agency (Gebrekidan, 2010). The mean score for mathematics (37.01) were found the least as described by National Educational Assessment and Examinations Agency (NEAEA, 2014). Also, according to the national educational assessment and examination agency (NEAEA, 2017) mean score in mathematics(33.18%), this was below the mean difference in achievement of students and the minimum policy target of 50% achievement in each subject. Moreover, a considerable number of Ethiopian students struggle with understanding of geometry concepts, problem-solving skills, and overall performance (NEAEA, 2020). In mathematics, the achievement of the students in geometry content domain (33.59%) was relatively the least mean score compared to numbers content domain (40.73%) and statistics content domain (34.57%).

Geometry is one of the national mathematics curriculums for secondary education in Ethiopia. Accordingly, students are supposed to do geometric problems in equal comparisons to other components of mathematics like, algebra, arithmetic, statistics and trigonometry (MOE, 2009). Many research revealed the factors that are responsible for students' difficulty in learning geometry. For instance, lack of proof by students, background knowledge, geometric language comprehension, visualizing abilities, poor reasoning skill in geometry, insufficient teachers' method of teaching, non-availability of instructional materials, gender differences among others(Mason, 2009; Özerem, 2012; Udousoro, 2011). Adegun and Adegun (2013) stated that students generally encountered difficulties in geometry and performed poorly in senior secondary school mathematics lesson. Moreover, lack of resources was among the challenges teachers faced in the teaching of the similarity of triangles. Based on these findings, students have not been performing well in mathematics especially on geometry. In Teacher-dominated class room instruction, which mainly focuses on passive transmission of knowledge from teacher to students, procedural and computational-oriented instruction, and the teacher as a sole source of knowledge (Hoyles, 1985; Rosenthal, 1995), ineffective to equip and empower students with profound mathematical understanding, communication, creativity, critical thinking, and problem-solving skills (Suh & Seshaiyer, 2013). On the other hand, students who are labeled as low mathematical proficiency demonstrate poor procedural and conceptual understanding, reasoning and problem solving skills, and negative dispositions (Bostic, 2011).

In order to address the issue and reduce students' knowledge gaps, guided discovery, a two-way process where learners are active in class guided by their teachers (Loibl and Rummel, 2014), to solve the problem and minimize learners' knowledge gaps (Martin, 2015). The other strategy is visually assisted strategy where learners express the information systematically and especially by using interesting and effective ways and, visualization important for facilitating learning and teaching mathematics (Tappenden, 2005). Using different visualization techniques or representations in learning and teaching can help students in problem solving, enhance concept mastery, generic science skills, and critical thinking, improve mental model, to develop their mathematical creativity in mathematics, to flexibly alternate their solutions when they encounter new situations, measure students' creative thinking abilities and as an intervention to promote students' mathematical creativity can be especially helpful for elementary and middle school students (Abdurrahman et al., 2019; Bicer, 2021; Boaler et al., 2016; Kohl & Finkelstein, 2008, Sunyono et al.,2015).

3 Research questions

The goal of the current study is to explore the contribution of conceptual understanding, creativity skill and motivation (when taken together) to student's problem-solving skill in learning plane geometry based on visually assisted with guided discovery based learning model. With this aim in mind, research questions can be stated as follows:

- *Is there a significant relationship between the students' conceptual understanding, creativity skill, motivation and problem solving skill the students in learning plane geometry with in the two interventions and control groups?*
- *To what extent did conceptual understanding, creativity and motivation (when taken together) contribute to the prediction of problem solving skill of the students in learning plane geometry with in the two interventions and control groups?*

4 Objectives

This study aimed to find the mean gains of contributions of 10th grade students' conceptual understanding, creativity skills, and motivation on problem-solving skills in learning geometry using visually assisted learning with guided discovery based instructional approaches.

5 Materials and Methods

5.1 Research design and method

The current study was employed a quasi-experimental design with non-equivalent as it is a pre-test, and post-test experimental and control group design. This was done by adding a nonequivalent comparison group, where students are considered as they are without random assignment. The pretest was required for both groups before the intervention in order to have some idea on how similar or different the three groups are. Similarly, the posttest was required to know the effect of the intervention.

