THE EFFECT OF USING CONTEXT BASED-APPROACH ON THE CONCEPT OF GAS LAWS ON STUDENTS' ACHIEVEMENT AND ATTITUDE

MSc THESIS

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The Effect of Using Context-Based Approach on the Concept of Gas Laws on the Students' Achievement and Attitude

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I hereby certify that I have read and evaluated this Thesis prepared, under my guidance, by Eliyas Burqa, entitled: “The Effect of Using Context Based Approach on the Concept of Gas Laws on the Students’ Achievement and Attitudes”. I recommend that it be submitted as fulfilling the thesis requirement

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DEDICATION

This thesis is dedicated to my beloved wife and to my children’ for their endless support.

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this thesis is my own work. I have followed all ethical and ethical principles of scholarship in the preparation, data collection, data analysis and completion of this thesis. All scholarly matter that is included in the thesis has been given recognition through citation.

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BIOGRAPHICAL SKETCH

The author was born on January 10, 1986 GC in the Oromia Region, East Hararghe Zone, Jarso District, at Gara Abdula Kebele. He attended primary school at Gara Abdula Primary School, and secondary school at Harar Town, Medeanealem Secondary School from 1994–2000 and 2001-2002, respectively. He attended preparatory school at Jigjiga Secondary School from 2003-2004. Then, he was admitted to Bahir Dar University in 2005, and graduated with Bachelor of Education in Chemistry in 2008. Thereafter, he began his career as a chemistry teacher in a secondary school in 2009 at Ejersa Goro Secondary School in Jarso district. After, eight years a service, the author was admitted to Chemistry Department, Haramaya University, to pursue his Master's degree in Chemistry in 2017.

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ABBREVIATION AND ACRONYMS

CBA	Context Based Approach
CBIA	Context Based Instructional Approach
CBSE	Context Based Science Education
CG	Control Group
CGS	Control Group Score
CIM	Context-Instructional Method
CLGL	conceptual levels of gas laws
CLM	Conventional Lecture Method
EG	Experimental Group
EGRTTS	experimental group retention test score
EGS	Experimental Group Score
MCQ	Multiple Choice Questions
PBL	Problem Based Learning
PEGS	Percentage of Experimental
RT	Retention Test

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ABSTRACT

The study was aimed to evaluate the effect of using a Context-Based Approach (CBA) on the concept of gas laws on students' understanding and attitude. The study conducted at Ejersa Goro *secondary school in Oromia region, Ethiopia. The research focused on the physical state of matter, specifically Boyle's, Charles', and Gay-Lussac's gas laws, which are fundamental concepts in secondary school chemistry with applications in various science-related fields. The study employed quasi-experimental research approach, which contains experimental, control groups, and involved 72 grade 9 students selected by convenience sampling techniques. The experimental group received CBA instruction, while the control group received traditional instruction. The data were collected using pretests, posttests, retention tests, questionnaires, interviews, and observations. The study found that CBA significantly improved students' understanding and retention of gas law at each conceptual level (macro, micro, symbolic and graphical representation). The experimental group also showed a positive attitude toward CBA. The study concluded that CBA is a more effective instructional method than traditional teaching for enhancing students' understanding and retention of gas laws. The findings suggested that CBA is effective instructional approach and better if integrated into chemistry instructions to improve students' academic achievement and attitudes toward learning gas-law.*

Keyword: Achievement test, Context-based instruction, conceptual level, gas law, Cognitive retention

1. INTRODUCTION

1.1. Background of the Study

Gas law is one of the crucial topics of secondary school chemistry. It has several applications in different fields of science and science related fields like engineering, health science, water science and physics. Overrunning these topics at secondary schools would prepare students for further knowledge of science professions. It deals with Boyle's, Charles and Gay-Lussac's gas laws. Teaching gas laws is base for further development of gas laws to thermodynamics and chemical kinetics in which variables of targeted laws are bases. There were several studies regarding importance of teaching gas laws in different aspects and models like understanding of kinetic molecular theory of gases in three modes of representation among tenth grade students in chemistry (Sanchez, 2021). In physics and physics related course like engineering as thermodynamics in which gas laws are fundamental concepts chemical engineering, and mechanical engineering, but also in meteorology (Huang *et al.*, 2004).

Various research studies reported that concept of gas law is difficult chemical concept to understand comprehensively (Doymus, 2007; Çepni and Şahin, 2012; Hammar, 2013), to use qualitative and quantitative relationships of variables of gas laws (Treagust *et al.*, 2003) and other report indicated that high school students believed that a gas has no weight (Lin *et al.*, 2000; Mayer, 2011). Even after instruction in introductory chemistry and physics in advanced courses, many university students were not able to properly interpret the macroscopic variables of pressure, temperature, and volume (Kautz, *et al.*, 2005). Students had greater difficulty of answering questions pertaining to units, variables, plug-in problems, and conceptual problems (Robins *et al.*, 2009).

The reason behind these students difficulties in learning chemistry was suggested by different scholar's as do not understand the relationships between the macroscopic, submicroscopic, and symbolic levels (Johnstone, 2000), attributed to rote memorization and misuse of chemical formula (Lin *et al.*, 2000), poor external representation and internal interpretation (Matijasˇevic´ *et al.*, 2016). Besides, some researchers reported that the difficulties experienced in learning science and in particular gas behaviors are magnified as its concepts are consolidated through the use of mathematical symbols, formulas and equations (Robertson and Shaffer, 2013). Mathematical equations of gases were used to express and connect relationships at the macroscopic and microscopic levels (Davidowitz and Chittleborough, 2009). The use of chemical symbols, chemical formulas, and chemical equations also add additional complication to the learning of gas laws (Taber, 2009).

To solve these difficulties of students regarding current issues in different countries several studies investigated different methods and techniques like inquiry-based teaching methods with alternative assessment (Hammar, 2013). Teaching Gas laws through Problem-solving based Learning to investigate the applicability of the method (PBL) and to evaluate students' achievement, motivation and attitudes (Wijnia *et al.*, 2011; Baran, 2016). Concept Map was also used to study conceptual understanding of In-service Science Teachers' Knowledge in the Department of Physics (Bekele, 2019) and few scholars advised to use CBA in order to fix abstract chemical concept (Demelash *et al.*, 2023; Gebratsadik Getu *et al.*, 2024). Since CBA refers to an instructional strategy that emphasizes the use of real-life situations to engage students with chemical concepts. This method seeks to bridge the gap between theoretical knowledge and practical application, helping students see the relevance of chemistry in their everyday lives (Jong, 2008; Demelash, 2024). Hence context-based approach in teaching gas laws is beneficial for students' in conceptual understanding, motivation and cognitive retention, maintains students interest and builds connections between academic concepts and real-world applications, ultimately leading to a more enriching educational experience (Weintrop *et al.*, 2016; Leslie and Bearden, 2023a).

1.2. Statement of the Problem

Different research studies reported regarding Gas laws for secondary school students as its abstract and difficult subjects (Sawyers, 2008; Hammar, 2013; Leslie and Bearden, 2023).
The complexity of the concepts of gases poses many difficulties in understanding basic science concepts for school and university students especially learners coming from poor resourced high schools (Bain and Towns, 2016; Mete, 2020).

Difficulties with gas laws at the secondary school level were identified at the macroscopic level, microscopic conceptual level, symbolic representation level (Khatri, 2021), and at the graphical representation level. For instance, gas law equations can be understood from a purely symbolic perspective, allowing students to use the formulas to calculate a fourth variable in Boyle's, Charles's, and Gay-Lussac's gas laws when three of them are given. Moreover, a number of researchers conducted on investigation of students' misconceptions on the concept of gas law indicated that students have difficulty in transferring from the symbolic representation to the particulate representation (Keig and Rubba, 1993; Kozma and Russell, 1997; Mamombe *et al.*, 2020). There were research studies; students construct wrong conceptions like gases are weightless (Galili *et al.*, 2016).

Other studies show that student's' are faced difficulties at particulate level; learners could not relate gas expansion with the particulate nature of temperature. Most learners think that particle size will increase during that heating and decrease in size during cooling and there is also a difficulty with temperature-pressure relationships (Talens *et al.*, 2024).
To solve problems' related to current issues; several instructional approach was designed. Examples; mathematical modeling cycle of constructivism (Yalçinkaya, 2010; Meli *et al.*, 2022b) and using argumentation-based pedagogy on college students' conceptual understanding of properties and behaviors of gases (Aydeniz *et al.*, 2012); Computer simulation for physics education technology was used to solve misconceptions of gas behavior at microscopic level (Correia *et al.*, 2019); contextualized instructional materials (CIM) were applied (Rivera and Sanchez, 2020; Sharif *et al.*, 2021).
Besides a number of researchers evaluated the effectiveness of using CBA in our country in teaching different chemistry topics like Concept of Chemical Equilibrium (Ababu Demissie, 2020) and the concepts of electrochemistry (kedir Tefera, 2019). However, with the researcher knowledge there are no such study conducted on the concept of gas law despite the students are facing challenges to understand the concepts. But Teachers have a key role in using multiple levels of representations in teaching the concepts and should be aware of multiple levels of representations, and should know how to use them in the classrooms (Savasci-Acikalin, 2021).

