

Use of GeoGebra in Geometric Construction

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Abstract: Use of ICT has become a popular tool in teaching and learning, especially for geometry teaching at the schools. The main purpose of this research was to measure the effectiveness of the use of GeoGebra in a geometric construction. For accomplishing this purpose, the researcher used pre-test post-test non-equivalent experimental method. The mathematics achievement of the students taught with the GeoGebra was significantly higher than that of the students through the traditional method ($P < 0.05$). Furthermore, a set of questionnaire based on five points Likert's scale and an interview were conducted on the experimental group to identify students' attitudes toward the use of GeoGebra on geometric construction. The results indicated that students have positive attitudes toward the use of GeoGebra in the geometric construction. Moreover, the use of GeoGebra not only increases students' achievement in geometry but also improves their creativity and visual thinking in geometric construction through active participation and enables students to work independently by up-rising their curiosity.

1. Introduction

An effective geometry teaching encompasses teaching for better understanding, teaching for better geometric construction, and reversing geometric misconceptions. However, geometry teaching in many schools still has adhered to the traditional construction (Mainali and Heck, 2015) that does not provide ample opportunities to the students in order to refine various visualization ability levels. As a result, it is realized that students still lack the cognitive and procedural understanding of the geometric construction process together with corresponding steps. Although, the teacher delivers required information and clues to assist students' better geometric construction and understanding. Therefore, the effective geometry teaching has become as a perplexed task for mathematics teachers or rather those who have been teaching there for a time in order to teach it meaningfully. In order to encourage an effective geometry teaching day to day in the classroom, a predictable flow of ICT tools and resources are mandatory elements (NCF, 2007). Thus, an effective geometry teaching is the possible by the means of ICTs particularly, GeoGebra.

GeoGebra is freeware, written in Java, and easily downloadable software from the internet for the purpose of the study of geometry, algebra, calculus at the different level. It comprises dynamic geometry and algebraic manipulation packages connecting a drawing window with an algebra window. It is useful in order to generate graphics and their visualization, test questions and mathematical games as well as mathematics-related problems together with their dynamic visibility in algebraic and geometric view. In addition, use of GeoGebra in geometry classes fosters the new discoveries and reduces the gap to learn geometric concepts and explore the relationship easily. Thus, possibilities with working GeoGebra are bottomless making the bridge between algebraic and geometric concepts.

1.1. Background of the Study

Over the last decades, the flow of information and communication technologies (ICTs) in curriculum material resources has broadened out mathematics learning in schools and universities. In fact, the ICTs have been the enabling factor in the changing pattern of mathematics education and scientific innovation, and there is now evidence of their impact on educational settings. Since integration of ICTs in mathematics lessons conveys many dimensions of learning that create endless opportunities for students to conceptualize and practice abstract mathematical ideas, to experience and negotiate diverse and unique solutions, to examine and probe answers and conjectures, to explore questions and curiosity, to generate and test hypotheses, and to construct mathematical knowledge. Many mathematics educators, education reformers, and policymakers advocate that ICT-based instruction in mathematics especially for geometry teaching is the best choice for replacing subsisting methods to a new one.

In teaching and learning geometry, an ability to construct geometric shapes, graphs, lengths and concepts are important to each learner for understanding construction of shapes with corresponding steps in order to apply them to required situation i.e. for meaningful learning and teachers for making geometry teaching effectively. To design effective instructional lesson in teaching geometry for understanding and better construction, there now is an availability of various computers

based software or ICT tools such as GeoGebra, Mathematica, Mat Lab, etc. that help the teachers and students to demystify the geometric construction and concepts dynamically and in the visualized manner. Among such software, GeoGebra is one.

An effective use of GeoGebra in classroom fosters dynamic geometry environment which is paradigm shifts in teaching (Andraphanova, 2015). One can use it for active and participatory learning and be the penetrating problem based learning in geometry. Furthermore, Moreno-Armella, Hegedus, and Kaput (2008) emphasized that mathematics teachers can use GeoGebra software in their instructional activities to explain, to explore, and to model mathematical concepts and to build connections between these concepts. Thus, use of GeoGebra in geometry teaching has become as a recent worldwide trend in mathematics education which is less or more related to policy principle of NCTM (2000) that technology is essential in teaching and learning mathematics in order to enhance student's learning.