5.2 Population and sampling techniques

In educational research, the population of interest is usually a group of teachers, students, or other individuals who possess certain characteristics (Creswell, 2014). The study was conducted in North Wollo, especially in Woldia City high schools. Thus, in this study, the population constitutes 10th Grade secondary school students found in Woldia City. To collect the most comprehensive source of data possible, sampling decisions was made. A purposive sampling method was used in selecting three government secondary schools which have been found in Woldia City based on the following criteria: availability of resources, facilities and personnel; Close proximity to schools allows for timely coverage and access. Topics covered in this study and equivalence with secondary schools in terms of equivalent composition. Three classes (one from each high school) were selected by simple random sampling technique. The researcher considered three naturally assemble groups (three sections) as intact classes. The experimental group-1(29 students) used a visually assisted guided discovery approach, the second experimental group-2 (39 students) used a guided discovery approach, and the comparison group (28 students) used a conventional method.

5.3 Instrument for data collection

To conduct this study, the researcher was found and selects data sources. In this study four different measurement tools were used through pretest and posttest testing tools for measuring the students' mathematics conceptual understanding test, the problem-solving skills test, creativity skills test and motivation questionnaire were used.

5.3.1 Conceptual understanding measuring questions

The conceptual understanding test consists of ten Two-Tier Multiple Choice Questions (TTMC) was prepared by the researcher and designed to measure levels of understanding among students concerning the subject of plane geometry, and to identify their ways of thinking and rationales. TTMC is two-level instrument that can solve the weakness of multiple choice instruments in the tendency of guessing. The main level (first tier) seems like traditional multiple-choice form (Multiple Choice Question/MCQ), in which it concerns about knowledge aspect. The second level (two-tier) seems like the format of the questions of traditional multiple-choice. Student's answer to each item was considered correct when both the correct choice and reason are given. Data was first analyzed by tabulating students' answers to the first tier of each question, and the percentages of the reasons they select for their answers. The average item difficulty index was 0.50 and it is an acceptable value. The item discrimination indices of the ten items were in the standard range [0.20, 1.00]. The average discrimination index was 0.793 and it is acceptable and a very good distinguishing power (Whitney, 1977). In addition, the internal-consistency reliability (Cronbach alpha) was 0.808. This value was considered satisfactory for the purpose of the study.

5.3.2 Problem solving skills measuring questions

In order to measure students' problem solving skills, the instrument consists of six geometry problems involving multi steps were developed by the researcher. These questions were taken from text books and references and subjected to pilot test. Students' problem solving skills was measured at each stage (understanding the problem, devising a plan, carrying out a plan and looking back) (Pólya & Conway, 1957). The detailed score for each step of problem-solving was adapted from Widodo (2015) and Widodo and Turmudi (2017). The average item difficulty index was 0.419 and it is an acceptable value (Allen & Yen, 2001). The average discrimination index was 0.781 and it is acceptable and a very good distinguishing power (Ebel & Frisbie, 1972; Mardapi, 2005, p. 5). In addition, the test instrument has a reliability index of 0.873(reliable).

5.3.3 Creativity skills measuring questions

In this study, geometry creativity test (GCT) of six items was prepared by the researcher. Problem solving according to Kind and Kind (2007) can be used to develop mathematical creativity. Kind and Kind (2007) stated that the indicators of students' creative thinking are fluency, flexibility and novelty. Fluency in problem solving means students ability to produce many solutions/ideas to a problem. Flexibility defined as students' ability to generate different types of solutions/ideas meanwhile novelty defined as students' ability to generate rare and uncommon solution/ideas. The scoring guide for mathematical creative thinking skills modifies the rubric developed by Siswono (2010) mentioned the levels of creative thinking in problem solving. The average item difficulty index was 0.427 and it is an acceptable value (Allen & Yen, 2001). The average discrimination index was 0.713 and it is acceptable and a very good distinguishing power (Ebel & Frisbie, 1972; Mardapi, 2005). In addition, the test instrument has a reliability index of 0.801(reliable).

5.3.4 Motivation measuring questionnaire

The survey instrument used to measure motivation to learn geometry adapt Keller (2010, pp. 283-284) Course Interest Survey (CIS) subscale score attention to specific situations by changing phrasing such as "this lesson" to "this geometry lesson". Furthermore, Fiorella et al. (2021) to examine students' motivation to learn mathematics, or the level at which students' strive to learn the mathematical domain in each of the items Enjoyment, Utility value, Self-efficacy and Test Anxiety. The data were collected from 68 randomly selected from grade 10 general secondary school students in Woldia City, Ethiopia. The questionnaire consisted of 29 items of which 7 were attention, 7 were utility, 5 Enjoyment, 5 were self-efficacy, and 5 were test anxiety on the five-point Likert-scale questionnaire. It is now worth to have an idea about the reliability coefficient values of Likert-scale motivation questionnaire in pilot study. This value was determined by the most often widely used reliability testing tool, Cronbach's alpha (Demircioglu et al., 2014). For each item, participants were chose a response from a five-point scale ranging from 1 (never) to 5 (always). Completion of the questionnaire was not timed. The data were collected from 68 randomly selected from grade 10 general secondary school students in Woldia City, Ethiopia. The motivation scale's reliability, Cronbach's alpha was obtained and the corrected item total correlations 0.869 and these are considered as acceptable.