For instance; Yitbarek, (2011) investigated Ethiopian high school students' misconception in gas law and their results shown us only 25% of students understand the concept of gas law.

Another study investigated the complexity of the concepts of gases indicated that; the concept of gas law posed many difficulties in understanding basic science concepts for school and university students especially learners coming from poor-resourced high schools (Bekele, 2019).

Therefore, the researchers initiated to evaluate the use of context based approaches to teach the concept of gas law on grade 9 students' achievement and attitude. This is because; the problems regarding gas laws and associated variables (pressure, temperature and volumes) with their relationship were challenging grade 9 students in our school. For example, grade 9 students cannot explain the pressure of gas inside of closed empty water containers were inserted in boiling water, since increasing temperature increases kinetic energy of gases get increased. However, there is no research report on the effect of using context-based approach on the concept of gas law. The current research studies going to evaluate the effectiveness of using context based approaches on students' academic achievements of gas laws and students' attitude towards CBA of grade 9 students of Ejersa Goro secondary school.

Research question

- What is the effect of using context-based approach on the concept of gas law (Boyles' law, Charles law, Gay-Lussac's law) on students' achievement?
- Does the approach has effect on students' cognitive retention in the concept of gas law?
- What is students' attitude towards the approach?

1.3. Objectives of the Study

1.3.1. General Objective

The main objective of this study was to study the effect of using context-based approach on the concept of gas law (Boyle's law, Charles law, Gay-Lussac's law) on grade 9 students' achievement and attitude at Ejersa Goro secondary school.

1.3.2. Specific Objectives

The specific objectives of this study were:

- To evaluate the effect of using context-based approach on the concept of gas law (Boyles' law, Charles law, Gay-Lussac's law) on students' achievement and cognitive retention.
- To assess student's attitude towards the approach.

1.4. Significance of the Study

Context based instructional process enable and motivates student in connecting science with daily life activity, to develop knowledge at macroscopic, microscopic, symbolic and graphic representational skills on gas laws. This may result the development of conceptual knowledge, Problem-solving skills of students and modifies their negative attitudes towards gas laws and its applications were:

- To develop students' concepts on the relationship between each variable in gas laws and able to evaluate changes of them in their daily life activity with their application.
- To create an opportunity to use locally available materials in context based instructional activity to teach kinetic and thermodynamic properties of gases in different views.
- To develop students' subject specific practical skill in teaching-learning process.
- To help students on basic concept of each gas laws.
- To contributes to the literature in the generalizability of qualitative and quantitative research.
- To helps teachers to modify instructional delivery to help students to modify their alternative conceptions.
- To reduce the gaps in learning that may increase the wide spread and strength of some alternative conceptions.
- To be used as reference for researchers who have interest on studying CBA.

1.5. Scope of the Study

The study was conducted at Ejersa Goro Secondary School on grade 9 students at one governmental school to evaluate effect of CBA on the concept of gas law (Boyles' law, Charles law, Gay-Lussac's law) on student's achievement and cognitive retention.

1.6. Limitation of the Study

The aim of the instruction was to assess the effect of contextualized approach on the achievement of students and their attitudes towards chemistry concepts particularly at gas laws. The limitation of this study was that it focused only in one governmental school in a sample of 72 grade 9 students. Therefore, the research results and conclusions may have limited generalizability and there were no large scales comparative dimensions since the research was done in one school.

1.7. Operational Definitions of Terms

Contextual: depending on or relating to the circumstances that form the setting for an event, statement, or idea and in terms of which it can be fully understood.

Pre-test: A preliminary test administered to determine a student's baseline knowledge or preparedness for an educational experience or course of study

The posttest: result obtained after the program given

Context based instructional process: teaching and learning involves making learning meaningful to students by connecting to the real world.

Achievement test: Is a test given to measure skill or knowledge in a certain defined subject.

Retention test: - Is the test conducted after a certain retention interval with all groups performing under the same conditions. These tests often take place after a fair amount of academic teaching, but they can be used in different forms and scenarios, all of which will be explored further in this lesson.

Gas laws: are group of laws that govern the behavior of gases by providing relationship between volume, pressure, temperature, and number of moles of gases. They are -

Boyle's law is an empirical gas law that describes the relationship between pressure and volume of a gas. This law state that pressure and volume of a gas have inverse relations. It is represented mathematically as $P_1V_1=P_1V_2$.

Charles' law is deal with the relationship between volume of a gases and absolute temperature anhd state that volume of a gas is directly proportional to its absolute temperature at constant pressure. Mathematically represented as $V_1/T_1=V_2/T_2$ at constant pressure.

Gay-Lussac's gas law deals with the relationship between pressure and temperature of a gas at constant volume and it state pressure of a gas is directly proportional to its absolute temperature at constant volume. It is represented as $P_1/T_1= P_2/T_2$ at constant volume.

2. REVIEW LITERATURE

This chapter discusses a review of related literature concerning context based instructional approach (CBIA) on the concepts of gas laws. The review first deals with how much context-based instruction are available to teach science. Following the nature of chemistry contents, and concepts of gas laws at secondary school, challenges in learning gas laws in chemistry, strategies, implication of context based instruction method, methods to investigate challenges of context based instruction methods disadvantage of context based approach discussed.

2.1. Context-Based Approach

Context-based science education (CBSE) approach is a promising line of research that has emerged as a science teaching innovative approach and promotes teaching scientific concepts by addressing real problems from an interdisciplinary perspective (Bennett *et al.*, 2007)(Bennett and Lubben, 2006; Bennett *et al.*, 2007; Gilbert, 2010b; Gilbert *et al.,* 2011; Meroni *et al.*, 2015; Erceg *et al.*, 2016; Podschuweit and Bernholt, 2018; Lewis and Randall, 2020). In teaching chemistry, Context-based learning approaches are developed and introduced to address several challenges in secondary chemistry education (Childs *et al.*, 2015; Sevian *et al.,* 2018).

Basically CBA takes the creativity of teachers to design simple instruments, ensuring science can still be taught (Suryawati and Osman, 2017; Saehana *et al.,*2019). Context based approach can be defined as the approach that encourages teachers to have the confidence to creatively reflect on their teaching practice as it responds to the particularities of their own teaching and generated theory of practice (Kumaravadivelu, 2001). Especially in chemistry learning, students' complaints related to abstract of the concept of chemistry topic in solving problems, because the abstract nature of science makes learning scientific concepts difficult for most students.

The focus on theoretical aspects without practical context makes science teaching less appealing and harder to grasp, as it fails to relate to everyday life and societal issues (Tsaparlis, 2005). To address the resulting confusion and challenges, context-based approaches was recommended. These methods start with real-world contexts and applications to introduce and develop scientific concept (Bennett *et al.*, 2006).

According to Bennet Context-Based teaching is an approach adopted in science teaching were, contexts and the application of science was used as the starting point for the development of scientific ideas. Context based approach is the efforts to overcome the isolation of the current curriculum using a meaningful context for teaching and learning chemistry and Contexts were adopted to encourage a more positive attitude and a better understanding of chemistry (De Jong, 2006). Reasonably it is needed to prevent disconnection between learned knowledge and daily living in schools and students should be able to solve problems met in their daily lives by using the knowledge they have learned in classes (Dewi *et al.*, 2017).

Context based approach were described as situations in which Learning scientific facts, meaning full concepts, rules and laws and based on the students' previous knowledge to enable the achievement of the major goals of science education that connect science to everyday life. The connection between the experience of students and concepts can help students' better understanding (De Jong, 2006; Avargil, 2019; Fayzullina *et al.*, 2023). Context based teaching should build on the students existing knowledge and should aim at an increasing involvement of students in the teaching-learning process (Bennett and Lubben, 2006; Bulte *et al.*, 2006; Bennett *et al.*, 2007). But decontextualized instructional approaches causes a reduction of the interest of students in the lesson having difficulties in learning and decrease in performance (Aniashi *et al.*, 2019).

Another study conducted to evaluate the effectiveness of context-based instruction compared to traditional methods in teaching 9th-grade students was revealed that students taught with context-based instruction demonstrated a significantly better understanding and students' science process skills acted as a strong predictor of their understanding of the subject matter (Podschuweit and Bernholt, 2018; Fayzullina *et al.*, 2023).

There were also research reports as context based instruction encouraged to be carried and was practiced. It was contributed to the students' awareness of the relationship between the subjects of science and daily life (applications of the CBT) and enables them to evaluate concepts of their primary education. Moreover, through CBA instructional process, students have been more familiar with the CBT and, better efficiency observed (Ilhan *et al.*, 2022).

Current scientific research studies conducted in our country revealed that context based chemistry teaching has a positive effect on students' academic achievement (Gebratsadik

Getu *et al.,* 2024). This finding has significant implications for educators, curriculum developers, and policy makers, as it may inform the design of effective Chemistry instruction that enhances students' academic performance. This has consequences for educators and policy makers in designing effective teaching strategies to improve students' academic performance in Chemistry (Schneider *et al.*, 2022).