Abiding such worldwide policy of gradual penetration of ICT tools in mathematics teaching, Government of Nepal has supposed that proper use of ICTs in mathematics may be remedial for the existing condition, the ebbing away abilities or capacities of students in constructing geometric figures, shapes and graphs with corresponding steps, by considering ICT as the principle for curriculum development (NCF, 2007) which is the enforcement of past students' national achievement on mathematics. As a consequence that the SLC result of 2073 in mathematics has more improved in those schools which have been abided by such policy practices of the use of ICT tools in Mathematics classroom than past one. However, GeoGebra yet not widely used in Nepalese education system and all ICT tools may not be effective without an appropriate pedagogical strategy in each topic of geometry. So, this study has examined the effectiveness of the use of GeoGebra in geometry teaching particularly, for geometric construction in public schools of Nepal.

1.2. Objectives of the Study

To measure the effectiveness of the use of GeoGebra on students' achievement in geometric construction at the secondary level was the primary objective of this study. Further, this objective has precisely stated in the following behavioral form:

- To compare the achievement of students taught by using GeoGebra and traditional approach.
- To explore students' attitudes toward the use of GeoGebra in a geometric construction.

1.3. Research Questions

- How does experimental group differ from the control group in terms of mean achievement for students at secondary level geometry?
- To what extent is GeoGebra software effective to teach geometric construction, especially connecting it with constructing process or not?
- What are students' attitudes toward creativity through GeoGebra?
- What are students' attitudes toward curiosity with GeoGebra?
- What are students' attitudes toward independence through GeoGebra?
- What are students' attitudes toward visual thinking through GeoGebra?

2. Review of Related Literature

2.1. Empirical Review

Throughout this paper, three key terms are in the focus: geometric construction, use of GeoGebra, and students' attitudes which are discussed below:

An effective teaching geometry comprises three key aspects, namely teaching for better understanding, better geometric construction and reversing geometric misconceptions, and better geometric construction is most important among them because of the remaining two accounted on its periphery. In ancient time, Construction of geometric shapes and lengths were confined to the use of Euclidean tools and in the case of Plato, compass only. Nowadays geometric construction has become relatively easy due to the availability of the dynamic geometry software such GeoGebra which provides the virtual platform for the construction of geometric shapes together with corresponding steps.

Use of dynamic software GeoGebra in geometric construction provides boundless opportunities to the students to observe the construction process of geometric shapes, dynamically. Because GeoGebra provides students in various visualization ability levels to learn geometric concepts and to explore relationship easily (Ayub, Saha, and Tarmizi, 2010). Furthermore, GeoGebra and students' attitudes toward learning are related to each other (Gomez-Chacon, 2011). Thus, use of GeoGebra in geometric construction helps students to change their both types of attitudes, attitudes about learning atmosphere and attitudes about classroom tasks, toward the construction process.

Attitude is defined as the tendency to respond positively or negatively toward certain situation based on an individual's choice of action and set of

stimulus. Erdemir (2009) stated that the students' attitude and methods of instruction, and attitude and achievement are correlated. It means that students' learning and classroom setting or classroom learning strategy which is going to be applied influences students' attitudes. Students' attitudes toward subject matter and classroom setting influence students' achievement. Thus, the effect of the use of the GeoGebra on students' achievement and attitudes toward geometric construction is incredibly important under the modified frame of constructivism learning.

Despite aforementioned vantage points, there are several reasons that support the effectiveness of GeoGebra in the geometry lessons in terms of students' achievement. In this regard, use of GeoGebra in geometric construction is beneficial to students and teachers. Therefore, relevant empirical pieces of literature have reviewed as below:

Bhandari (2015) conducted a study entitled "Effectiveness of GeoGebra assisted Instruction in Mathematics at secondary level" in order to find out the effectiveness of GeoGebra on secondary level students' achievement Reflection and Rotation. The data were collected from 48 students from two public schools in Kathmandu using quasi-experimental design by the way of test items and questionnaires. The reliability of these tools was ensured through Split-half method. The result shows that GeoGebra assisted instruction improves the students' achievement in mathematics in the comparison of subsisting pedagogy.

Bhagat and Chang (2015) carried out a study entitled on "Incorporating GeoGebra in Geometry learning: A lesson from India" using a quasi-experimental design of research to examine the effectiveness using GeoGebra as a tool in teaching and learning mathematics. Their finding indicates that use of GeoGebra has the positive impact on students' achievement. Moreover, Dogan and Icel (2011) underscored that GeoGebra as a valuable tool for motivating students toward their geometry learning and retaining knowledge for a longer time. And they added that GeoGebra can be used for enhancing higher order thinking skills.

