THE EFFECTIVENESS OF GUIDED INQUIRY-BASED LEARNING STRATEGY ON LEARNING PHYSICAL AND CHEMICAL CHANGES

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ABSTRACT

The purpose of this study was to investigate the effectiveness of guided inquiry-based learning strategy over traditional teaching method in improving grade seven students' learning about physical and chemical change concepts. The participants, N=55 (28 males and 27 females), were seventh grade Sadasa elementary school students in Kemissie town of Amhara regional state, Ethiopia. Quasi-experimental nonequivalent pretest-posttest design was used. Two classes (groups) from the school were randomly selected from four available classes (groups). The experimental and control group was assigned after their pretest was analyzed. The experimental group was taught by guided inquiry-based learning strategy while the control group was taught by traditional teaching method. Open ended questions related to physical and chemical changes were administered as pre- and post-tests to students in both groups. Furthermore, structured interview was conducted to students in the experimental group at the end of the study in order to get students' attitudes about guided inquiry-based learning strategy. The pretest and posttest data were analyzed by using independent samples t-test and paired samples t-test. The students' interview about guided inquiry-based learning strategy was transcribed and then analyzed. Independent samples t-test revealed that experimental and control groups were scored almost similar before the intervention. After the interventions, independent samples t-test and paired samples t-test analysis indicated that students in the experimental group scored significantly higher than in control group. Thus, guided inquiry-based learning strategy was more effective to improve student's achievements in physical and chemical changes concepts than traditional teaching method. Thematic analysis indicated that students in the experimental group demonstrated high level of interest and positive attitudes toward the guided inquiry-based learning. *[African Journal of Chemical Education—AJCE 12(2), July 2022]*

INTRODUCTION

Chemistry is the study of the structure, properties, and uses of matter. Chemistry plays important roles in everyday life. Despite its importance, many factors make chemistry difficult to learn. Among the factors affecting the students' learning of chemistry are teacher-centered method of teaching and the abstract concepts of chemistry [39]**.** Most Chemistry concepts have proved to be difficult for students. In particular, the concept of physical and chemical changes considered difficult for students. [61] explored students' difficulties in physical and chemical changes. Students have different conceptions on the topic of physical and chemical changes. For example, [23] identified few of students had scientific conceptions and most of them had partial conceptions and alternative conceptions.

Researchers criticize that teacher-centered approach of teaching is ineffective in comparison to inquiry-based learning [1]. For this reason, teachers need to design appropriate instructional approaches to overcome students' misconceptions related to physical and chemical changes. Effective strategies for some topics in chemistry include inquiry-based learning. Research findings show that inquiry-based learning was more effective in enhancing students understanding of electrochemistry [54][57][50] chemical reaction rate [56] acid-base [55] chemical equilibrium [49]. Additionally, simulations have been shown to increase students' achievements [53]. Studies on the topic of physical and chemical changes showed that using word association test was more effective in revealing students' cognitive structure and their misconceptions [62]. Results from experimental

studies on the topic of physical and chemical changes identified teaching students with animation enhanced worksheet-based instruction was more effective in enhancing students' understanding and overcoming alternative conceptions than traditional way of teaching [32].

Multimedia-based instruction improved students' understanding of particulate representation related to chemical change [4]. Furthermore, experimental studies on the topic of physical and chemical changes reported that utilizing student centered teaching method was more effective in improving students' understanding of these topics than using traditional teaching method. For instance, teaching this topic through jigsaw cooperative teaching [59], science writing heuristic approach [31], storylines embedded within context-based learning approach [17] improved their understandings.[19][51] showed that guided inquiry-based learning improved students' achievements and understanding. Physical and chemical changes require critical thinking of students rather than memorizing. Inquiry based learning possess more advantage over traditional teaching method. For instance, [43] reported that process oriented guided inquiry-based learning enhanced six grade Southern Turkish students' achievement in the "particulate nature of matter concept and density concept." However, there was no difference in the achievement between experimental group who taught through process oriented guided inquiry-based learning pedagogy and control group who taught through teacher centered whole-class instruction related to "physical and chemical change concept." But what is not yet clear is the effectiveness of guided inquiry-based learning on the achievement of students related to physical and chemical changes. Therefore, the purpose of this

study was to investigate the effectiveness of guided inquiry-based learning over traditional teaching method in enhancing seventh grade students' achievement related to the conceptualization of physical and chemical changes, which are not yet common in Ethiopian schools.

Statement of the Problem

Many of the students were not able to distinguish physical change from chemical changes [29]. For example, a lot of students had misconceptions because they "treated chemical changes such as rusting as physical changes in form or state" [25], "The candle wax in a burning candle is not burning, but only melting"[10] as cited in [45], and "Terms such as *evaporation* and *burning* can be used interchangeably when describing burning alcohol" and "Phrases such as chemical change and physical change can be used interchangeably when describing burning things"[12] as cited in [45]. Students have different conceptions on the topic of physical and chemical changes. For instance, [23] asked students from first year senior high school in Ghana to explain the concept of physical changes. Their responses indicated that 32% of the students were able to explain aligned to scientific consensus, 32% of them had partial conception and 36% of them had alternative conception. Similarly, students explained the concept of chemical changes.