5.4 Intervention procedure

Two senior mathematics teachers from each of the selected schools were trained by the researcher for the study. The training was lasted for two hours each day for five days with the teaching manual was prepared by the researcher in respect of the two teaching methods i.e. visually assisted learning with guided discovery based methods and guided discovery based methods.

5.4.1 Treatment

After training the two senior mathematics teachers from each of the selected schools, students' plane geometry problem-solving skill tests were administered as a pre-test to the students. Thereafter, treatment was given by selecting mathematics concepts, plane geometry from secondary grade 10 mathematics curriculums for the administration of post-test after the treatment. Two independent variables (visually assisted learning with guided discovery based method and guided discovery based method) and conventional method groups were investigated on students' geometric problem-solving skills learning in plane geometry. The participants were tenth grade students from three intact classes from three different Secondary Schools in Woldia, North Wollo, and Ethiopia. Three intact classes label A, B and C was used for the study in each of the schools select. Intact class A serve as the experimental group one (EG-1) was treated using VAGD based method, intact class B serve as the experimental group two (EG-2) was treated using GD teaching method, while class C the control group using the conventional learning approach (CLA). Moreover both conventional and experimental groups were received 22 periods and delivered over one month focused on plane geometry based on the Ethiopian grade 10 mathematics text book syllabuses. After and during the intervention the data was collected to examine the effect of the three teaching approaches on the students' plane geometry learning through post-test. The post-test scores of students in the control and experimental groups obtain from the students' geometry problem-solving skills test was analyzed and presented using tables and descriptive statistics.

5.5 Methods of data analysis

This research data is data about geometry conceptual understanding test, problem-solving skills test, creativity skills test and motivation questionnaire collected through pretest and posttest. The difference value between pretest and posttest was analyzed using multiple regression analysis with SPSS 20.0 for Windows program. The analysis results are used to determine the multiple correlations between three criteria and one predictor. Before analyzing the multiple regressions, the data were firstly tested with the normality test data using skewness test.

6 Results

Table 1: Pearson Product-Moment Correlation Results

Variables	Correlations between Variables											Mean	SD
	CU	PSS	Cr	Fl	Fx	Or	M	At	En	UV	TA		
Conceptual Understanding (CU)	1											6.2708	1.59261
Problem-solving skills (PSS)	.526**	1										33.9375	10.8616
Creativity	.374	.435	1									10.09	3.152

(Cr)	**	**										38	54
Fluency (Fl)	.249*	.338**	.747**	1								3.8854	1.43542
Flexibility (Fx)	.561**	.606**	.697**	.364**	1							3.4583	2.01529
Originality (Or)	.235*	.169	.741**	.360**	.431**	1						2.0313	1.26868
Motivation (M)	.481**	.700**	.538**	.390**	.689**	.288**	1					3.3849	.55169
Attention (At)	.349**	.628**	.399**	.200	.574**	.264**	.794**	1				3.3021	.92189
Enjoyment (En)	.484**	.642**	.535**	.393**	.675**	.292**	.888**	.601**	1			3.5091	.77422
Utility value (UV)	.440**	.639**	.508**	.451**	.645**	.256*	.826**	.628**	.638**	1		3.8396	.74190
Test anxiety (TA)	-.186	-.180**	-.225*	-.186	-.333**	-.171	-.065	-.200	-.295**	-.241*	1	6.2708	1.59261

**. Correlation is significant at the 0.05 level (2-tailed).*

***. Correlation is significant at the 0.01 level (2-tailed).*

Research question1: *Is there a significant relationship between the students' conceptual understanding, creativity skill, motivation and problem solving skill in learning plane geometry with in the two interventions and control groups?*

Table 2: The correlation of PSS with students Cr, Fl, Fx, Or, M, At, En, UV, SE TA

Correlations												
CU		PSS		Cr	Fl	Fx	Or	M	At	En	UV	TA
PSS	Pearson Correlation	.526**	1	.435**	.338**	.606**	.169	.700**	.628**	.642**	.639**	-.180**
	Sig. (2-tailed)	.000		.000	.001	.000	.100	.000	.000	.000	.000	.079