Shadaan and Eu (2013) conducted a study entitled "Effectiveness of use of GeoGebra on students understanding in learning circles in order to investigate the effectiveness of using GeoGebra on students' understanding circles, students' perceptions about GeoGebra in the learning circles. A quasi-experimental design with pre-test and post-test had been completed to control and experimental group considering year nine students in Selangor. Their finding indicates that use GeoGebra in learning circles has the positive impact on students understanding. This study established GeoGebra as an effective tool for teaching circles focusing students' understanding. Furthermore, technology

has become a motivational tool in learning circles. Thus, use of GeoGebra in geometric construction may be beneficial to both students and teachers for better geometric construction.

Gomez-Chacon (2011) conducted a study entitled "Mathematics attitudes in computerized environments" to determine the relationship between computerized environment regarding GeoGebra as integrating software and students' attitudes toward mathematics. And that study was completed into two parts: the first part was survey and second was the case study. The data were collected from 15- and 16-years old 392 students (207 boys and 185 girls) using questionnaires. The reliability of questionnaires was calculated by Cronbach's Alpha. The result reveals that attitudes toward mathematics and technology have scanty related.

Mousoulides (2011) has made a conclusion based on his research about "the modeling approach to GeoGebra-integrated problem-solving in the middle grades" where GeoGebra is employed as a conceptual tool to help students make connections between real world situations and mathematical ideas. One class of 21 fourteen-year-olds and their mathematics teacher worked on the two modeling problems as part of a two-year longitudinal study, which focuses on exploring students' development of models and processes and students' interaction with technological tools in working with engineering modeling problems. The students were from a public K-12 middle school in the urban area of a major city in Cyprus. As a conclusion, results of that research show that students constructed sophisticated dynamic models, which broadened their mathematical exploration and visualization skills.

Iranzo and Fortuny (2011) conducted a multiple case study entitled "influence of GeoGebra on problem-solving strategy" to explore the influence of using GeoGebra (conceptual understanding, visualization and resolution strategies) on each type of students, characterize resolution strategy, and analyze instrumentation and instrumentalization processes to characterize resolution strategies. The data were collected considering 10th grade twelve students from a high school in Catalonia. Their research findings of the 'influence of GeoGebra use secondary level students' problem-solving strategies in plane geometry indicates that the use of GeoGebra influenced students' resolution strategies, but this influence depended on the given tasks and the type of students. The result of that research indicated that use of GeoGebra helped students to construct multiple representations of geometrical concepts and they further underscored that GeoGebra helped students avoid algebraic obstacles to focus on geometrical understanding. In addition, they identified three levels of instrumentalization and instrumentation for proper use of GeoGebra in the classroom with reference to GeoGebra tools.

Lingefjård (2011) explores the prospect of revitalizing Euclidean geometry in school mathematics in Sweden and internationally by taking advantage of GeoGebra resources. Perceptions toward teaching and learning mathematics have been changed with the open sources of GeoGebra over the past decades. It is likely that the open accessibility and the dynamic nature of GeoGebra may contribute to or initiate a similarly profound evolution of school mathematics and its classroom practice.

From review of these literatures, it seems clear that much research has focused on determining effectiveness of GeoGebra on students' achievement regarding a specific content of geometry (Bhandari, 2015; Bhagat & Chang, 2015; Ayub et al. 2010; Shadaan & Eu, 2013) but there is still gap that whether GeoGebra helps to foster teaching geometry for better construction together with subsequent steps to learn basic concepts related to constructed figures. While many researchers accentuate that use of GeoGebra in geometry lesson fosters motivation toward learning environment (Shadaan & Eu, 2013; Bhandari, 2015) however Gomez- Change (2011) embedded that use of GeoGebra in Geometry lessons improves students' attitudes toward classroom tasks and learning environment. Insofar as it is pointed out that GeoGebra discovers the resolution strategy of the problems through geometrical modeling and students' perception about the use of GeoGebra in geometry lessons is positive. Thus, use of GeoGebra in geometric construction is necessary for underscoring teaching geometry for better construction and understanding.