The result showed that 32%, 38% and 30% had sound conception, partial conception, and alternative conception respectively. This demonstrated student had high partial conceptions and alternative conceptions regarding physical and chemical changes. [61] explored students' difficulties in physical and chemical changes. Many of the students had low achievements in chemistry in Sadasa elementary school. However, understanding the concepts of physical and chemical changes is important in everyday life because matter change in everyday life. Inadequate understanding of these concepts make failing to know the changes happens in matter. For this reason, more research is required to overcome students' difficulties and misconceptions related to physical and chemical changes. Therefore, this study, tried to fill this gap by forwarding the following leading research questions.

Research Questions

1. Is there a statistically significant difference between the mean scores of the experimental and control group on pretest achievement?
2. Is there a statistically significant difference between the mean scores of the experimental and control group on posttest achievement when guided inquiry-based learning strategy and traditional teaching method is used related to physical and chemical changes?
3. Is there a statistically significant difference between the mean scores of pretest and posttest for both experimental and control group?

4. What attitudes are developed on the parts of the seventh-grade students about guided inquiry-based learning strategy after they learned physical and chemical changes within this method?

General Objectives of the Study

The general objective of this study was to know if there is any difference in students' achievement when the physical and chemical changes concepts of chemistry are taught using the guided inquiry-based learning strategy and when taught using the traditional teaching methods at the Sadasa grade seven elementary school in Kemissie in Ethiopia.

Specific Objectives of the Study

1. To compare the relationship between the mean score of experimental and control group on pretest achievement.
2. To investigate the effectiveness of guided inquiry-based learning strategy over traditional teaching method in improving seventh grade students' achievement related to physical and chemical changes.
3. To compare the relationship between the mean scores of pre-test and posttest for both experimental and control group to check the significance difference between the two performances.
4. To explore students' attitudes about guided inquiry-based learning strategy after they learned physical and chemical changes within this approach of teaching.

THEORETICAL FRAMEWORK OF THE STUDY

The theory used in this study was the Bybee 5E learning cycle model [14] which is an inquiry-based learning approach. The 5E learning cycle model sequences learning experiences so that students can construct their understanding of a concept during the teaching and learning process [14]. The model leads students through five phases of learning that are easily described using words that begin with the letter E: Engagement, Exploration, Explanation, Elaboration, and Evaluation. Bybee's 5E learning cycle model is represented in Figure 1.

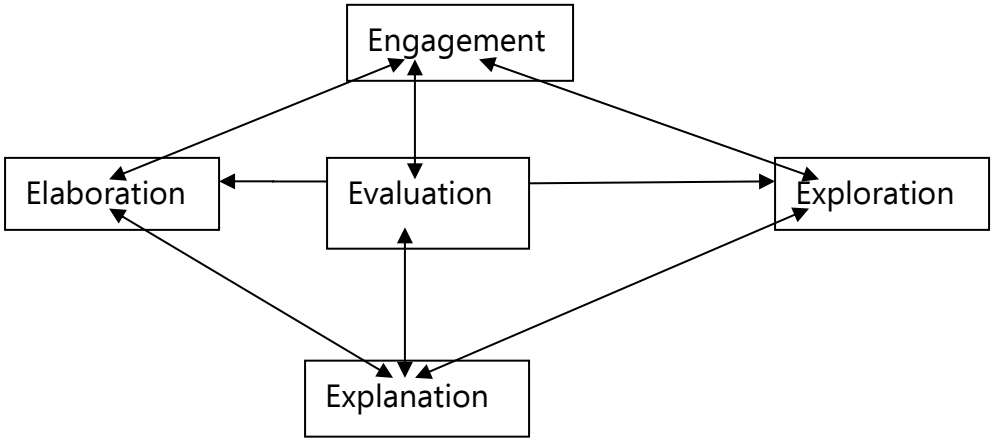

Figure 1: Bybee 5E learning cycle model

Inquiry Based Learning

"A definition of inquiry-based learning is not clear-cut" [40]. Inquiry learning 'refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world' [35]. National research council

describes inquiry as ‘a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanations and predictions; and communicating results’ [2].

> **“**Other definitions encompass processes, such as using investigative skills; actively seeking answers to questions about specific science concepts; and developing students’ ability to engage, explore, consolidate, and assess information’’[16].

> “Students engaged in simple inquiry engage in processes such as observing, comparing, contrasting, and hypothesizing. Students engaged in full inquiry use these skills in the context of well-structured, science-subject-matter knowledge and the ability to reason and apply scientific understanding to a variety of problems” [16].