From Table 2 bivariate Pearson's correlation coefficients were run to determine the degree of relationship between the students' PSS, Cr, Fl, Fx, Or, M, At, En, UV and TA. PSS and CU, Cr, Fl, Fx, M, At, En, UV had significant correlations with at the 0.01 level. However, there was no significant correlation between PSS, Or and TA (p>.05). On the other hand the strong correlation score was detected between CU and PSS was computed at the level of 0.05(r=.526; p=0.000<0.05). According to this finding, 27.66% of the variation in students' PSS was explained by CU score (r-square) (effect size) =.2766. The moderate correlation score was detected between PSS and creativity(r=.435, p=0.000<0.05). This result indicates that standardized measures of scores explain 18.92% of the variation in students' PSS was explained by creativity score (r-square) (effect size) =.1892. The other strong correlation score was detected between M and PSS was computed at the level of 0.05(r=.700; p=0.00<0.05). According to this finding, 49.0% of the variation in students' PSS was explained by motivation score (r-square) (effect size) =.490 .This finding reveals that conceptual understanding, creativity and motivation skill is an important factor to students' success in PSS. Hence, from the correlation analysis, it can be concluded that all three measured independent variables are significantly correlated to the problem solving skill, whereby CU and M have the strongest correlation with the dependent variable.

Research questions 2: *To what extent did conceptual understanding, creativity and motivation (when taken together) contribute to the prediction of problem solving skill of the students in learning plane geometry with in the two interventions and control groups?*

In the present study, multiple regression analysis was carried out to determine the relationship between the study's independent variables namely conceptual understanding, motivation, and creativity skill factors, and

the dependent variable namely problem solving skill in learning plane geometry for Visually Assisted with Guided discovery learning approaches group. This method of analysis was chosen to identify how much variance in the dependent variable could be predicted by the independent variables, and whether this contribution was significant (Kerr et al., 2013). Each regression model was first assessed to determine whether it met the necessary assumptions of multiple regressions. Such as, homoscedasticity, the independent residuals and absence of multi-collinearity, linearity, and data are independent from each other and the data's residuals are normally distributed. First Assumption was normally distributed residuals. Skewness and kurtosis (Table 3) were examined and issues of normality were highlighted for the CU, PSS, Cr, Fl, Fx, Or, M, At, En, UV and SE test scores. All of the measures were considered within acceptable limits. As we can easily see, the Skewness and Kurtosis Values test result indicates that the errors are normally distributed as we can see this value were between -2 and 2 (Table 3). In addition, a linear relationship was determined between the independent and dependent variables by plotting the studentized residuals against the standardized predicted values of the dependent variable.

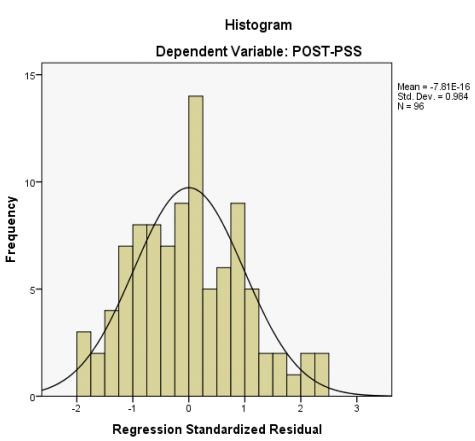
Table 3: Summary results of normality test data on CU, PSS, Cr, Fl, Fx, Or, M, At, En, UV and SE test

Test	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
CU	96	6.1875	1.48191	-.152	0.246	-.590	0.488
Ps	96	27.8125	9.76817	.042	0.246	-.822	0.488
Cr	96	9.5417	2.96618	-.297	0.246	.412	0.488
Flu	96	1.9635	.73357	-.607	0.246	-.129	0.488
Flex	96	1.7552	.65291	-.067	0.246	-.353	0.488
Or	96	1.0208	.64038	.412	0.246	-.510	0.488
M	96	3.5448	67152	-.068	0.246	-1.179	0.488
At	96	3.6424	.78806	-.266	0.246	-1.187	0.488
En	96	3.6896	.88490	-.252	0.246	-1.102	0.488
UV	96	3.7021	.91949	-.405	0.246	-1.185	0.488
SE	96	3.6042	.85044	-.102	0.246	-1.075	0.488
TA	96	2.7674	.82095	-.016	0.246	-.158	0.488

Based on all of the obtained results, we can conclude that the assumption of normally distributed residuals has been met.