1.4. Theoretical Framework

This study was based on the constructivist approach to learning. According to this theory "learning is an active process in which learners construct and internalize new concepts, ideas, and knowledge based on their present and past knowledge and experiences" (Cohen, Manion, & Morrison, 2013, p. 167). In addition, this theory emphasizes that knowledge is constructed by learners rather than received (Crowther, 1997). There are especially two types of constructivism: cognitive and social constructivism. But Cohen et al. (2013) avowed that both of them share common characteristics such as knowledge are constructed through reflective abstraction, through learner's cognitive structure and processing, through active and participative learning, and through recognition. Insofar as such learning is not fixed and inert, but continually developing. The impact of constructivist theorists' work in contemporary mathematics is seen as vivid since constructivism and its numerous versions have been taken by mathematics teachers in the classroom, curriculum writers in the curriculum, and researchers in their research setting.

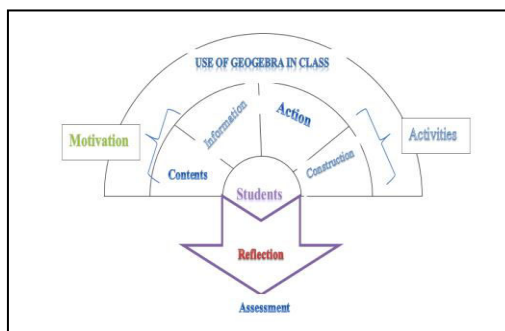
Jorgensen and Dole (2011, pp. 23-24) have emphasized that there are a number of different forms of constructivism, but underpinning all versions are three premises. First, knowledge is actively constructed by students rather than being passively received. It means that students in learning mathematics should have actively participated in learning activities for constructing new knowledge based on his present experiences. Second, mathematical knowledge is created by students as they reflect on their physical and mental actions. By observing relationships, identifying patterns and making abstractions and generations, students come to integrate new knowledge into their existing mathematical schemas. Third, learning mathematics is a social process where, through dialogue and interaction, students come to construct more refined mathematical knowledge. Through engaging in the physical and social aspects of mathematics, students come to construct more robust understandings of mathematical concepts and processes through processes of negotiation, explanation, and justification

In addition, they stated that it recognizes that mathematics must make sense to students if they are to retain and learn mathematics. For students to develop the appropriate knowledge they must be provided with rich learning experience so that their constructed meanings and understandings are in keeping with the discipline of mathematics. From this, it is concluded that learner constructs the meaning of mathematics based on individual cognitive structure and process through interaction. And in this study, learning in Geogebra based instruction is defined in terms of three characteristics: Action, Construction, and Reflection. Behind the reason of selecting constructivism as theoretical grounds of this study is that in GeoGebra based instruction, learners construct the meaning of the geometric shapes or concepts for making 'learning geometry for understanding and better easier'.

2.3. Conceptual Framework

The student is a center point of the learning process in GeoGebra based instruction because the use of GeoGebra in the geometric construction gives a chance to each individual student to internalize the new knowledge and experience. Each of the scenarios had been completed into five terms contents, information, action, construction, and Reflection.

Figure 2.3.
The Conceptual Framework



The above framework demonstrates that GeoGebra can be used in each phase of learning such as in motivation, activities as well as reflection. In fact, there is no hard and fast rule to abide these phases. However, for simplicity, in the initial phase contents are presented and students are encouraged to engage to recall individually structured information, previous experiences, and concepts related to the contents and then GeoGebra software was used for the purpose of demystifying the concepts. In an action, students perform at least one actionable activity such as construction, recalling the subsequent steps. Finally, students reached to the construction of new knowledge or meanings.

Presentation of contents and recalling preliminary information are connected with the motivation and motivational factors of GeoGebra based instruction whereas Action and Construction are connected by the activities and interactions. Learning cycle is recycled through Reflection and Performance-based assessment.

3. Methodology

3.1. Design and Sample of the Study

The research was conducted based on pre- and post-test non-equivalent experimental design which is presented in the following table:

Table 3.1.
Design of the Study

Control Group	Pre-test	No Treatment	Post-test
Experimental Group	Pre-test	Experimental Treatment	Post-test

This study was conducted within Kirtipur Municipality, especially regarding two mathematics classes of two public schools. In addition, the sample for this study comprised non-equivalent students on two groups. One was supposed as control which comprised sixteen students and next as experimental which comprised thirty students.