Inquiry teaching is defined as ‘providing a classroom where learners can engage in scientific oriented questions to formulate explanations based on evidence’ [35].

Types of Inquiry

Different authors have developed different classifications of inquiry-based learning. But this study focuses on [58] classification of inquiry-based learning. [58] classified inquiry-based learning as follows:

a. **Confirmation**. The teacher tells students the outcome of a problem and gives instructions on how to carry out an experiment or investigation in order to confirm the outcome.
b. **Structured inquiry**. Students are given a structured step by step process in how to investigate a given prompt or question.
c. **Guided inquiry**. The teacher gives a prompt or questions as a starting point, and students find their own way to answer the question.
d. **Open inquiry**. Students initiate their own questions and formulate their own processes to answer their questions.

Guided Inquiry Based Learning

In guided inquiry-based learning, the teacher provided the question for the students and students find their own way to answer the question. For example, table 1 demonstrates the role of teacher and students during the implementation of guided inquiry-based learning strategy in the classroom [21].

Table 1: The role of teacher and students during the guided inquiry-based learning

Type of inquiry	Questioning	Planning	Implementing	Concluding		Reporting	Applying
GIBL	Teacher	Students/ teacher	Carrying out plan Students	Analyze Data Students	Draw Conclusions Students	Students	Students

RESEARCH DESIGN

This study applied quasi-experimental design nonequivalent pretest-posttest control group. Two naturally occurred classrooms (groups) were randomly selected from four available classes. The experimental and control group were assigned after their pretest was analyzed. It involves random assignment of intact groups (classes) to experimental or control group, not random assignment of individuals [22]. According to [24] "obtaining pretest measurements for both the intervention and control groups allows one to assess the initial comparability of the groups. The assumption is that the smaller the difference between pretest measurements, the less likelihood there is of there being important confounding variables between the 2 groups." After the intervention, both groups took posttest. The experimental group was taught through guided inquiry-based learning strategy and the control group was taught by traditional teaching method. Table 2 demonstrates the design of the study [5].

Table 2: Nonrandomized control group, pretest-posttest

Group	Pretest	Treatment/intervention	Posttest
EG	Y_1	X	Y_2
CG	Y_1	-	Y_2

Note: EG: experimental group, CG: control group, Y_1=pretest, Y_2=Posttest, X=treatment

Research Setting and Targets

The study was conducted in Kemissie town in grade seven Sadasa elementary school. The population of this study was 135 grade seven Sadasa elementary school students. The Sadasa elementary school was selected by the researcher purposefully because this school has many students.

Table 3: Population and sample size distribution in Sadasa elementary school, Kemissie town

Name of school	Total population			Samples size					Description
	M	F	T	M	F	T	Grade	section	
Sadasa elementary school	70	65	135	14	14	28	7	A	Experimental group
				14	13	27	7	D	Control group

Sources: School report

Source of Data

The researcher used primary data to get information. Two groups (classes) were randomly selected by using lottery method from four available groups (classes) due to all classes were equivalent in terms of achievements in chemistry before the study. The data was obtained from grade seven students' one experimental and one control group by using physical and chemical changes achievement test and students were interviewed about their conceptions on the guided inquiry-based learning strategy. The participants (N=55) were seventh grade elementary school

students aged 11- 17. Generally, grade 7 "A" and "D" students' were the primary data source of this study.

Data Collection Methods

To determine the effectiveness of guided inquiry-based learning strategy on the achievement of students' concerning physical and chemical changes concepts two instruments were used: (i) the physical and chemical changes open-ended questions was used as pre- and post-tests to students. (ii) Structured interview about guided inquiry-based learning strategy was conducted to the students. For the interview about the effectiveness of guided inquiry-based learning strategy, open-ended questions were adapted from the studies of [60][7]. Students from high score N-gain, medium score N-gain and low score N-gain [6] were selected purposively (maximum variation sampling) from experimental group for structured interview.

Teaching Method

In order to control the confounding variables, the teaching-learning process in both groups were conducted by one teacher (the researcher). Students' score on this topic was similar as analyzed from their pre-test. Most of the hands-on activities are found in the students' textbook except some concepts that got less consideration in the book. Therefore, in both groups the same material: students' textbook and diagrams depicting physical change and chemical change were used. The

same content was covered in the experimental group as in the control group. The teaching-learning process accompanied for two weeks, which is three days per week, and 40 minutes for each contact.

Teaching Method in the Control Group

The students in the control group were taught by the teacher (researcher) of this study using traditional teaching method such as telling how to do the experiment step-by-step, demonstrating, verbal explanation, defining concepts, text materials, lectures, and questioning and answering to the whole class. The teachers' role was to demonstrate the experiments, to transfer the facts, and concepts to students. During the teaching-learning process, students acted as passive listeners and observing the experiment. At the same time in these classes the teacher also asked questions without creating discussions. In some cases, students failed to respond to the questions. In this case, the teacher gave the answer to the question. In the control group, the students were only motivated by teacher directed questions; there were hands on activities done only by the teacher and no group work in class during the teaching of the topic physical and chemical changes.