Furthermore, the researcher assessed the data for homoscedasticity through Levine's statistic, which produced an adjusted (for unequal sample sizes) test statistic of 0.336 (p = .336), indicating that the variance of the data's residuals has the same distribution across the range of the data. Normally distributed residuals: Prior to analysis, each of the independent variable data sets was assessed to determine the degree to which a normal distribution was represented. The residual statistics indicated that there was no issue regarding the assumption of the homogeneity of variance. The histogram and P-P plot indicated a normal distribution as these values were relatively close to zero (Field, 2009). The third assumption, the regression model can be expressed in a linear way. A preferable method of detection is examination of residual plots (plots of the standardized residuals as a function of standardized predicted values, readily available in most statistical software). Figure 1 displays a scatterplot showing this relationship for the regression.

Figure 1: Scatterplot of studentized residuals and standardized predicted values for the regression



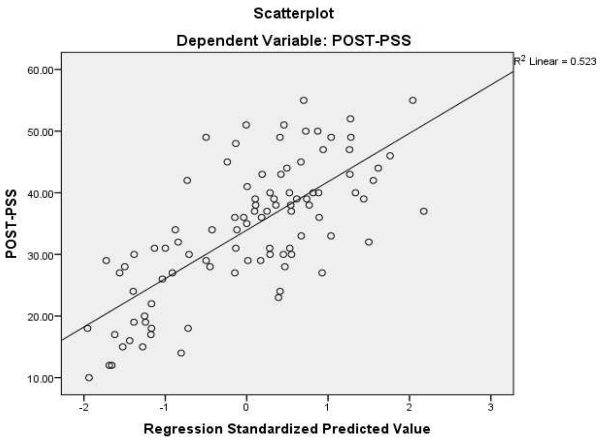


Figure 1 is free of patterns, thus indicating that the assumption of homoscedasticity has been met. Thereby, we came to the conclusion that the linearity assumption has been met. Moreover, due to the confirmed linearity of relationships between the separate independent variables and the dependent variables the precondition to run regression analysis is met (Saunders, 2014). Finally, data are independent from each other. Participants were individuals who anonymously completed tests and questionnaires and their responses could not be related to each other. In addition, the independent variables were assessed for multi-collinearity. Typical measures of multi-collinearity include the Tolerance and the Variance Inflation Factor (VIF).

Table 4: Tolerance value, the variance inflation factor (VIF) and independent residuals test for visually assisted guided discovery learning approach group

Model	**Collinearity Statistics**		**Durbin-Watson**
	Tolerance	**VIF**	
Experimental Group-1 Post- CU Test	.964	1.038	1.885
Experimental Group-1 Post- M Score	.954	1.048	
Experimental Group-1 Post-CS Test	.922	1.085	

Table 5: Tolerance value, the variance inflation factor (VIF) and independent residuals test for guided discovery learning approach group

Model	**Collinearity Statistics**		**Durbin-Watson**
	Tolerance	**VIF**	
Experimental Group-2 Post- CU Test	.918	1.090	2.401
Experimental Group-2 Post- M Score	.913	1.095	
Experimental Group-2 Post-CS Test	.980	1.020	

Table 6: Tolerance value, the variance inflation factor (VIF) and independent residuals test for the comparison group

Model	**Collinearity Statistics**		**Durbin-Watson**
	Tolerance	**VIF**	
Control Group Post- CU Test	.953	1.049	1.643
Control Group Post- M Score	.939	1.064	
Control Group Post- CS Test	.974	1.027	

Note. Predictors Post-CUT: Post-conceptual understanding-test, Post-M: Post-Motivation score and Post-CST: Post-Creativity skill-test

We may conclude that there is no multi-collinearity between them because the tolerance statistics values (see Tables 4, 5, and 6) are much higher than 0.2 and the variance inflation factor (VIF) value was less than 3, thus,

the research question can be examined and resolved. Additionally, the Durbin-Watson statistics are 1.885, 2.401, and 1.643. We can say that the assumption of independent residuals has been satisfied because this is near the ideal value. The requirements for the visually assisted guided discovery learning approach were met by examining all of the multiple regression analysis's assumptions.

A. Interpreting Regression analysis for Visually Assisted with Guided Discovery learning approaches group

The stepwise multiple regression procedure was used to examine the contribution of the three independent variables (CU, M and Cr predictor) to the prediction of problem solving skill for the Visually Assisted with Guided discovery learning approaches group in learning plane geometry. The results of multiple regression analysis are presented in Table 7 below.