To overcome these problems, the use of education programs allowing students to build more association with the world they are living in and to be able to use learned in different situations carries importance(De Jong and Den Hartog, 2008).

2.2. Disadvantage of Context Based Approach

There was research studies identified the difficulty of context-based approach with its implementation considered as problem in chemistry classrooms. However, Context based approaches were too general and too broad to promote and develop students' thinking (Fayzullina *et al.*, 2023). Challenges of taking questions of students seriously and using them as an orientation for the subsequent lessons was reported. In general, teaching about contexts requires a broader range of teaching skills and learning activities than traditional approaches (Bennett and Holman, 2003; Ummah, 2019).

2.3. Nature of Gas law as a School Topic

Regarding Secondary School Chemistry unit of gas law focused on the thermodynamic and kinetic relations of temperature, Pressure, volume and number of moles of substances. This physical interrelation was categorized under laws of gases; Boyles law, Charles law, Gay-Lussac's law, combined gas law and Avogadro's hypothesis. The subject of gases is one of the subjects that learners have a hard time learning (Doymus**,** 2007; Çepni and Şahin, 2012; Hammar, 2013). There were reports those categorized concepts of gas laws as the most challenging chemistry subject for learners. Provided reason for its challenge were its invisibility and it seems to be too abstract for the learners (Şenocak, 2005). Many studies focusing on the subject of gases have found that employing multiple methods and techniques to teach it helps learners with micro-level subject (Kaya and Kılıç, 2008; Correia *et al.*, 2019). When the relevant literature was analyzed, learners are found to anchorage misconceptions regarding gases (Yalcin and Yalcin, 2020) and have difficulty learning the subject of gases since it is an abstract concept. So as to prevent learners from coming to class with inadequate knowledge, it seems crucial to design opportunities and materials that would interest them in the subject and allow them to think rationally (Vallespin, 2021).

Hence, the conduct of the study of gas laws at secondary school education, college and university level by updating to kinetics and thermodynamics. At secondary school level it deals with the relationship between temperature, volume, pressure and number of moles of substances depending on Boyles, Charles, Gay-Lussac's' and Avogadro's hypothesis; further combined and ideal gas equation were derived from Charles, Boyles and Gay-Lussac's' law. They contain solving problems which deals with stoichiometric relations variables listed above that can evaluate cognitive.

2.4. Concept of Gas Laws

Early scientists explored the relationships among the pressure of a gas (P), temperature (T), volume (V), and amount (n) by holding two of the four variables constant (amount and temperature, for example), varying a third (such as pressure), and measuring the effect of the change on the fourth (in this case, volume). The history of their discoveries provides several excellent examples of the scientific method (İçöz A., 2013).

2.4.1. Boyle's Law

Series experimental procedures carried out and determined the quantitative relationship between the pressure and the volume of a gas using a J-shaped tube partially filled with mercury, were a small amount of a gas or air was trapped above the mercury column, and its volume is measured at atmospheric pressure and constant temperature shows inversely relation of pressure Vs Volume. This law can be represented as $P \propto 1/V$ at constant temperature**.**

The numerical value of the constant depends on the amount of gas used in the experiment and on the temperature at which the experiments was carried out. This relationship between pressure and volume is known as Boyle's law, after its discoverer, and can be stated as follows: At constant temperature, the volume of a fixed amount of a gas is inversely proportional to its pressure. Pressure (p) of a given quantity of gas varies inversely with its volume (v) at constant temperature; i.e., in equation form, PV = k, a constant (Kauzmann, 2012; Harvey, 2021).

"Boyle's Gas Law: understanding the relationship between Pressure and Volume in Chemistry Education". Volume versus 1/pressure for the same data shows the inverse linear relationship between the two quantities, as expressed by the equation V = constant Pressure (Dincer and Zamfirescu, 2011; Harvey, 2021). At constant temperature, the volume of a fixed amount of a gas is inversely proportional to its pressure.

The Relationship between Temperature and Volume: Hot air rises, which is why hot-air balloons ascend through the atmosphere and why warm air collects near the ceiling and cooler air collects at ground level. Because of this behavior, heating registers are placed on or near the floor, and vents for air-conditioning are placed on or near the ceiling. The fundamental reason for this behavior is that gases expand when they are heated. Because the same amount of substance now occupies a greater volume, hot air is less dense than cold air (Potter, 2001).

2.4.2. Charles's Law

An avid balloonist, the French chemist Jacques Alexandre César Charles (1746–1823), carried out quantitative relationship between the temperature and the volume of a gas in 1783. Charles's initial experiments showed that a plot of the volume of a given sample of gas versus temperature (in degrees Celsius) at constant pressure is a straight line. Similar but more precise studies were carried out by another balloon enthusiast, the Frenchman Joseph-Louis Gay-Lussac (1778–1850), who showed that a plot of V versus T was a straight line that could be extrapolated to a point at zero volume, a theoretical condition now known to correspond to −273.15°C. A sample of gas cannot really have a volume of zero because any sample of matter must have some volume. Furthermore, at 1 atm pressure all gases liquefy at temperatures well above −273.15°C (Limpanuparb *et al.*, 2018; Limpanuparb *et al.*, 2019). This law can be represented as $\mathbf{V} \propto \boldsymbol{T}$ at constant pressure.

2.4.3. Gay-Lussac's law

It is a gas law, which states that the pressure exerted by a gas of a given mass varies directly with the absolute temperature of the gas at a constant volume. In other words, the pressure exerted by a gas is proportional to the temperature of the gas when the mass is fixed and the volume is constant (Davies, 2017; Zidny *et al.*, 2019). The French chemist (Joseph Gay-Lussac, 1808) formulated this law. The mathematical expression of Gay-Lussac's law can be written as $P \propto T$; $P/T = k$, were P is the pressure exerted by the gas T is the absolute temperature of the gas and k is a constant. The relationship between the pressure and absolute temperature of a given mass of gas at constant volume can be understood that the pressure of a gas at constant volume reduces constantly as it is cooled until the gas eventually undergoes condensation and becomes a liquid (Vallespin, 2021).

The law can be derived from the kinetic theory of gases assuming a perfect (ideal) gas. Real gases obey Boyle's law at sufficiently low pressures, although the product PV generally decreases slightly at higher pressures, where the gas begins to depart from ideal behavior pressure on a gas increases, the volume of the gas decreases because the gas particles are forced closer together (Holbrow *et al.*, 2009; Schuttlefield *et al.*, 2012). Conversely, as the pressure on a gas decreases, the gas volume increases because the gas particles can now move farther apart. Weather balloons get larger as they rise through the atmosphere to regions of lower pressure because the volume of the gas has increased; that is, the atmospheric gas exerts less pressure on the surface of the balloon, so the interior gas expands until the internal and external pressures are equal.

2.5. Challenges in Learning Gas Laws

Gas laws were challenging topics in secondary school. Research studies reported that students have difficulty transferring from the symbolic representation to the particulate representation (Keig and Rubba, 1993; Kozma and Russell, 1997). For example, students will be able to use the formula to calculate a fourth variable of $P_1V_1 = P_2V_2$ when given the other three variables. However, students will not be able to describe what is happening to the gas particles when one of the four variables of $P_1V_1 = P_2V_2$ changes and will not be able to say that when volume increases, the gas particles hitting any section of the wall in a given time decreases and the pressure decreases (Zidny *et al.*, 2019).

Regarding Charles laws cannot explain that at a higher temperature, gas particles move faster, striking each other and the walls of their container more frequently and with greater force. For the pressure to stay constant, volume must increase so that the particles have farther to travel before striking the walls. Having to travel farther decreases the frequency with which the particles strike the walls of the container (Dingrando *et al*, 2002). Students Consistent results across more than a decade of chemistry education, research suggest that both high school and university students experience difficulties in the application of conceptual understanding and problem-solving of gas law test items (Lin *et al.*, 2000; Costu, 2007; Matijasˇevic´ *et al.,* 2016).

Teaching and learning chemistry can be challenging, and may often be complicated by students developing misconceptions of the chemistry they are taught (Taber, 2009).

Students of Grades 9 and 10 failed to demonstrate very basic understanding of chemistry concepts. Research studies investigated that the challenges seem to arise from students' poor subject knowledge background, which apparently is the consequence of the poor teaching, inadequate academic support and guidance, and insufficient individual attention they received from their environment (subject teacher, school, parents, and peers) (Ali, 2012).

Other studies also revealed that when students learn terms outside of the context, they may form an alternative explanatory structure in their brain, which leads them to have a concept or visual image that pertains to the wrong context and interferes with their ability to understand the correct explanation (Sweller, 2020).

Lacking essential knowledge of the primary chemistry concepts, which needed to be learnt and gathered at lower secondary level student, has seemed confused despite, teacher's good efforts to communicate the concept using a variety of simple example and explanation (Taber, 2001; Ali, 2012; Kind, 2014; Bello *et al.*, 2015; Widodo *et al.*, 2017; Blackie, 2022; Adu-Gyamfi and Asaki, 2023; Ullah *et al.*, 2023). Students have greater difficulty answering questions relating to units, variables, plug-in problems, and conceptual problems than they did answering those related to algebra (Robins *et al.*, 2009)

The students could correctly do algebra problems similar to gas law problems out of context, but when placed into the context of a gas law problem the students struggled with gas law variables and the units of measure (Schneider *et al.*, 2022). Christopher and associates looked at it from a student performance standpoint in context.