Teaching Method in the Experimental Group

The teacher (researcher) of this study taught the student in the experimental group using guided inquiry-based learning strategy in the small group. The researcher divided the students into smaller cooperative groups of four and questions were distributed for each group. The students were given a hands-on activity and they conducted an experiment. Students recorded their observations

from the experiment. Students communicated their observations and reported their finding to the class. Students applied their macroscopic findings from the experiment to the submicroscopic level by interacting with drawings or picture representing physical and chemical change.

Students were evaluated regarding their understanding by means of listening student's reflections, observing students' discussion and discussing related questions with students in the class. In general, the researcher treated the experimental group according to the figure 2 at the time of implementation of the lesson plan in the classroom.

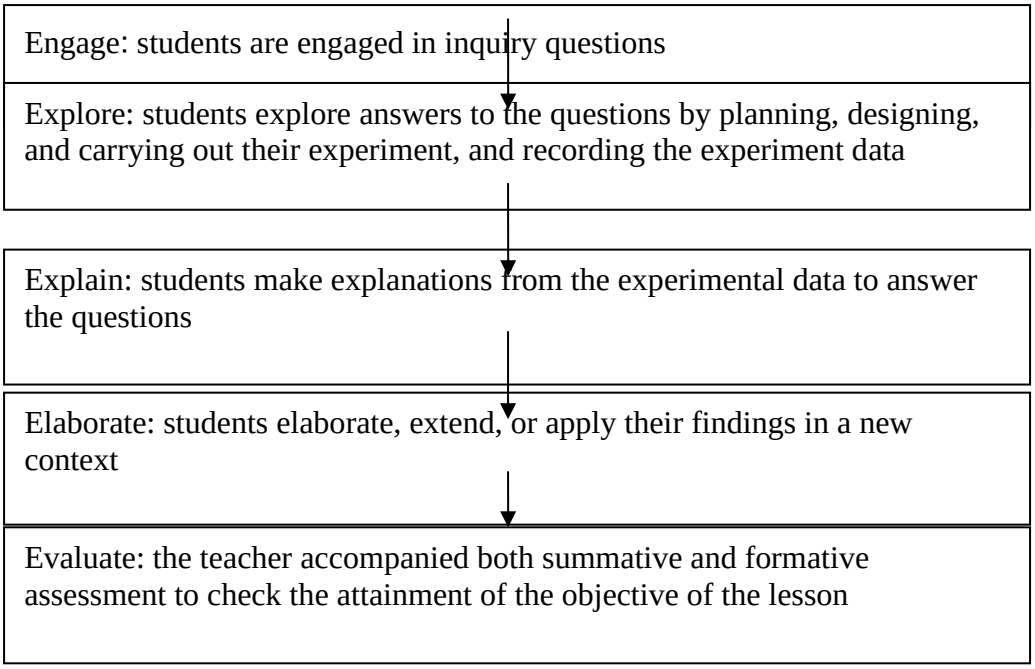

Figure 2: Diagram of guided inquiry-based learning strategy

Description of the Concepts Related to Physical and Chemical Changes in the Classroom

The teacher (researcher) planned a lesson plan on the concepts of physical and chemical changes such as melting of sulphur, burning magnesium ribbon, burning candle, rusting of iron nail, and fermentation of sugar. In each lesson plan the following table 4 describes the learning activity in both experimental and control groups in the classroom.

Table 4: Key learning activities of physical and chemical changes in the classroom

content	**macroscopic representation**	**sub-microscopic representation**	**time**
physical changes (melting of Sulphur) main question: what has happened to the Sulphur when heated?	observing the color and state (form) of Sulphur before and after melted	diagrams depicting physical change	40’
chemical changes (burning magnesium ribbon) main question: what has happened to the magnesium ribbon when burnt?	observing the change in color, state, appearance and ductility before and after burning	drawing or picture depicting chemical change	40’
physical and chemical changes (burning candle) main question: what has happened to the candle when burnt?	observing the change in size, state and appearance before and after burning	drawing or picture depicting physical and chemical change	40’
chemical changes (rusting of iron nail) What happens when iron nail is exposed to moisture?	observing the change in the color, and texture before and after iron nail exposed to moisture	drawing or picture depicting chemical change	40’
chemical changes (fermentation of sugar) What happens when you add sugar to yeast?	observing the change in odor and volume of balloon before and after sugar is added to yeast	drawing or picture depicting chemical change	40’

Validity and Reliability of the Instruments

The test was developed by researcher based on Bloom's taxonomy. Advisor, classroom teacher, and researcher were validated the content of the tests item in pretest. The test was piloted with a sample of 23 (15 females and 8 male) seven-grade students to determine item difficulty, item discrimination and the reliability (Cronbach alpha) by using the formula adopted from [47]. After the item analysis, ten items were eliminated. The item difficulty (p) for each item was in the range of 0.41-0.54, the discrimination index (r) for each item was in the range of 0.5-0.91 and the reliability based on Cronbach alpha for the entire test was 0.816.