3.2. Data Collection Tools

In this study quantitative and qualitative both types of data collection tools were used. In order to collect relevant quantitative and qualitative data, the following data collection tools were used:

3.2.1. Test Items. A set of test item was used to measure the effect of Geogebra on students' achievement in geometric construction. The researcher developed two types of test items subjective and objective from geometric construction with the help of a subject expert. The objective type questions (only ten questions, after ensuring validity and reliability of the test items) were used to identify students' factual knowledge and information whereas, the subjective type questions (only ten questions, after ensuring validity and reliability of the test items) were used to explore students' comprehension skills, analyzing skills, and its application. Thus, mathematics achievement test (same test items used twice) containing were used as a source for the data collection tools.

3.2.2. Likert's Scale. The researcher had administered five points Likert's scale in order to find out the students attitudes toward learning geometric construction with GeoGebra. For this study, the researcher modified mathematical attitudes scale named students attitude scale (SAS) which was used by Gomez-Chacon (2011) in his study. After ensuring the validity and reliability of questionnaire, its dimensions and number of items from each dimension are presented in the following table:

Table 3.2.2.
Distribution of items across the selected dimensions of SAS

Dimensions	Creativity	Curiosity	Independence	Visual thinking
Number of Items	3	5	5	6

3.2.3. Interview. After administration of the questionnaire, the researcher carried out a semi-structured interview selecting only ten students to identify their attitudes regarding creativity, curiosity, independence, and visual thinking dimension of SAS. During the interview session, the researcher asked exact questions to capture students' belief and thinking about the use of GeoGebra in their classroom to account for their action.

3.3. Validity and Reliability of the Tools.

3.3.1. Test items. The researcher had developed a set of thirty mathematics test items (fifteen objective and fifteen subjective) in reference with Educational Taxonomy and Grid list of grade nine. The set of test

items was administered to a group of grade nine students at Janbikash Higher secondary school, Balkhu, that were not included in the sample of the study in order to test the reliability of each item. Items were analyzed in terms of difficulty level and discrimination index, and then moderate difficulty level items were selected. The reliability coefficient of a set of test items was tested by performing a Cronbach's alpha reliability using SPSS 21.0 statistical software. The reliability coefficient of the overall test was 0.91 using alpha model. And the content validity of the test items was accounted by the experts' judgment.

3.3.2. Likert's Scale. The researcher had a modified students attitude scale (SAS) used by Gomez-Chacon (2011) reducing its dimensions. A questionnaire consisting 30 items that appertain to the dimensions of SAS had been developed for the purpose of the pilot test. The pilot test was administered at Jan Sewa Secondary school, Panga, where the students had experience about the GeoGebra in their geometry class but not included in the sample. The reliability, Cronbach's alpha analysis model, of the questionnaire, was calculated by using SPSS 21.0 statistical software. The set of questionnaires received overall Cronbach's alpha = 0.86. The validity of SAS was ensured by the curriculum, textbook, previous test items, and the expert judgment.

3.3.3. Interview. The reliability of the semi-structured interview was piloted at Jan Sewa Secondary School, Panga, where students had experience about the GeoGebra in their Geometry lessons but not included in the sample and validity was ensured by the expert judgment.

3.4. Data Collection and Analysis process

The researcher granted permission from the Head of the Schools and Subject teachers to conduct an experiment. Before starting the experiment, students of both groups were assessed in terms of mathematics achievement test for the purpose of identifying knowledge level of participants of the groups. Then the results of pre-test were analyzed, quantitatively. The experimental group had received regular treatment of GeoGebra in the geometric construction lessons for one and half month and control group did not receive such treatment. During the classroom experiment, students were working with a combination of paper/pencil and GeoGebra based problems of geometric construction. After classroom experiment, students in both groups were again assessed in terms of same mathematics achievement test for the purpose of determining their progress. Results of the post-test were analyzed

quantitatively. Finally, the researcher administrated a set of questionnaires based on five points Likert's scale consisting nineteen items across the selected dimensions of SAS on the experimental group to explore their attitudes toward the use of GeoGebra in the geometric construction. The questionnaire was distributed to thirty students but only twenty-eight students returned the questionnaire. Then, an interview was conducted with the students from the experimental group. In the interviews, the researcher asked students to answer a question related to their attitudes about the role of GeoGebra on geometric construction regarding creativity, curiosity, independence and visual thinking.

The scores of the mathematics achievement test were analyzed using inferential statistics. More specifically, the t-test was carried out performing Statistical Package for Social Science (SPSS) version 21.0 software setting at 0.05 confidence level. After collecting the questionnaire, it had reduced in terms of Agree (strongly agree, agree) and Disagree (strongly disagree, disagree), but discarding Neutral, categories for the purpose of analysis. The questionnaire data were analyzed using descriptive statistics only. And, interview data were analyzed through the thematic approach of analysis in which theme of each individual's response had coded for generating final theme.