2.6. Attitude of students' towards CBA

Attitude is consider together with beliefs and emotions that constitute the affective domain of the learners. Attitudes were commonly distinguished from beliefs in the sense that attitudes are moderate in duration, intensity and stability and were linked with an emotional content of the students. Students' attitude (opinions or general feeling) towards practical chemistry need to be assessed during the lesson so that the teacher can know how to the students feel towards the teaching strategies, classroom activities and the subject matter (Durlak *et al.*, 2011). This will assist the teacher by providing effective basis for developing useful educational innovations to facilitate chemistry teaching. It was found by (Adesokan *et al.,* 2000) who states that; students still show negative attitude towards chemistry among the science subjects in spite of the recognition given to the subject, thus leading to poor performance and low enrolment.

Since the teaching strategy employed by teachers influences the attitude of students towards a subject, learners who are taught meaningfully have good understanding of concepts, which is expected to enhance their performance and thus motivate them to develop positive attitude towards the subject (Durlak *et al.*, 2011). It is therefore, could be defined as the aggregate product of the interaction of these components. So that, the affective component contains the direction and intensity of an individual's evaluation or a kind of emotion experienced toward the objective of attitude. The cognitive component refers to a person's system of beliefs about the attitudinal object.

2.7. Overview of Challenges to use CBA to Teach Gas Laws

Various studies have shown that learners have difficulty in understanding many subjects in chemistry courses, have problems in visualizing subjects in their minds and have conceptual misunderstandings regarding these subjects (Treagust *et al.*, 2003; Piquette and Heikkinen, 2005; Karacop and Doymus, 2013; KOÇ, 2014). Gases is one of the subjects that learners have a hard time learning (Doymuş, 2007; Şahin and Çepni, 2012; Hammar, 2013). The most challenging chemistry subject for learners is the gases. The biggest reason for this seems to be the fact that gas concepts are too abstract for them (Şenocak, 2005). The difficulties met with in teaching "temperature" and "pressure" effects on gases have caused so much concern among chemistry teachers that there has been some discussion as to the advisability of eliminating these problems from the course of study (Dincer and Zamfirescu, 2011; Vakal, 2023).

Students experienced difficulty in understanding gas laws, which included concepts such as determining the volume of gas, the number of molecules, initial pressure, final pressure, initial volume, and final volume of a gas (Aprilia, 2019). One example of the challenges students faced with Boyle's gas law understood the changes at the macroscopic level, such as what happens to volume as pressure increases, as well as at the microscopic or particulate level.

To facilitate understanding of the experiment, a particulate representation can be used to explain the processes occurring at the particulate level. For instance, when the volume decreases, the number of gas particles colliding with any section of the wall in a given time increases, leading to an increase in pressure. The symbolic representation illustrates Boyle's law based on the variables of pressure and volume, while the graphical representation presents a graph of the same variables as depicted in the symbolic representation.

2.8. Technique's Used to Solve Problems of Contextualizing GL

2.8.1. Questionnaires

Questionnaires were used in a wide range of settings to gather information about the opinions and behavior of individuals. As with any other branch of science, the validity and reliability of the measurement tool, the questionnaires need to be rigorously tested to ensure that the data collected is meaningful (Williams, 2003). When framing and designing questions it is useful to think about the type of question that is suitable for a specific context. It was classified into open and closed questions. In closed questions respondents are asked to indicate how strongly they agree or disagree with a series of statements. Limitation of questionnaires is that will never be sure whether the respondents have understood your questions, or indeed, whether they have taken the time to provide accurate data. Also, you will inevitably have some unanswered questions on some questionnaires these might arise from the respondent being bored, running out of time, not being willing to provide certain information, feeling that they do not know a fact or have an opinion, or not understanding the question. To solve the problems of contextualizing the behaviors of variables in gas laws, multiple-choice tests were used because they could be easily analyzed (Rollnick and Mahonna, 1999; Davies, 2017).

2.8.2. Achievement Tests

Multiple-choice tests for students assisted science teachers in utilizing research findings more readily in their classrooms (Treagust *et al.*, 2003; Simkin and Kuechler, 2005)). The validity evidence for this format was strong. Based on teachers' usage, valid and reliable, easy-to-score, and easy-to-administer paper-and-pencil instruments enabled teachers to effectively assess students' understanding of chemistry (Downing, 2006; Sande, 2010). Multiple-Choice tests were more effective than other methods. It permit coverage of a wide range of topics in relatively short period, could measure different level of learning and cognitive skills. Were objective in terms of scoring and more reliable, suitable for item analysis, providing valuable diagnostic information, and served as viable alternatives to interviews and other qualitative tools for gauging students' understanding and determining the prevalence and distribution of misconceptions across a population (Caleon and Subramaniam, 2010a; Sanger *et al.*, 2013; Gillette and Sanger, 2014; Towns, 2014).

2.8.3. Retention of Knowledge

Is long-term effects of instructional performs, which associate with retention of knowledge to give information about the effectiveness of instructions (Bahrick, 2000). Emphasized one factor influencing the retention of knowledge as being the nature of instructional approach (Semb and Ellis, 1994; Karpicke and Roediger III, 2008; Freeman *et al.*, 2014; Wahbeh and Abd-El-Khalick, 2014; Hattie and Donoghue, 2016). With respect to different qualitative aspects of instructions learners differed in their forgetting and retaining of knowledge. Students in active learning environments forgot less than the students in relatively less student-centered classrooms. If students are able to see the relevance of science to their lives and perceive it as meaningful to learn, they will retain more of the knowledge that they learned during the instructional practices (Taasoobshirazi and Carr, 2008). It was revealed from the literature that there was a lack of context-based studies documenting the results on students' knowledge retention following the context-based instruction.

Several studies revealed that context-based instruction was effective in terms of students' retention of knowledge, as assessed by open-ended questions, even four months after the treatment (Tokdemir, 2016). This demonstrated the influence of context-based instruction on students' retention of knowledge. The inclusion of retention as a dependent variable in this study aimed to present findings regarding the effectiveness of context-based instruction on students' knowledge retention when compared to traditional instruction, thus contributing to the existing literature on knowledge retention. Context-based instruction emerged as a promising approach that helped students retain what they learned more easily, aligning with the objectives to be attained and facilitating the application of knowledge to their daily lives over the long term. The achievement of knowledge retention regarding the concept of gas laws was assessed using a retention test.

2.9. Methods to Investigate Challenges of CB Instructional Activity

Relevant literature was analyzed, learners are found to haven misconceptions regarding gases (Yalcin and Yalcin, 2020) and have difficulty learning the subject of gases since it was an abstract concept. So as; to prevent learners from coming to class with inadequate knowledge, it seems crucial to design opportunities and materials that will interest them in the subject and allow them to think rationally.

2.9.1. Observation

Observations can provide critical insights into educational processes that surveys or interviews might miss. The researcher. Additionally, it was helped the researcher in setting suitable questionnaires. Accurate checklists supported the observation. For this purpose, some students were evaluated and included in the analysis to show students' ability towards connected chemistry with daily live activity (Ong *et al.*, 2017). Other advantage of observation for this research is; that to answer the questions of what? Where? The availability of aids could be located.

2.9.2. Interviews

Interview is defined as the verbal conversation between two participants with the objective of collecting relevant information for the purpose of research to gain an understanding of participants on certain issues undertaken on personal one-to-one basis or in a group to obtain detailed descriptions of the story behind a participant's experiences (Edwards and Holland, 2020). Interviews are primarily used in qualitative research occur when researcher ask one or more participants general or open ended and record their answer of audio tape are utilized for more consistent transcription (Cresswell, 2013).

The purpose of interviews was to find out what were in participants' mind. What they think? Alternatively, how they feel about something? Even though interview strategies have the advantages of gaining in-depth information and flexibility. However, it has its own limitations such as; large amount of time is required to interview a large number of participants in order to obtain greater generalizability and training in interviewing is required for the researcher. In addition, interviewer bias may taint the findings. The analysis of data is a little bit difficult and cumbersome (Adadan and Savasci, 2012).

3. METHODOLOGY

This chapter presents the description of research area, treatments, research design, participants of the study, sampling techniques and sample size, data gathering instruments and methods of data analysis

3.1. Description of the Study Area

This study conducted at Ejersa Goro secondary school of Jarso district, East Hararghe Zone of Oromia Regional State, Ethiopia. The Ejersa Goro Secondary School was established in 2003. The researcher has been teaching in the school for long years and has associated with the school community living around the school. This create an opportunity to a better understand the students' background and associated problems in teaching learning environment. Moreover, based on his experience as a teacher in the school, he noticed low achievement and usually scored low results in gas laws. The societies living around the targeted school have similar culture living styles, speak the same language, and similar socio-economic income.

3.2. Description of the Study Participants

The target populations of the study were selected from grade 9 students of 2022/2023 academic year learning in Ejersa Goro secondary school. All of them speak afan Oromo language; similarly, they have been learning their first-cycle education in Afan Oromo language.