Data Analysis

The respondent's replays for the test (pretest and posttest) and for the interview (see appendix A) were analyzed in quantitative and qualitative method respectively. For the physical and chemical changes open-ended questions, descriptive and inferential statistics were used via Statistical Package for the Social Sciences (SPSS version 20). Regarding the descriptive statistics analysis, the mean and standard deviation were calculated in experimental and control groups. Concerning inferential statistics analysis, independent samples t-test and paired samples t-test were conducted for the pre-test and post-test scores to determine the effectiveness of guided inquiry-based learning strategy (independent variable) on achievement of students' concerning physical and chemical changes concepts (dependent variables). All statistical analyses were performed at the 0.05 significance

level. For the Interview about guided inquiry-based learning strategy open-ended questions, students' responses on the interview were transcribed and then thematic analysis was conducted.

Table 5: The criteria of scoring the physical and chemical changes open ended questions for each item

score	Level of understanding	Criteria for scoring
1	Sound Understanding: (SU)	Explanations with all concepts corresponding to both scientific consensus and scientific concepts of scientists
0.75	Partial Understanding: (PU)	Explanations with at least one concept corresponding to scientific consensus and scientific concepts of scientists
0.5	Partial Understanding with Specific Misunderstanding: (PU+MU)	Explanations with at least one concept corresponding to scientific consensus and scientific concepts of scientists but partially alternate to scientific concepts
0.25	Specific Misunderstanding: (MU)	Explanations with no concept corresponding to scientific consensus and scientific concepts of scientists
0	No Understanding: (NU)	Explanations with no detail or no scientific concepts scored 0 point and were defined as "No Understanding

Source: adopted from [57]

Ethical Issues of the Study

Permission from the school director and classroom teacher were received in order to conduct the study in the schools. Two groups or classes were permitted to participate in the study. The data collections were carried out based on the willingness of study population. Every information including the name of participants were kept secret and seen only by the researcher. Subjects or participants can ask any unclear questions whenever.

RESULTS

Quantitative Data Analysis

Using an independent t test and paired t test the following results were obtained.

Table 6: Results of descriptive statistics for pretest scores

Test	Group	N	M	SD	SE
pretest	EG	28	5.0268	3.10043	0.58593
	CG	27	4.0278	3.35076	0.64485

Table7: Results of independent t test for the pretest scores

Test	**F**	**t**	**df**	**p**	**P(2 tailed)**
pretest	0.209	1.148	53	0.650	0.256

Physical and chemical change achievement pretest analysis for experimental and control group given on table 7 shows there was not a significant difference found between the two groups

at t value 1.148 as p value 0.256 was greater than 0.05. The mean pretest and their standard deviation for both experimental and control groups given in table 6 is (M = 5.0268, SD = 3.10043) and (M = 4.0278, SD = 3.35076) respectively. Therefore, at p=0.05 both groups are similar.

Table 8: Results of descriptive statistics for posttest scores

Test	Group	N	M	SD	SE
Post-test	EG	28	6.8304	2.65366	.50149
	CG	27	4.3426	2.90817	.55968

Table 9: Results of independent t test for the posttest scores

Test	**F**	**t**	**df**	**p**	**P (2 tailed)**
Post-test	0.425	3.316	53	0.517	0.002

According to hypothesis 1 there is no statistically significance difference in students' achievements between the experimental (those who were taught through guided inquiry-based learning strategy and control group (those who were taught through traditional teaching method) on posttest scores at p= 0.05. Physical and chemical change achievement posttest analysis for experimental and control group given on table 9 shows there was a significant difference found between the two groups at t value 3.316 as p value 0.002 was less than 0.05. The mean posttest and their standard deviation for both experimental and control groups given in table 8 is (M =6.8304, SD = 2.65366) and control group (M = 4.3426, SD =2.90817) respectively. The experimental group scored 0.84 higher than the control group (effect size = 0.84). Therefore, hypothesis 1 which says

there is no statistically significance difference in students' achievements between the experimental (those who were taught through guided inquiry-based learning strategy and control group (those who were taught through traditional teaching method) on posttest scores at p= 0.05 is rejected.

Table 10: Paired samples correlations of pretest and posttest for experimental and control groups

Group		**N**	**correlation**	**Sig(p)**
EG	Pretest-posttest	28	0.887	.000
CG	Pretest-posttest	27	0.760	.000

Table 10 showed that there was a correlation between the pretest and posttest achievements of students in the experimental group with a correlation value 0.887 as statistical p value of ($p=0.000<0.05$) and there was a correlation between the pretest and posttest achievements of students in the control group with a correlation value 0.76 as statistical p value of ($p=0.000<0.05$).