Table 7: Multiple regression analysis with dependent variable PSS and independent variables CU, CS, and M in learning plane geometry for Visually Assisted with Guided discovery learning approaches group

Problem-solving Skills (PSS)						
Multiple R = .542				R^2 =.294		
ANOVA Table						
	Sum of Squares	Df	Mean Square	F	P	
Regression	452.987	3	150.996	3.463	.031	
Residual	1089.979	25	43.599			
Total	1542.966	28				
Variables in the Equation						
Variables	R	B	Std. Error		T	P
Conceptual Understanding (CU)	.536	3.045	.979	.532	3.109	.005
Motivation (M)	.046	1.672	3.610	.080	.463	.647
creativity (Cr)	-.123	-.126	.575	-.038	-.219	.828

As Table 7, the multiple regression analysis revealed 29.4% (R2 = .294) of the variance in problem solving skill could be accounted for by the independent variables and the contribution to be significant, while the rest of 70.6% is explained by other factors that are not in the model. That is they might be affected by another factor that affects students' ability to solve problems. In the regression table above, the value of F (3, 28) = 3.463 and P =.031<0.05 indicates that the multiple correlation R were statistically significant. That is the contributions all variables conceptual understanding, motivation and creativity skills were significantly affect problem solving skill. The contribution of each component Conceptual Understanding (CU), Motivation (M) and creativity skills (Cr) on Problem Solving Skill calculated as:

*29.4% ≈(.532 *.536+ .080*.046-.038*-.123)x100%*

29.4%≈28.52% + 0.368%+0.4674%. Accordingly, the contribution of conceptual understanding in plane geometry enhanced the problem solving skill of plane geometry by 28.52%, the contribution of motivation of plane geometry enhanced the problem solving skill of plane geometry by 0.37%, and the contribution of creativity skill of plane geometry enhanced the problem solving skill of plane geometry by 0.46%. As presented in the table, the conceptual understanding scores (CU) was the dominant significant predictor among the variables included in this study for Visually Assisted with Guided discovery learning approaches group students' problem solving skill of plane geometry.

B. Interpreting Regression analysis for Guided Discovery learning approaches group

The stepwise multiple regression procedure was used to examine the contribution of the three independent variables (CU, M and Cr predictor) to the prediction of problem solving skill for the Guided discovery learning approaches group in learning plane geometry. The results of multiple regression analysis are presented in Table 8 below.

Table 8: Multiple regression analysis with dependent variable PSS and independent variables CU, CS, and M in learning plane geometry for Guided Discovery learning approaches group

Problem-solving Skills (PSS)						
Multiple R= .479			R^2 = .229			
ANOVA Table						
	Sum of Squares	Df	Mean Square	F	P	
Regression	463.390	3	154.463	3.466	.026	
Residual	1559.841	35	44.567			
Total	2023.231	38				
Variables in the Equation						
Variables	R	B	Std. Error		T	P
Conceptual Understanding (CU)	-.308	-2.405	.992	-.377	-2.424	.021
Motivation (M)	.234	3.955	3.393	.175	1.165	.252
creativity (Cr)	-.228	-1.155	.563	-.318	-2.050	.048

As Table 8, the multiple regression analysis revealed 22.9% (R2=.229) of the variance in problem solving skill could be accounted for by the independent variables and the contribution to be significant, while the rest of 77.1% is explained by other factors that are not in the model. In the regression table above, the value of F (3, 38) = 3.47 and P =.026<0.05 indicates that the multiple correlation R were statistically significant. That is the contributions all variables conceptual understanding, motivation and creativity skills were significantly affect problem solving skill. The contribution of each component Conceptual Understanding (CU), Motivation (M) and creativity skills (Cr) on Problem Solving Skill calculated as:

22.9%≈(-.377 -.308+.175*.234-.318*-.228)x 100%*

22.9%≈11.61% +4.095% + 7.2504%. Accordingly, the contribution of conceptual understanding in plane geometry enhanced the problem solving skill of plane geometry by 11.61%, the contribution of motivation of plane geometry enhanced the problem solving skill of plane geometry by 4.09%, and the contribution of creativity skill of plane geometry enhanced the problem solving skill of plane geometry by 7.25%.

C. Interpreting Regression analysis for Conventional learning approaches group

The stepwise multiple regression procedure was used to examine the contribution of the three independent variables (CU, M and Cr predictor) to the prediction of problem solving skill for the conventional learning approach group in learning plane geometry. The results of multiple regression analysis are presented in Table 9 below.