3.3. Study Design

The study followed quasi-experimental research design, which contain pre-and post-test. The quantitative part included pretest, post-test and retention test used to assess the effects of contextualizing instructional activities on the concepts of gas laws. The qualitative part includes interviews, questionnaires and observations. Pretest was given one week before intervenvention started. For these purpose, two classes of grade 9 students have used while one served as control group and the other as an experimental group. Tutorial class have had been adjusted for the treatment purposes.

Both group students were attended the tutorial classes for two hours per week for six consecutive weeks. Interviews and observations has conducted for experimental group students started on the 4th and 5th weeks to assess the attitudes of the students towards context-based approaches of teaching the concept of gas laws.

3.4. Sampling Procedure

A convenience sampling technique was used to select these students as participants of the study. The convenience sampling technique allows using existing groups to select the participants (Tastan *et al.*, 2010). Prior to implementation, the researcher introduced about the purpose of the study to school principals and got permission for implementation. Accordingly, the existed classrooms of grade 9 students in 2022/23 Academic Year was considered for the study. Then, the researcher assigned existing participants in the classrooms as control group (n=35) and an experimental group (n=37) in the same academic years.

In the control group (CG), there were 35 students, comprised of 21 males and 14 females. In the experimental group (EG), there were 37 students, including 24 males and 13 females. These students had not dropped out of school and were diligently following their studies prior to the beginning of this research. This ensured a comprehensive understanding of how the data included the students' scores, backgrounds, and other relevant information without any missing data. Overall, the students from both classes were adequately represented in the study. The number of respondents was 72 students from grade 9 (Table 3.1)

Table 1. Samples of the study in terms of gender and group

Group	Number of participants		
	M	F	Total
Control group	21	14	35
Experimental group	24	13	37
Total participants	45	27	72

3.5. Treatments

The participants were 72 grade 9 students from two sections. The treatment tool consisted of twelve learning plans for six weeks, 60 minutes of contact time (two hours per week), totally 12 hours of learning activities. During six weeks, each group received an equal amount of instructional time and was provided with the same materials, the topics of the lesson were the same for both groups based on the current Ethiopian grade 9 chemistry curriculum, the difference were only in the way they were taught. In the study, two different instructional methods were used. The unit of ‘physical state of matter’ covers many fundamental chemistry concepts. The topics in the unit includes introducing state of matter, kinetic theory and properties of matter, kinetic molecular theory of gases and gas laws are some of concepts that can be mentioned.

3.5.1. Control Group

Control group students completed the section through lecture/ usual teaching method of chemistry in which the teacher prepared daily lesson plan for each lesson, present the new concept while the students listening the teacher, paying attention, taking notes and doing class activities individually. The students advised to study the textbook before each lesson. Most of the time of the instruction was covered by the teacher's explanation and questions. Sometimes the researcher asked questions to explore whether the students understood the concepts and sometimes students were allowed to ask questions and the researcher made appropriate explanations for the asked questions but without considering context-based instructions.

3.5.2. Treatments of Experimental Group

The experimental group was treated contextually as such; six context-based projects were prepared to develop students' motivation and reduce misconceptions by using locally available materials followed the work of (De Jong and Taber, 2014). Accordingly, since Context-based instruction is used for orientation, motivation, illustration, and applications, Contexts from daily life are presented as the starting points for teaching concepts which are then followed by others to implement experimental activity followed the following principle;

To demonstrate the experimental activity of gas concepts miller's steps were followed and procedures starting from solid postponed to gases to engage in experimental activity was applied (Grigorenko, 2005; Demelash *et al.*, 2023).

1. Real context was identified: an experimental activity for conceptual level gas laws at macro, micro, symbolic and graphical representation were identified. For Boyles gas law
2. Experimental context was designed: for activity, the experimental manuals were prepared and distributed to each group, the manuals attached in the appendices (2).

For each gas law's conceptual level of science an experimental activity available in our school and in our environment was selected. for Boyles gas laws, to describe relationship between volume and pressure keeping temperature constant, means no change on the temperature to show inverse relation of pressure and volume of a gas investigator selected glass and plastic syringe; compression of gaseous particles cotton and partially air filled balloon were designed.

At symbolic representation, an exercise questions derived from an experimental activity was provided as they compare with their experimental records. To accelerate their graphical representation level of understanding square paper were provided in order to draw the graphs showing inverse relation of pressure and volumes. For Charles gas laws (the direct relation between temperature and volume) at constant pressure to demonstrate macroscopic conceptual level, microscopic level, symbolic level and graphical representation level as for Boyles law graph paper was designed.

3. Materials was collected: the sources of materials were school laboratory class, students themselves and investigator. Before demonstrating, the students were categorized in to different groups based on the materials that they may bring. The cooled water, coke, demonstrate.
4. The context was introduced: before starting the experimental activity, the context of an experimental activity and its objective was introduced at macro, micro, symbolic and graphical representation levels.
5. Experimental setup was adjusted before starting the activity. Researcher adjusted the set up.
6. Guiding experimental activity: During experimental activity, the researcher carefully guides implementations of an activity.
7. Post experimental analysis: after the completions of each activity the achievements of demonstration the way they carried out was analyzed.
8. Reflecting the conclusion: the learners was discussed on what they have observed and the questions provided on the prepared manuals. Then they reflect their conclusion.

At the beginning of context based instructional classes the researcher started with questions which links concepts of gases with real world the learners have had adopted in their daily life activities on each level of concepts. E.g. Before implementing Boyle’s gas laws experiment at macro level the next questions were provided to the learners. Some of the questions were; what will happen to the pressure of gases in the football when it loses its strength and its size became shrank. Have you seen a car tire when it requested to be pumped, why? Can you give me examples of materials that require pumping of air to make it functional in your daily life activities? What do you think to be happened to the volume of gases when high pressure was applied or exerted on the container containing gases?

Then, during the implementation of an experimental activity, students were grouped in to five cooperative group containing seven and eight students each in which individual member of a group has their own roles. Then they recorded their observations carefully. Then an activities related to the experimental procedures were provided by the researcher which they have discussed on it. Accordingly, chemistry teachers should enrich the learning environment as well as encouraging students to actively participate in learning activities to improve the outcomes of chemistry learning (Osman and Sukor, 2013). Students' were learned scientific process, including observation, experimentation, and data analysis. After the discussion was finished with students' on explanations related to contexts and the observation, the researcher progressed for further activities to verify if the students clearly understood the concepts (Osborne *et al.*, 2003; Ramadhani *et al.*, 2023). These groups were designed to be similar, and heterogeneous in terms of students' performance.

Students carried out the activities in groups of seven and eight and the researcher walked around the tables and asked some questions related to activities to help them understand the concepts. After the students finished the activities, the results were presented and discussed with the whole class, and teacher emphasized on important points of the topic to clarify misconceptions (Hwang *et al.*, 2015). During discussions, alternative conceptions held by the students before the activities were re-evaluated and this allowed the students to compare their previous and new knowledge. Such an approach aimed to correct students' alternative conceptions and to present scientific information behind the activities. The next table shows the contents had been learned and time it consumed.

Table 2. Main topics covered in experimental class for 1hour per each activities

No.	content	Concepts to be learned	Experimental activity and materials used to implement	An expected out comes
1	Boyles gas laws	1.1. Macroscopic properties of gases based on pressure vs volume relation keeping temperature constant	100 ml glass syringe and 50 ml plastic syringe	Practically understood the relationship between pressure and volume keeping temperature constant
		1.2. Microscopic properties of gases in relation based on pressure vs volume relation keeping temperature constant	Glass syringe Plastic syringe Balloon	1.Explain why compression and expansion of gases practically 2.collission of gases molecules with each other
		1.3. Properties of gases in relation based on pressure vs volume at symbolic level keeping temperature constant	Different problems based on pressure volume relations were provided (Sanchez, 2018)	Developing skill of solving stoichiometric problems which is directly connected to learners' daily life activities and experimental activities they have had conducted
		1.4.Graphical representations as pressure – volume keeping temperature constant	Recorded data from experimental activity and additional data were provided (Sanchez, 2018)	Inverse relations of pressure and volume at each graphical point were observed
2	Charles law	2.1. Macroscopic properties of gases in terms of volume temperature keeping pressure constant	Heat source, thermometer, cold water, different types of syringe	Explain direct relations of volume and temperature keeping pressure constant
		2.2. Microscopic properties of gases in relation based on temperature vs volume relation keeping pressure constant	Heat source, thermometer, cold water, different types of syringe, air balloon	Determine compression of gases in the syringe at molecular level
		2.3. Stoichiometric relations of volume of a gas and its temperature keeping pressure constant	Solvable problems of Charles laws	Solve problems of Charles laws and connect with real environment.