Table 11: Paired samples statistics for experimental group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	pretest	5.0268	28	3.10043	.58593
	posttest	6.8304	28	2.65366	.50149

Table 12: Paired samples statistics for control group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	pretest	4.0278	27	3.35076	.64485
	posttest	4.3426	27	2.90817	.55968

Table 13: Results of paired t test for the experimental and control groups on pretest and posttest

Group		**Paired differences**			**t**	**df**	**p**
		M	SD	SEM			
EG	Pair1 pretest Posttest	-1.80357	1.43268	.27075	-6.661	27	.000
CG	Pair1 pretest Posttest	-0.31481	2.20750	.42483	-0.741	26	0.465

According to hypothesis H_2: There is no statistically significance difference between the mean scores of pretest and posttest for both experimental and control group ($p<0.05$). The paired samples t test analysis given in table 13 indicates that there was a significant difference found between the mean score of pretest and posttest for experimental group at t value -6.661 as p value 0.000 was less than 0.05. The mean scores of pretest and posttest and their standard deviation for

experimental group given in table 11 is (M =5.0268, SD =3.10043) and (M =6.8304, SD =2.65366) respectively. Therefore, at p=0.05 level the null hypothesis is rejected for experimental group. The paired samples t test analysis given in table 13 indicates that there was no a significant difference found between the mean score of pretest and posttest for control group at t value -0.741 as p value 0.465 was greater than 0.05. The mean scores of pretest and posttest and their standard deviation for control group given in table 12 is (M =4.0278, SD =3.35076) and (M =4.3426, SD =2.90817) respectively. Therefore, at p=0.05 level the null hypothesis is accepted for control group.

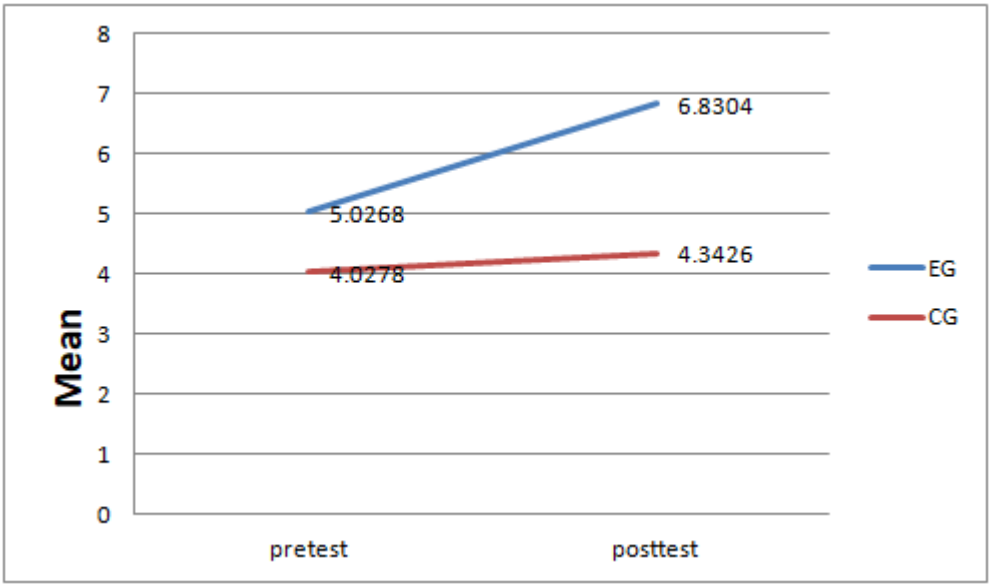

Figure 3: Graph of posttest mean scores in comparison to pretest mean scores for experimental and control groups

Figure 3 indicates that the mean achievement score of experimental group in pretest is 5.0268 and in posttest 6.8304. The mean achievement score of control group in pretest is 4.0278 and in

posttest 4.3426. This shows that the achievement score of experimental group is better than the achievement score of control group on the posttest.

Qualitative Data Analysis

Table 14: Themes and codes for students' views about guided inquiry-based learning strategy

Theme	code	Samples	f	%
Students' perceptions about the effectiveness of Guided inquiry-based learning strategy	Effective	I was interested in as I could understand easily the difference between physical and chemical changes. Therefore, it was effective	4	100%
Students' interest to the guided inquiry-based learning strategy	Interested	I was interested when the teacher asks questions and I answered the questions by doing experiment	4	100%
Difficulties students encountered during the guided inquiry-based learning strategy	Difficulty	I encountered difficulty when some students disturb	1	25%
	No difficulty	There was no difficulty we encountered	3	75%
Students' perceptions about the teacher's role during guided inquiry-based learning strategy	Helping students	The teacher helped, motivated us to do experiment and answer questions	4	100%

After the intervention, the experimental group students' views about guided inquiry-based learning strategy were collected through structured interview were analyzed in thematic analysis to answer the fourth research question. Thematic analysis indicated that four essential themes were developed: Students' perceptions about the effectiveness of guided inquiry-based learning strategy, students' interest to the guided inquiry-based learning strategy, difficulties students encountered during the guided inquiry-based learning strategy, and Students' perceptions about the teacher's role during guided inquiry-based learning strategy. The thematic analysis is presented one by one in the following subsections as a, b, c, and d.