4. Results and Discussion

The results of this study are presented in this section according to the research question:

4.1. Comparison of students' achievement

4.1.1. Comparison of achievement score of control to experimental groups in pre-test. Mathematics achievement test comprising twenty items was administered in both experimental and control groups to identify the student learning level of the research course and to compare the starting point of post-test.

Table 4.1.1.
Results of Independent t-test on pre-test

Groups	Mean	SD	t	Significance (2-tailed)
Experimental (n = 30)	16.30	4.64	-0.553	0.583
Control (n = 16)	17.09	4.62		

t- value significant at $p < 0.05$., SD = standard deviation

An independent-sample t-test was used to compare the students' mean achievement scores for control and experimental groups. The above table reveals that, there was no significant difference in scores for control group students (mean = 17.09, SD = 4.62) and experimental students (mean = 16.30, SD

= 4.64) in the pre- test. The magnitude of the differences in the means was very small (eta squared = 0.006). This result demonstrated that students in control and experimental group were homogenous in terms of their achievement or rather their similar abilities.

4.1.2. Comparison of achievement score of control to experimental groups in post-test. After lessoning the experimental group with the use of GeoGebra, control and experimental groups were again assessed in terms of post-test containing slightly different items than pre-test.

Table 4.1.2.
Results of Independent t-test on post-test

Groups	Mean	SD	t	Significance (2-tailed)
Experimental (n = 30)	29.48	6.18	4.425	0.000
Control (n = 16)	20.25	7.70		

t-value significant at $p < 0.05$., SD = standard deviation.

An independent-samples t-test was carried out to compare students' achievement scores for control and experimental groups. The above table exhibits that there was a statistically significant increase in post-test scores for experimental group students (mean = 29.48, SD = 6.18) and experimental students (mean = 20.25, SD = 7.70, $p < 0.05$). The Eta squared statistics of experimental group and control group were 0.8581 and 0.3466 respectively. In fact, 85.81% magnitude of the effect on experimental group students' achievement was explained by GeoGebra whereas; only 34.66% magnitude of the effect was explained by traditional approach on the achievement of control group students.

4.2. Students' attitudes toward the use of GeoGebra in geometric construction

4.2.1. Creativity. Creativity is a skill that can be developed by using the current state of knowledge, experiences and mastering way of thinking. In this study, creativity dimension of SAS has consisted only three items.

Table 4.2.1.
Students' attitudes in Creativity dimension of SAS

SN	Items	Agree%	Disagree%	Results
1	It helped me to invent new construction strategy.	100	0	Positive
2	I can think creatively and critically when using GeoGebra.	88.46	0	Positive
3	It did not explore a new	7.7	84.61	Positive

strategy for constructing geometric shapes.			
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The above table reveals that students, about 91% of them gave positive attitudes toward GeoGebra regarding creativity. Almost all students, about 100%, mentioned that GeoGebra helped them to invent new construction strategy and to learn basic ideas allied to constructed figure better through GeoGebra, while the majority of the students, about 88.46% of them, said that they could think creatively and critically together with GeoGebra.

The researcher asked respondents: *How do you believe that GeoGebra improves your construction strategy?* The students explained that: *we had the opportunity to think creatively and critically because as an example, we used to create angles in construction as a rigid motion but through GeoGebra, it was flexible, which is new for us. In addition, it was dynamic so that we hadn't lost steps of construction throughout the construction that has made us construct easily, even in our test.*

According to constructivism, creativity is not the only repetition of ideas because it involves critical thinking and active participation. The case of respondents, GeoGebra helped them to think critically and creatively for better understanding. Furthermore, use of GeoGebra has successfully changed their rigid construction process into flexibility. Jianzeng et al. (1997) indicated that the systematic training on the components of creativity such as fluency, flexibility, originality, and elaboration has led to creative thinking (as cited in Masek & Yamin, 2010) and systematic use of GeoGebra in geometric construction may equip students with this competency. It means that use of GeoGebra fosters students' creativity step by step through active participation. Thus, GeoGebra provides an opportunity to each individual for unlocking the creativity which is a key element of constructivism learning.