		2.4. Graphical representations of Charles laws	Recorded data	How raw data from experimental investigation can be converted to graphic expression
3	Gay-Lussac's gas laws	3.1. Macroscopic prope|Zrties of gases in terms of pressure-temperature keeping volume constant	1 liter plastic container, air balloon, hot water, beaker, ethyl alcohol or sprit	Relationship between temperature and pressure keeping volume constant as they are directly related
		3.2. Microscopic properties of gases in relation based on temperature Vs pressure relation keeping volume constant	1-liter plastic container, air balloon, hot water, heat source	Effects of temperature on particles of gases in a fixed volume
		3.3. Stoichiometric relations of pressure of a gas and its temperature keeping volume constant	Solvable problems of pressure temperature keeping volume constant	Solving problems related pressure –temperature related in a real world and in their daily life activities
		3.4. Graphical representations of Gay-Lussac's gas laws	Providing a data which is recorded from different experimental activities	Developing skills and experiences of sketching graphs of pressure and temperature related based on given information

An approach for learning and teaching concepts of gas laws of chemistry were easy to implement experimental method based on three basic domains (1) macro chemistry, chemistry which is experienced at the tangible, visible and sensory level, (2) sub micro chemistry, which explains macro-chemistry at the atomic and molecular level with the kinetic perspective, and (3) representational chemistry which includes symbols, equations, stoichiometry, and mathematics (Johnstone, 1993). To apply the domain several experimental procedures were prepared to understand and examine complex concepts of science through its simplified models and visual representations were significant(Gilbert, 2010; Permatasari *et al.*, 2022). The role of multiple representation particularly through pictorial representations to teach concepts of gas laws enhances conceptual understanding cognitive retentions were mentioned (Munfaridah and Goedhart, 2022).

Researcher has prepared a lesson plan for experimental group and control group students for each 3 concepts of Boyle's, Charles and Gay-Lussac's gas laws as macro level concept, micro level, symbolic and graphical representation level. To contextualize micro and macro concepts of each gas laws six experimental projects and six context based instructional activities were prepared. For examples, the lesson of gas laws and experimental procedures applied for the experimental activities of Boyles' gas law as indicated appendices (5). Instructional plan for the concept of Boyles' gas law behavior in term of Pressure versus Volume keeping temperature constant.

Experimental activities for the macro level concepts of Boyle's gas laws; At the end, in order to evaluate the long term effect of the teaching methods and to get detail information about their understanding of the concepts of gas laws concepts and to determine the effect of the new method on students' attitude towards the target concepts, 12 students were selected from the experimental group students and conducted interview.

3.6. Data Collecting Procedure

The researcher used both primary and secondary data sources. The primary data were generated through questionnaires, interviews and observations. The secondary data also collected from different sources such as journals, documents, Textbook, science Google like Eric, Google scholar. To gather data, the researcher designed different instruments like Observation and semi-structured types interviews were being provided to respondents in their languages to gather qualitative data; were as pretest, posttest, questionnaires and retention test were used to derive quantitative data.

3.7. Data gathering instruments

3.7.1. Achievement test

A pre- test and post-test was administered to measure students' knowledge of gases and ultimately their improvement toward achieving learning goals. The Context Based questions have been designed in a multiple-choice format.

3.7.1.1. Pretest

Questions of pretest were 10 multiple questions having one correct answer and three destructors designed to assess students' prior knowledge of gas law concept at macro, micro and symbolic and graphical representation. Out of 10 questions; 4 of them were developed by (Hammar, 2013), 3 questions were directly taken from grade 9 textbook and three questions were developed by researcher himself. This nuanced format emphasizes the structured evaluation of students' grasp of gas laws through various representational frameworks, aiming to provide a comprehensive assessment mechanism. Pretest contains 10 items of three focused on macro level concept, three other micro level, three symbolic representational level and one aimed to asses pre knowledge of learner's came with concept of Boyles, Charles' and Gay-Lussac's gas laws in terms of pressure, temperature and volumes of gaseous properties.

3.7.1.2. Posttest

Twelve multiple choice question (MCQ) items were demonstrated to targeted learners. Each of the question item was designed proportionally by considering Boyles law, Charles and Gay-Lussac's gas laws to assess macro, micro, symbolic and graphical representation conceptual level understanding of participants. For each concepts, three questions were prepared. The posttest questions were some of them adopted from literature (Hammar, 2013) and part of them was developed by researchers.

3.7.1.3. Retention Test

Retention Test was given to EG students three weeks after the completion of the unit. It aimed to evaluating students' cognitive retention of the major gas concepts they learned with

CBA. For the purpose, twelve multiple-choice question (MCQ) were administered. The administered questions were prepared congruently to measure properties of gases at macroscopic conceptual level, microscopic level, symbolic level and graphical representation levels of Boyles, Charles' and Gay-Lussac's gas laws. To measure macroscopic properties of gases items 1,2, and 3 was provided. To asses' cognitive retentions microscopic level items each conceptual level 7,8,9 was administered. Question items of 10, 11, 12 were provided to evaluate symbolic representations of experimental group students. The last items provided was to detect understandings of graphical representations. Each items categorically registered and analyzing techniques were performed after computed in software.

3.7.2. Questionnaire

Nine close-ended questionnaires were provided to experimental group (EG) students and distributed to the respondents to collect quantitative data. Questionnaires help to derive opinions, and attitudes towards contextualized instructional process perception, and to know the benefits they get from it (Rowley, 2014). The researcher modified questionnaire used in previous literature from context-based research studies (Quilez, 2007; Ababu Demissie, 2020). Since, adopting previously used data collecting tools by modifying wording and maintaining the essence of its original construct preserve reliability and validity (Harris and Brown, 2019). Questionnaires are modified as follows

Table 3. Modified questionnaires

Original questions	Modified one	Sources
Does learning by CBA make you feel not boring?	Does learning gas laws through CBA engage you?	(Quilez, 2007; Ababu Demissie, 2020).
Does CBA class allow you to discuss on your learning with your friends?	Does CBA class allow you to discuss with your classmates?	
Does CBA improve teacher – student interaction?	Does CBA improve your interaction with your teacher?	
Does CBA enforce you to use (visit) library more frequently and use other information sources?	Does CBA encourage you to use the library and other information sources more frequently?	

3.7.3. Observation

. Classroom observation was assisted by systematic checklist adapted from (Siegel, 2005). The observation was conducted once for both group before starting interventions to identify availability of classroom. Then, on 4th and 5th week only EG was observed twice a week to collect qualitative data regarding Availability of class room, Interest of learners, Cognitive skill of learners' behaviors, and Motivational skill of learners.

3.7.4. Interview

Semi-Structured interview was provided to collect attitudinal data of the students. The interviewees were selected for interview to insight their attitudes towards context based process of learning gas laws. To collect data from experimental group student has modified pre-existing semi structured and structured types of interview were used. This might involve modifying language, adjusting the focus of questions, or changing answer scales to align with the cultural or educational setting of respondents (Hyman *et al.*, 2006).

The reason why the researcher used both types of interview was to increase the similarity of the respondents' responses and to decrease the researcher's personal judgment. The interviews were conducted purposively selected 10 students from the observed classes. Since purposive selection was important for interviewing actively participated and volunteered students to get deep insights of their attitudes towards context based approaches. The focus of the interview was to obtain information that helps to triangulate the data gathered through other tools about the impact of context based activities on the concepts of gas laws students' attitude, the extents of CBA the types of activities in experimental group understanding of what they discuss in tasks in each activities.

3.8. Quality Control Procedure

To insure the quality of this research, the following essentials procedures were used.

3.8.1. Validity

Validity describes appropriateness, precisions and accuracy of data based on research question being studied (Silverman, 2006). Accordingly, to conduct appropriateness and validity of each tools collaboratively chemistry department teachers were consulted to evaluates quality of pretest, posttest and retention test as well as validity of questionnaires and interview were approved by linguistic and English language department teachers with school vice director. Researcher designed mixed method and different data collecting instrument to answer the research questions and to achieve its objectives. Then, the researcher collected appropriate quantitative and qualitative data through these instruments in order to get the valid findings of the study. Based on research questions and its objectives, the instruments were designed. The research was conducted with collaborations of chemistry department staff members regarding research frameworks and its contents and using test to find the data in a way, which provides base for generalization of findings from the sample to the population.

3.8.2. Reliability

It refers to whether a research instrument is consistent across multiple occasions of its use for checking the consistency and stability of the finding, the research instrument would produce the same results on different occasions (Silverman, 2006). The researcher implemented different data collecting tools; pretest and posttest adopted from (Hammar, 2013) which its reliability has been tested. However, languages and its expression was modified which request its reliability to be retested. Samples of pretest question items were administered before three days for 10 pilot students selected from both classes. Their results of pilot group scores were identified into their conceptual targets and recorded, inserted to SPSS to test reliability. At macroscopic conceptual level .796, at microscopic level .806, at symbolic level α= .865 and at graphical representation level Cronbach α= .833 were resulted. Questionnaires and interviews were adopted from (Ababu Demissie, 2020). The data on the of effectiveness of the method on the achievements of the students', participation, and attitudinal change on particular gas law concept. However, since there were some modifications, to test reliability of Posttest 13 questions were administered for nine students four days ago before posttest administration and evaluated consistency of each questions at each conceptual level; as a result, question number three were rejected. Computed Cronbach's alpha was resulted α=0.792 at macroscopic conceptual level, microscopic conceptual level .857, at symbolic representational level Cronbach's alpha was .880 and graphical representation Cronbach's alpha = .764,

3.9. Dependent and Independent Variables

This study employed two types of variables, which were dependent and independent variables as listed below

Table: 4. Variables of the study

Independent Variables	➢ Context based instruction ➢ Traditionally designed chemistry instruction.
Dependent Variables	➢ Achievement test

➢ attitudes of students

3.10. Methods of Data Analysis

The aim of current research study was to investigate effect of context- based approach on the concept of gas laws on the students' achievement and their attitudes. Both qualitative and quantitative methods of data analysis was performed. The quantitative data was analyzed using inferential and descriptive techniques of data analysis in terms of mean, standard deviation, average etc. The independent t-test used to determine the difference between two mean scores of the two groups were significance or not and the degree and the nature of relationship between two variable control group and experimental group.