(a) Students' perceptions about the effectiveness of Guided inquiry-based learning strategy

Students' views about the effectiveness of guided inquiry-based learning strategy were examined in one theme: It is effective. 100% of the students thought that guided inquiry-based learning strategy was effective in gaining deeper understanding. They explained that guided inquiry-based learning strategy provided experimentation and appropriate questions. For example, one of the students stated that: "I was interested in as I could understand easily the difference between physical and chemical changes." For different student, "Learning by doing experiments made me advantageous." Therefore, guided inquiry-based learning promotes higher order thinking skills.

(b) Students' interest to the Guided inquiry-based learning strategy

The entire students 100% reported that, "We liked to do experiments during the guided inquiry-based learning strategy." For instance, one of the students said that: "I was interested in

learning by being asking and answering and doing the experiment." For another student: "I was interested when the teacher asks questions and I answered the questions by doing experiment."

(c) Difficulties students encountered during the Guided inquiry-based learning strategy

Students' views on the difficulty they encountered were analyzed in two themes: no difficulty and there was difficulty. Most of the students 75% expressed that they did not encounter any difficulties during the implementation of guided inquiry-based learning strategy; the rest students (25%) expressed that they had some difficulties during guided inquiry-based learning. Those who stated that there was a difficulty indicated one causes. That cause was: ''I encountered difficulty when some students disturb."

(d) Students' perceptions about the teacher's role during Guided inquiry-based learning strategy

Students' perception about the teacher's role during guided inquiry-based learning strategy was analyzed in one theme. All of the students 100% described that the teacher asks questions during the teaching and learning process. As an illustration, one of the students said that: "Because the questions the teacher asks are related to the experiment we did, it makes the lesson easy and clear for us."

DISCUSSION

The purpose of this study was to investigate the effectiveness of guided inquiry-based learning strategy over traditional teaching method in improving seventh grade students' achievement related to physical and chemical changes. Independent t test indicated that before the intervention there was no statistically significance difference between the mean score of experimental group and control group when compared on pretest. This showed that before intervention both groups are similar in the physical and chemical changes concepts. However, the independent t test and paired t test showed that after the intervention the students who were learned through guided inquiry-based learning strategy achieved better than the students who were learned through traditional teaching method on posttest on physical and chemical changes. Students who were taught by guided inquiry-based learning strategy illustrated significantly higher scores on the physical and chemical changes concept test than those who were taught by traditional teaching method. Particularly, this study indicated that the guided inquiry-based learning strategy was more effective than traditional teaching method to increase students' achievements in physical and chemical changes concept.

Therefore, this study supports the existing studies that showed the effectiveness of guided inquiry-based learning strategy over traditional teaching method [6]. Because in the experimental group students were mentally and physically active, the students establish relationships, observe patterns and identify variables [14]. In the previous studies, it is understandable that inquiry-based learning was more effective in enhancing students understanding of chemistry

subject[54][57][50][56][55][48]. However, this study is contradicting with some of the results of previous studies conducted in the effect of process oriented guided inquiry-based learning pedagogy on the students' achievement in physical and chemical change. For instance, [43] reported there was no difference in the achievement between experimental group who taught through process oriented guided inquiry-based learning pedagogy and control group who taught through teacher centered whole-class instruction related to "physical and chemical change concept.

Different from this study, the present study provided the effectiveness of guided inquiry-based learning in enhancing students' achievement in physical and chemical changes. In the experimental group of this study, Students were engaged in scientific oriented questions to formulate explanations based on evidence' [35]. In the experimental group students engage in discussions and information seeking activities [14]. The students in the control group were passive during the traditional teaching method. Students acted as passive listeners and the teacher was demonstrating the experiments, transferring the knowledge and concepts to the students. This brought the students low achievements in physical and chemical changes test in the control group. Nevertheless, during the guided inquiry-based learning the hands-on activities provided the students with better achievements in physical and chemical changes test in the experimental group. Students in the experimental group was making observations; posing questions; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanations and predictions; and communicating results' [2].