Table 9: Multiple regression analysis with dependent variable PSS and independent variables CU, CS, and M in learning plane geometry for comparison group

Problem-solving Skills (PSS)						
Multiple R = 530			R^2 = .281			
ANOVA Table						
	Sum of Squares	Df	Mean Square	F	P	
Regression	378.995	3	126.332	3.122	.045	
Residual	971.112	24	40.463			
Total	1350.107	27				
Variables in the Equation						
Variables	R	B	Std. Error		T	P
Conceptual Understanding (CU)	-.221	-.899	1.268	-.126	-.709	.485
Motivation (M)	.510	11.207	4.034	.496	2.778	.010
creativity (Cr)	.000	.228	.464	.086	.491	.628

As Table 9, the multiple regression analysis revealed 28.1% (R2 = .281) of the variance in problem solving skill could be accounted for by the independent variables and the contribution to be significant. It explains 28.1% of

the variation in the dependent variables by the independent variables, while the rest of 71.9% is explained by other factors that are not in the model. In the regression table above, the value of F (3, 27) = 3.122 and P =.045<0.05 indicates that the multiple correlation R were statistically significant. That is the contributions all variables conceptual understanding, motivation and creativity skills were significantly affect problem solving skill. That is they all separately affect problem solving skill of the control group. The contribution of each component Conceptual Understanding (CU), Motivation (M) and creativity skills (Cr) on Problem Solving Skill calculated as:

28.1% ≈(-.126x-.221+.496x.510+.086x0.00)x100%

28.1%≈2.7846%+25.296%+0.0%. Accordingly, the contribution of conceptual understanding in plane geometry enhanced the problem solving skill of plane geometry by 2.78%, the contribution of motivation of plane geometry enhanced the problem solving skill of plane geometry by 25.29%, and the contribution of creativity of plane geometry was neither enhanced nor declined the problem solving skill of plane geometry by 0.0%.

7 Discussions

This study examined how students' conceptual understanding (CU), creativity (Cr), and motivation (M) improved their problem-solving skills (PSS) when learning plane geometry. Using the Visually Assisted Guided Discovery Based Learning (VAGDBL) model, the results showed an F-test value of 3.38 with a significant value of.031<0.05, indicating an association between conceptual understanding, creativity, and motivation on problem solving skills. This is further demonstrated by the fact that learning plane geometry improved problem-solving skills by 28.52%, 0.37%, and 0.47%, respectively, due to the contributions of conceptual understanding, motivation, and creativity. Furthermore, using the Guided Discovery Based Learning (GDBL) model, the results showed an F-test value of 3.41 with a significant value of.026<0.05, indicating an association between conceptual understanding, creative skill, and motivation on problem solving skills. This is additionally illustrated by the fact that learning plane geometry improved problem-solving skills by 11.61%, 4.09%, and 7.25%, respectively, due to conceptual understanding, motivation, and creativity. Furthermore, using the Conventional Based Learning (CBL) model, the results showed an F-test value of 4.22 with a significant value of.045 < 0.05, indicating a correlation between conceptual understanding, creative skill, and motivation on problem solving skills. This is further illustrated by the fact that learning plane geometry improved problem-solving skills by 2.78% and 25.29%, respectively, due to conceptual understanding and motivation. Nevertheless, there was no 0.0% increase or decrease in plane geometry's creative contribution to problem-solving skills. This is consistent with Al-Mutawah et al. (2019) results show that conceptual understanding and problem solving skills are positively correlated. Laily et al. (2020) also showed that there was a significant relationship between conceptual understanding and procedural knowledge to solving the problem. Further, the findings of this study imply that a VAGDL approach enhances students' creativity skill and improves their problem-solving skills for geometry problems. This finding of the study is in line with the findings of studies by Sharma (2014), Midhundas and Vijayakumari (2016) and Johny (2008) among secondary school students. Haylock (1987a) in a study on three middle school students also reported the same result. In addition, to some extent the results obtained earlier by Pehkonen (1997) and Silver (1997) without appraisal of mathematical creativity and mathematical problem-solving ability in learner, parents and teachers should not stress on them to opt out mathematics as a subject at senior secondary or higher level. Good problem solvers are also creative students who have moderate anxiety and high degree of interest in solving the mathematical problems. Ellwood et al. (2009) claimed that there is a great overlap between the literature on creativity and that on problem solving, while Plucker et al. (2004) consider creativity as an important component of problem solving. Somashekhar (1998) and Aslan (2012) found significant relationship between mathematical creativity and mathematical problem solving. Moreover, there are relationships between mathematical creativity and other concepts such as "academic ability, visualization and verbal abilities, and mathematical background" (Krutetskii & mathematics, 1969). Similarly, Tyagi (2016) suggests that significant predominant causal relationship was found between Mathematical Creativity (MC) and Mathematical Problem solving (MP). Moreover, learning motivation is usually considered to be contributing to problem solving as it influences the initiation, direction, and intensity of