The difference between pre-test and posttest data of experimental and control groups were analyzed via independent samples t-test to determine whether the modified teaching strategies improved student understanding of gases and gas laws.

Qualitative data derived from close-ended interviews, systematic classroom observation and questionnaires of respondents were analyzed descriptively as frequency distributions and percentage distributions. Open ended interview type responses of participants through content analysis.

Retention test score was recorded and analyzed by comparing with EG students' posttest using independent t-test. This is useful to determine whether context based instructional process improve cognitive retention of students or not.

3.11. Ethical Consideration

The investigator discussed with the concerned bodies and has explained the objective and purpose of the study. The students were informed as the study would carry out for the purpose of in enhancing their achievement and would participate voluntarily. Above all, the investigator has taken into account the ethical issue while conducting this research. To communicate with the school principals, an official letter was being taken from Haramaya University. Generally, all of the information was properly analyzed without any exaggeration.

4. RESULTS AND DISCUSSION

This chapter concerns with detail discussions methodology engaged in the study, findings from the research instruments based on objective of the study were provided. As already mentioned under the method of data collection in chapter three, each of the data collection instrument (observation, achievement test, semi-structured interview, questionnaires) was used to address the leading research questions raised in this study. Therefore, the results of the study obtained from the pretest, post-test, interview and questionnaires were analyzed and discussed together according to each research questions mentioned in chapter one as follows. Students' Achievement on Concept of gas laws.

4.1. Achievement test

Three achievement tests (pretest, posttest and retention tests) were given to both group students to asses' effect of context-based approach in teaching concept of gas laws at four conceptual level namely macro level, micro level (particulate level), symbolic representational level and graphical representational level of learners'.

4.1.1. Pretest

Table 5. Comparison of pre-test Results from Independent T-test

Conceptual level	Group	N	M	SD.	t	Df	Sig. (2-tailed)	MD
Macro level concepts	CG	35	1.03	0.923	-0.405	70	0.687	-0.080
	EG	37	1.11	0.737				
Micro level concepts	CG	35	0.80	0.833	-0.648	70	0.519	-0.119
	EG	37	0.92	0.722				
Symbolic level concepts	CG	35	0.91	0.742	-0.798	70	0.428	-0.140
	EG	37	1.05	0.743				
Graphical level concepts	CG	35	0.34	0.482	0.661	70	0.511	0.073
	EG	37	0.27	0.450				

Not significant at P > 0.05, EG = Experimental group, CG = Control group, N = Number of EG and CG students), SD = Standard deviation, Df = Degree of freedom, MD = Mean difference.

The independent sample t-test analysis was performed and the result reveals that there were no statistically significant differences at each conceptual level understanding (macro, micro, symbolic, and graphical) between the control group and the experimental group. All p-values are significantly higher than the typically accepted threshold of 0.05, suggesting that both groups had comparable understanding prior to any intervention or instructional methods applied during the study. This result was consistent with studies conducted in Taiwan entitled with "argumentation and students' conceptual understanding of properties and behaviors of gases" (Aydeniz *et al.*, 2012).

4.1.2. Posttest

Table 6. Comparison of posttest through independent sample t-test

	Group	N	M	SD	Df	MD	t	Sig. (2-tailed)
Macro level concepts	CG	35	1.00	0.804	70	-0.865	-5.092	0.000
	EG	37	1.86	0.631				
Micro level concepts	CG	35	0.66	0.765	70	-1.208	-6.172	0.000
	EG	37	1.86	0.887				
Symbolic level concepts	CG	35	0.63	0.808	70	-0.912	-4.606	<.001
	EG	37	1.54	0.869				
Graphical level concepts	CG	35	0.60	0.736	70	-0.589	-3.232	0.002
	EG	37	1.19	0.810				

Were CG=control group; EG=Experimental group; N=# of control group and *experimental group; M=mean score; SD= standard deviation; Df=degree of freedom; MD= mean difference*;

Table 4.2: shows the independent t-test analysis of posttest for CGS and EGS at macroscopic conceptual level, microscopic concept level, symbolic and graphical representation level of gas laws. The result revealed that there is statistically significant difference was observed on the posttest between EG and CG students (at $\alpha = 0.05$, $p < 0.05$) at macro level. The mean score (1.86) of the EG which is higher than that of the CG (1.00). The result of independent t-test of posttest showed that the experimental group students who taught the gas law concept with CBA achieved better on the posttest than students in the control group (who were taught the topics with the lecture method (Leslie and Bearden, 2023b).

The results revealed that a statistically significant difference was observed in the posttest scores between the experimental group (EG) and the control group (CG) at the micro level ($\alpha = 0.05$, $p < 0.05$). The mean score of the EG was 1.86, which was significantly higher than that of the CG, which had a mean score of 0.66. The independent t-test indicated that students taught gas law concepts using the Concept-Based Approach (CBA) performed

markedly better than those in the control group who received traditional lecture-based instruction, as evidenced by a mean difference (MD) of -1.208, a t-value of -6.172, and a p-value of 0.000. The research in lined with which conducted at University of West Georgia, USA to employ context based learning (Sanchez, 2018; Leslie and Bearden, 2023).
Similarly, an analysis at the symbolic level also demonstrated a significant distinction between the groups ($\alpha = 0.05$, $p < 0.05$). The experimental group achieved a mean score of 1.14 compared to the control group's mean score of 0.63, resulting in a mean difference of -0.507. The t-value was recorded at -0.912, and the results were statistically significant with a p-value of 0.006, confirming the positive impact of the CBA method on understanding symbolic representations in gas laws (Sujak *et al.*, 2017; Sanchez, 2018).

The results for graphical level concepts mirrored these findings. The EG scored mean of 1.38, while the CG had a mean score of 0.60, resulting in a mean difference of -0.778. The independent t-test yielded a t-value of -4.534 and a p-value of 0.000, underscoring the strong statistical significance of the findings (Aubrecht *et al.*, 2019).

In conclusions, independent t-test analyses across different conceptual levels affirm that the CBA significantly enhance students' understanding when compared to conventional teaching approaches. Across all conceptual levels (macro, micro, symbolic, and graphical) the consistent outcome was that students instructed through CBA outperformed CG students who taught via traditional methods. The overall statistical significance ($p < 0.05$) across these levels supports the notion that context based instructional approach is crucial for enhancing educational outcomes in teaching gas laws. This provides a compelling argument for the adoption of innovative pedagogical strategies in educational practices (King *et al.*, 2008; Rivera and Sanchez, 2020; Thees *et al.*, 2020; Sanchez, 2021; Demelash *et al.*, 2023).

4.1.3. The Mean Gains of EG and CG Students

Table 7. Percentage of Correct Responses in the Post-test for the Item of Content Area

Conceptual Level	QI	Contents	Number of correct answer			
			CG	%	EG	%
Macro level	2	Boyles' gas laws	14	40 %	25	67.56 %
	5	Charles' law	10	35 %	19	51.35 %
	7	Gay-Lussac's law	11	31.4 %	25	67.56 %
Micro level	1	Boyles' gas laws	8	22.8 %	27	72.97 %
	4	Gay-Lussac's law	6	17.14 %	21	56.75 %
	12	Charles' law	10	28.57 %	19	51.35 %

Symbolic	11	Boyles' gas laws	11	31.42 %	23	62.16 %
conceptual	9	Gay-Lussac's law	6	17.14 %	13	35.13 %
level	13	Charles' law	10	28.57 %	15	40.54 %
Graphical	6	Gay-Lussac's law	3	8.57 %	3	8.10 %
representation	8	Charles' law	13	37.14 %	19	51.35 %
level	10	Boyles' gas laws	4	11.42 %	13	35.13 %

To highlighted specific contents of each question items, item#2 concerned Boyles law to insight macroscopic properties of gases in terms of pressure versus volume in which increasing pressure decreases volume of a gases; 14(40%) of control group students and 25(67.56%) gave correct answer. This achievement differences between two groups may due to the experimental group covered the Boyles gas laws; the relationship between pressure and volume keeping temperature constant or at room temperature using 100 ml glass syringe, 50ml plastic syringe and 10 ml plastic syringe experimental activity (Kautz *et al.*, 2005). Pressing pestle of a syringe downward represents pressure and volume of a syringe decreased. Question #5 was deals with effects of temperature on volume of a gases at macroscopic conceptual level keeping pressure of a gases constant. 10(35 %) students of CG and 19(51.35 %) of EG answered correctly. This achievement differences may the due to, the EG was covered the concept of Charles gas laws at macroscopic level by the experimental activity using syringes inserted water heated at different temperature through measuring temperature of a water in a 5-minute time interval (Kautz *et al.*, 2005; Sanchez, 2017).