Thus, guided inquiry-based learning strategy helped the students to construct their own knowledge. Above all, physical and chemical changes are one of the chemistry topics which students were not able to distinguish physical change from chemical changes [29][25][45][23][61]. [25] proposed that students commonly experienced difficulties at three different epistemological levels: chemical knowledge (failed to invoke atoms and molecules as explanatory constructs, even though they had been emphasized in their chemistry course. Some students also listed "substances" such as heat, cold, or decay as reactants or products), conservation reasoning (many students could not predict or explain mass changes in the chemical reactions. Their most common problems included (a) a tendency to treat chemical changes such as rusting as physical changes in form or state, and (b) failure to understand the role of invisible (in this case gaseous) reactants or products in the reactions), and explanatory ideals (many students demonstrated a preference for explanations based on superficial analogies with everyday events (e.g., rusting is like decay) over explanations based on chemical theories). Concerning to this students' difficulty, this study shows that the guided inquiry-based learning provided an effective learning strategy that increases students' understanding and achievement. Moreover, analysis of students' attitudes through thematic analysis about guided inquiry-based learning that was collected by structured interview indicated that the students taught with the guided inquiry-based learning had positive attitudes about the guided inquiry-based learning. They expressed that the lessons are more interesting and understandable. Further, they specified that the importance of asking questions and experimentation during the teaching and

learning process. This finding supports the previous study that showed students had positive attitudes towards guided inquiry-based learning strategy [9][42][7]. Therefore, from this finding one of the positive factors influencing students' attitudes toward chemistry learning is using guided inquiry-based learning. The guided inquiry-based learning provided for the students' deeper understanding of the concepts and enhances their attitudes towards chemistry learning.

For this reason, Students in the experimental group had positive attitude towards learning and high interest due to the usage of guided inquiry-based learning. This study opposes some of the results of previous studies conducted in the effect of 5E inquiry learning activities on the students' attitude in chemistry. For example, [48] showed that there was no statistically significant mean difference between experimental and control groups with respect to attitude toward chemistry. However, the present study provided evidence for the students had positive attitudes towards guided inquiry-based learning during chemistry learning. The students taught with guided inquiry-based learning showed that more interesting and motivated during chemistry lesson.

The application of guided inquiry-based learning strategy in classroom has various implications for students. Learning through guided inquiry-based learning strategy enhances students' achievement in chemistry. Students are able to achieve better conceptual understanding of the physical and chemical changes. It is possible to overcome students' alternative conceptions regarding physical and chemical changes through guided inquiry-based learning strategy. It can increase the skill of doing experiments and make understandable. It can encourage students to

construct knowledge by themselves. Additionally, students' attitudes towards learning were increased, specifically on the topic of physical and chemical changes. Therefore, from this study it is possible to claim that guided inquiry-based learning strategy was more effective than traditional teaching method.

CONCLUSIONS

The main purpose of this study was:

- To determine the difference in students' achievement when the physical and chemical changes concepts were taught using the guided inquiry-based learning strategy compared to the traditional teaching method at the grade seven Sadasa elementary school in Kemissie town in Ethiopia.
- To explore students' attitudes about guided inquiry-based learning strategy after they learned physical and chemical changes within this approach of teaching.

As demonstrated in chapter one, many students had misconceptions and low achievements related to the physical and chemical changes concepts. To determine the effectiveness of guided inquiry-based learning strategy over traditional teaching method in chemistry lessons, the quasi-experimental design nonequivalent pretest-posttest control group was used. The teacher-centered

method of teaching is one of the factors affecting the students' learning of chemistry and the abstract concept of chemistry is the other factor [39].

Therefore, the main results of this study include the following:

- Students who were taught through guided inquiry-based learning strategy performed better than those who were taught through traditional teaching method on posttest.
- Students in the guided inquiry-based learning strategy had positive attitudes and more interested.
- Effect size was larger for the achievements of students who were taught through guided inquiry-based learning strategy that demonstrates guided inquiry-based learning strategy was better than traditional teaching method.
- The result of thematic analysis indicated that students who were taught through guided inquiry-based learning strategy showed more interested and motivated.
- Thus, guided inquiry-based learning strategy was more effective to improve student's achievements in physical and chemical changes concepts than traditional teaching method.

In this study the individual students were not randomly assigned to the experimental and control groups because the school principal had already formed the classrooms which did not permit to assign individual students to either experimental or control groups randomly. Therefore, this study randomly assigned intact groups (classes) to experimental or control groups. This study has no

information about how guided inquiry-based learning strategy influence students' achievements in different populations and settings since the study was limited to grade seven Sadasa elementary school in Kemissie town. This limited the study due to findings is not generalizable to other populations and settings. The investigation revealed that guided inquiry-based learning strategy was more effective than traditional teaching method. Due to this, Chemistry teachers should use guided inquiry-based learning strategy in order to increase students' achievements, attitudes towards learning chemistry. It is more recommended that teacher should use various learning resources and teaching aids which supports hands-on activity in guided inquiry-based learning strategy that overcome students' misconceptions in chemistry. The effect of guided inquiry-based learning on different topics of chemistry in elementary school is recommended to be examined. It is also recommended to conduct a study in different settings and participants in elementary schools.

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