4.2.2. Curiosity. Curiosity is defined as the desire for knowledge which is central to motivation. In this study, curiosity dimension of SAS has consisted five items to identify students' attitudes toward the use of GeoGebra in geometric construction for up-rising their curiosity.

Table 4.2.2.
Students' attitudes in Curiosity dimension of SAS

SN	Items	Agree%	Disagree%	Results
1	The dynamic platform of geometric construction was interesting.	92	0	Positive
2	It was boring to construct new	7.69	88.46	Positive

	geometric concepts and shapes using GeoGebra.			
3	It helped me to learn basic ideas better through GeoGebra.	100	0	Positive
4	I would like to learn more geometric concepts using GeoGebra.	96.15	3.84	positive
5	The use of GeoGebra in geometric construction excited me.	96.15	3.84	Positive

The above table shows that students, about 94.61% of them, gave positive attitudes toward the use of GeoGebra regarding curiosity. Almost all students, about 100%, mentioned that GeoGebra helped them to learn basic ideas better, while the majority of the students, about 96.15% of them, said that they would like to learn more geometric concept through GeoGebra that excited them.

The researcher asked respondents: *To what extent did you think GeoGebra has aroused your curiosity?* The respondents: *Completely, GeoGebra had reconstructed our basic ideas, concepts and knowledge related to constructed figure better which motivated us to solve geometrical problems and their application in theorem proving and others. Moreover, we would like to learn more geometry through GeoGebra because the dynamic platform of GeoGebra was very interesting for better understanding.*

Curiosity is evoked by mutually unusual experiences and when students were actively participated in resolving the inconsistencies, it was observed that students have their curiosity aroused (Palmer, 2005). The use of GeoGebra helped students to reconstruct their existing state of knowledge and enforces them to engage in inquiry-based activities such as searching application of construction. And Cohen et al. (2013) described that constructivism learning as the search for meaning, looking for the whole as well as part considering curiosity and inquiry as important principles. It added that use of GeoGebra up-rises students' curiosity under constructivism frame of learning. And, GeoGebra has become as a motivational force and an important motivational tool in geometry learning (Eu & Sadaan, 2013) for motivating students.

4.2.3. Independence. Independence refers to an ability to think and work out with implications for reaching solutions. It encourages curiosity,

motivation, inspiration, discernment, critical thinking and persistent. Thus, it does not refer to work in the absence of specific direction. In this study, independence dimension of SAS consists five items to identify students' attitudes toward the use of GeoGebra in geometric construction for improving independence.

Table 4.2.3.
Students' attitudes in Independence dimension of SAS

SN	Items	Agree%	Disagree %	Results
1	I can do what the GeoGebra can do equally as well.	88.46	0	Positive
2	GeoGebra helped me improve myself in constructing geometric shapes, meaningfully.	80.76	11.53	Positive
3	GeoGebra helped me to construct systematically due to the visualization of subsequent steps.	96.15	0	Positive
4	I interacted with my group mates or the teacher during the lessons.	92.3	0	Positive
5	I needed much time to learn geometric concepts by using GeoGebra.	26.92	57.69	Positive

The above table demonstrates that students, about 83% of them, gave positive attitudes toward the use of GeoGebra regarding independence. The majority of the students, about 96.15% of them, mentioned that GeoGebra had helped them to construct systematically due to visualization of subsequent steps.

The researcher asked respondents: *Did GeoGebra have helped your construction strategy to work independently after using it and how?* The respondents explained: *Sure, we argued that we took only one or two days in order to accustom with it. However, we consent that we have improved our geometric construction together with corresponding steps through GeoGebra. Since GeoGebra develops invaluable confidence and self-motivation that has enabled us to utilize our skills to solve situational problems.*

Independence in learning is all about students seizing available opportunities and time to think, plan and work properly in intended ways. Use of GeoGebra in geometric construction promotes independent, self-regulated learning and active learning that are key characteristics of cognitive

constructivism teaching (Cohen et al., 2013). In the case of respondents, GeoGebra helped them to develop invaluable confidence and self-motivation that unlock students’ potential. Moreover, GeoGebra enabled them to utilize their independent skills and knowledge to solve new problems. Thus, systematic use of the GeoGebra may equip students with such competency under the setting of constructivism learning.

4.2.4. Visual Thinking. Visual thinking is higher order thinking skills for learning geometric construction, meaningfully. It helps students to distinguish one concept to another. In this study, visual thinking dimension of SAS has consisted six items.