cognitive processing (Baars et al., 2017). The findings of this study imply that a VAGDL approach enhances students' motivation and improves their problem-solving skills for geometry problems. This study results align with students with low motivation cannot solve the given problem because they perceive that mathematics is a difficult lesson but believe that learning more diligently can improve their abilities(Liu & Lin, 2010), and with motivation, students can solve mathematical problems (Mazana et al., 2019). This thought was also supported with some research findings of the study. Under appropriate conditions motivation may help insight problem solving and contributes to the ability to solve problems (Wieth & Burns, 2000). In increasing student learning motivation, strategies are needed in the process of learning mathematics. Motivation in learning can help students use the right strategies in applying known mathematical concepts to solve problems (Juniati & Budayasa, 2021). Likewise, motivation has a relationship with students' ability to solve problems (Cheung & Kwan, 2021). Moreover, from the connection between motivation and problem-solving skills, it can be concluded that they are positively correlated. This result is consistent with the study of Peña and Baluyos (2022), who stated that motivation predicts mathematics students' problem-solving skills. This implies that the level of motivation in mathematics among students is a determinant factor for their proficiency in mathematical problem-solving. In addition, it is consistent with the findings of Del Villar and Napawit (2018), who observed a high correlation between motivation and problem-solving of the students. This is due to their performances are the result of their accomplishments. The results, however, contradict with a study by Tran and Nguyen (2021) that found a negative correlation between students' motivation and their capacity for problem-solving. Furthermore, Liu et al. (2020) claimed that students' motivation and problem-solving abilities are negatively correlated. They stated that even if the students have high motivation in learning mathematics, it is not guaranteed that they can also get a high performance in problem-solving in mathematics. Contrary to the findings from (Baars et al., 2017; Fatimah et al., 2019), which indicate a positive relationship between motivation and problem-solving skills. Hence, the results of this study confirmed that conceptual understanding, creativity skills and motivation contribute to problem solving skills so that teachers in the learning process should facilitate students with certain lessons that can develop students' conceptual understanding, creativity skills and motivation. Such learning process will lead the students into people who have the skill to solve problems, able to make informed decisions and become independent thinkers who are ready to live in real life.

8 Limitations

The absence of existing research on the effect of visually assisted with guided discovery approach on students' conceptual understanding, creativity skill, problem solving skill and motivation in mathematics in general and in geometry in particular is one of the study's weaknesses. Additionally, there is a lack of evidence on how visually assisted with guided discovery strategy affects geometry conceptual understanding, creativity skill, problem solving skill and motivation for students who treated with visually assisted guided discovery approach compared to conventional approach.

9 Conclusions

It is clear from the results and discussions that students' problem-solving skills are significantly correlated with their conceptual understanding, motivation, and creativity. Furthermore, utilizing the visually assisted guided discovery-based learning (VAGDBL) approach, it is recognized that students' conceptual understanding contributes more to their problem-solving skills than their motivation and creativity. Based on these findings, more research should be conducted to determine how students' conceptual understanding, motivation, and creativity skills relate to their ability to solve problems across various demographics and tools. Teachers of mathematics should therefore think about using appropriate learning models to strengthen students' conceptual understanding, motivation, and creative skills. This is due to the fact that motivation, creativity, and conceptual understanding are significant indicators of successful learning.

10 Author contributions

All authors were involved in concept, design, interpretation, and critically revising the article. All authors approved the final version of the article.

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12 Data availability statement

Data generated or analyzed during this study are available from the corresponding author upon reasonable request.

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Ethical Issues

The Conjoint Faculties Research Ethics Board (CFREB) of Bahir Dar University provided ethical clearance for the study. In accordance with the research ethics guidelines endorsed by the University Senate on December 26, 2022 G.C., with reference number Math/57/2022, the Institutional Review Board of the College of Teacher Education Department of Science and Mathematics Education approved the study at the proposal stage and granted permission in accordance with the code of research ethics on humans, animals, and the environment. The researcher was assured that written consent was obtained. Further, study participant teachers' willingness to participate in the research was also solicited, and responses were collected orally. According to Bless et al. (2006), the researcher informed the participants about all of the important information they should be aware of, such as the purpose of the study, ensured of their namelessness, what they were expected to do if they agree to participate, the type of information collected, the benefits and risks associated with their participation, their rights to withdraw or discontinue their participation at any time, and what would happen to the information they provided orally in advance. An inform consent form was requested of each participant, indicating that they have fully perceived the information present to them.

Conflicts of Interest

The authors declare that they have no conflict of interest

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