Table 4.2.4.
Students’ attitudes in Visual Thinking dimension of SAS

S N	Items	Agree %	Disagree %	Results
1	It was valuable to construct geometric shapes together with corresponding steps.	88.46	3.84	Positive
2	GeoGebra provided visual interpretation of geometric construction.	88.46	11.53	Positive
3	GeoGebra does not show the relationship between drawing or graphics with algebraic elements	42.30	19.23	Negative
4	Visualization of geometric construction helped me to construct single figure in more than one way	73.07	0	Positive
5	GeoGebra encouraged me to participate in classroom activity	80.76	3.84	positive
6	GeoGebra helped me easily to understand geometric construction.	92.3	0	positive

The above table shows that students, about 73.71% of them, gave positive attitudes toward the use of GeoGebra regarding visual thinking. The majority of the students, about 92.3% of them, mentioned that GeoGebra had helped them easily to learn basic ideas better, while the majority of the students, about 88.46% of them, considered

GeoGebra as a valuable tool for constructing geometric shapes and figures together with corresponding steps clearly.

The researcher asked respondents: *Did GeoGebra have changed your visual thinking regarding construction of geometric shapes and figures?* The students answered: *Why not, it has made us able to construct one single figure in more than one method because it reconstructed what we had already known and figured out what we did not, for instance; we used to take base angles of an isosceles triangle were only 60° or 70° so we were confused about its construction. But the use of GeoGebra has demystified such concept which has helped us to construct our own construction. And GeoGebra helped us to understand geometric construction easily, and we were satisfied with it— like square became exactly square, not a rectangle.*

Students were able to differentiate between drawings or geometric object, which is the cue for visual thinking under the designed conceptual framework, to transfer it to the required sector and to learn more complex subject matters. It means that GeoGebra enables students to use existing cognitive and visual skills to develop efficiency, experiences, autonomy and hence confidence in their construction. Furthermore, Dikovic (2009) stated that use of GeoGebra helps students make the connection between visual and symbolic representations by visualizing the adequate process. And the case of respondents, the use of GeoGebra successfully improved their visual thinking that is higher order thinking skill.

5. Findings

- There was not a significant difference between mean achievement of the control group and experimental group in the pre-test.
- The mean achievement of experimental group students was higher than the control group students in the post-test.
- The use of GeoGebra has become effective strategy than traditional approach in order to teach geometric construction because 85.81% magnitude of effect on students’ achievement in the experimental group has been explained by the use of GeoGebra.
- GeoGebra has provided an opportunity to each individual for unlocking creativity step by step through active participation which is a key element of constructivism learning.
- GeoGebra helped students to reconstruct their existing state of knowledge and enforces them to engage in inquiry based activities such as searching application of construction.

- The use of GeoGebra promoted an independent and self-regulated learning that enables students to develop invaluable confidence for unlocking their potentials.
- The use of GeoGebra in geometric construction helped students to embed geometric concept more visual, and understandable.

6. Conclusion

The use of GeoGebra in geometric construction has proven best strategy in geometry teaching for better construction and better understanding than traditional approach in the context of Nepal. The use of GeoGebra not only increases students' scores in geometric construction but also helps students to become more creative, independence as well as to improve their visual thinking. Moreover, the use of GeoGebra in mathematics provides an ample opportunity to each individual for unlocking creativity step by step through active participation. And it up-rises students' curiosity because GeoGebra helps students to reconstruct their existing state of knowledge and enforces them to engage in inquiry-based activities such as searching application of construction. Furthermore, the use of GeoGebra in geometry lesson enables students to use existing cognitive and visual skills to develop efficiency, experiences, autonomy and hence confidence in their construction. Thus, it is necessary to penetrate use of GeoGebra gradually into secondary level school geometry for the purpose of eradicating educational waste in learning and teaching of mathematics.

It is affirmed that GeoGebra helps students to construct geometric figures and concepts systematically owing to its visualization of subsequent steps. In addition, the use of GeoGebra exhorts the approachable interaction between students- students and teacher- students, during the learning scenarios. This supports the findings of Sadaan and Eu (2013). Moreover, this study also underscores that GeoGebra provides a cognitive and procedural understanding of the geometric construction through visualizing corresponding steps. Therefore, the use of GeoGebra in the geometry is necessary for teaching geometry for better construction and better understanding.

Acknowledgement

I would like to thank my supervisors, Mr. Bed Prasad Dhakal and Mr. Abatar Subedi for taking time to understand my ideas.

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