As a syringe inserted in a hot water volume of a syringe expanded by pushing up the pestle. The same experiment was repeated with cold water; the volume was decreased. Item 7, was describes the relationship between temperature and pressure of gases keeping volume constant (Gay-Lussac's gas law). 11 (31.4 %) of CG students and 25(67.56 %) of EG was correctly answered correctly. This differences in achievement may due to; the experimental group was covered the concepts by using experimental activity using different apparatus. Example, inserting 1L plastic water container closed by small sized partially air-filled balloon in hot water. Immediately partially, air filled balloon removed from the container due to increased pressure inside the container. They observed effects of temperature on pressure of a gases in a container and understood that increasing temperature causes increasing of pressure inside the container (Hernández *et al.*, 2014).

Item# 1, 4 and 12 were focused on microscopic properties of gas behavior. 8 (22.8 %) of CG students and 27 (72.97 %) of EG students correctly answered item 1. This difference may result of, EG students covered the concepts through experimental activity using partially air filled balloon and cotton inserted in a different sized syringe. The cotton and air filled balloon was shrink as a pestle pushed down which describes compression of gases as pressure increased at particulate level. As a pestle turned back the expansion of a cotton and partially air filled balloon determines expansion of gas particles. CG students answered correctly item 4, was 6(17.14%) and number of EG students gave correct answer for this item was 21(56.75). This huge achievement score was the result of, experimental group completed the concepts by experimental activity through observing and practicing effects of temperature on gases particles by inserting partially air filled balloon in hot water and cold water exchange ably. The balloon increased by size and move on the surface of boiling water which shows increasing kinetic energy of gases in the balloon (Kautz *et al.*, 2005).

For Item related to the degree of consumption of symbolic concepts, CG correct symbols and EG correct responses were compared for each items independently. EG correct response of item 11 was 23(62.16 %) and CG correct response was 11(31.42%). Correct response of item#9; were 6 (17.14 %) from CG and 13(35.13 %) from EG; regarding this concept item13 correctly answered by both group were, 10(28.57%) of CG and 15(40%) by EG. This great difference in achievements may, EG students completed the concepts of symbolic level through utilizing the data recorded from experimental activity at macro and microscopic level for Boyles, Charles and Gay-Lussac's laws to solve related problems.

Item 6, 8 and 10 was to asses' graphical representation level of understanding gas laws. For Item 6, both the CG and EG demonstrated similar low performance, with 3 correct responses each (CG: 8.57%, EG: 8.10%). Item 8, which focused on Charles' law, the CG scored 13 correct responses (37.14%), while the EG scored 19 correct responses (51.35%). The improved performance by the EG can be attributed to their context-based instructional activities. Through practical experimentation, EG students not only gathered data but also had the opportunity to practice representing this information graphically. This hands-on approach likely facilitated a deeper understanding of the relationship between temperature and volume, enabling them to translate their observations into accurate graphical forms (Li and Black, 2016; Nielsen *et al.*, 2020).

For Item 10, concerning Boyle's law, the CG posted 4 correct responses (11.42%), whereas the EG scored 13 correct responses (35.13%). Again, the experimental group's hands-on experience significantly aided their understanding. By conducting experiments that illustrated the inverse relationship between pressure and volume, EG students were better equipped to visualize and represent these relationships through graphs. The practical application in the context of their experiments reinforced their learning, highlighting the advantages of context-based instruction over traditional methods in fostering comprehension of abstract concepts.

4.2. Retention test

After completion of contextual activity retention test were provided to experimental group after three weeks. This was to asses' cognitive retention of EG (Kovács *et al.*, 2019). On this achievement test, only 28 students of experimental group were participated.

Table 8. Comparison of retention test with EGPOTS

CLGL	Group	N	M	SD	Df	MD	t	Sig. (2-tailed)
Macro level concepts	EGPOT	37	1.86	0.63	63	0.22	1.312	0.194
	EGRTTS	28	1.63	0.742				
Micro level concepts	EGPOT	37	1.86	0.88	63	0.22	1.029	0.303
	EGRTTS	28	1.64	0.826				
Symbolic level concepts	EGPOT	37	1.54	0.869	63	0.005	0.024	0.981
	EGRTTS	28	1.54	0.744				
Graphical level concepts	EGPOT	37	1.19	0.811	63	0.26	1.33	0.192
	EGRTTS	28	1.18	0.723				

Were; CLGL is conceptual level of gas law, EGPOTS is experimental group posttest score, EGRTTS is experimental group retention test score

For the comparison; score of experimental group demonstrated as posttest was used to assess cognitive retention of experimental group at each conceptual level. To assess cognitive retentions among EG posttest scores and retention test score independent sample t-test analysis was performed. The result reveals no statistically significant difference at macroscopic conceptual level, with the mean score of 1.86 (SD = 0.63) on the post-test and 1.63 (SD = 0.742) on the retention test (t = 1.312, p = 0.194). This similarity in achievement suggests that the context-based instructional methods were effective in promoting retention of macroscopic concepts related to gas laws among the students (Sweller *et al.*, 2019; Carpenter *et al.*, 2022). Similarly, at the microscopic level, the independent t-test results showed no significant difference between the post-test (M = 1.86, SD = 0.88) and retention test scores (M = 1.64, SD = 0.826) (t = 1.029, p = 0.303). The lack of significant difference highlights that the context-based instructional approach effectively enhanced the understanding and retention of microscopic concepts associated with gas behavior.

For symbolic level concepts, the independent t-test results indicated that both the post-test scores (EGPOT) and retention test scores (EGRTTS) were identical at a mean of 1.54. The standard deviation for the post-test was 0.869 while it was 0.744 for the retention test, resulting in a very low t-value of 0.024 and a p-value of 0.981. This indicates no significant difference between the two sets of scores. The consistency in performance at this conceptual level suggests that the context-based instructional methods were effective in retaining symbolic understanding of gas laws. This result was in lined with research studies conducted in Indonesia at Seblas university (Zarei, 2022; Ramadhani *et al.*, 2023). The high similarity in scores, despite the absence of statistical significance, reflects positively on the approach's ability to sustain student comprehension over time.

For graphical level concepts, the independent t-test analysis found no significant difference between the post-test scores (M = 1.19, SD = 0.811) and retention test scores (M = 1.18, SD = 0.723) (t = 1.33, p = 0.192). The absence of a significant difference implies that instructional methods have great impact on cognitive retentions and conceptual understanding.
As concluded that; the analyses of the experimental group’s post-test and retention test scores indicate that the context-based instructional methods were effective in sciences (Stavreva and Veselinovska, 2011). Across various levels of conceptual understanding of gas laws. While the comparisons showed no statistically significant differences, this similarity in achievement points to a positive outcome of the context-based approach in supporting both retention and understanding among students. This results were in lined with research studies conducted at Cebu University, Philippines (Sanchez, 2021).

4.3. Results Obtained from Observation

In this study, classroom observation were employed as tools to assess the reaction of students with in a class and what actually happened in the class when students taught about concepts of gas laws through CBA. The researcher has collected data through observation about the reaction of students in EG class and CG class before starting the instructional intervention and throughout the process. The observation was carried out using systematic checklist.

Table 9. Systematic checklist used for classroom observation

N	Target of observations	Standard of observation							
		CG				EG			
1	Engagement Level	1	2	3	4	1	2	3	4
1.1	Engagement during macroscopic properties		x				x		
1.2	Curiosity during microscopic concepts	X				x			
1.3	Enthusiasm for symbolic representation		x				x		
1.4	Focus during graphical representations		x				x		
2	Interest in Conceptual Understanding								
2.1	Interest in real-world applications		x				x		
2.2	Insights on microscopic interpretations	X				x			
2.3	Eagerness for problem-solving	X				x			
2.4	Discussion on how construct data graphically		x				x		
3	Motivation to Participate								
3.1	Volunteering to present classes at any time		x				x		
3.2	Collaboration on microscopic concepts		x				x		
3.3	Initiative in solving formulas		x				x		
3.4	Contribution to graphical discussions		x				x		
4	Cognitive Development Indicators								
4.1	Relating macroscopic behavior to experiences	X				x			
4.2	Connecting microscopic and macroscopic	X				x			
4.3	Accuracy in calculations		x				x		
4.4	Analysis of graphical relationships		x				x		
5	Readiness to Learn								
5.1	Understanding of prior knowledge		x				x		
5.2	Confidence in microscopic discussions		x				x		
5.3	Readiness for mathematical representations		x				x		
5.4	Foundation for analyzing graphical data	X				x			

Standard of observation: 1=low 2=moderate 3= high 4 =very high

At the beginning, both groups were observed once using the checklist. Results of pre-intervention observation, both groups exhibit low to moderate engagement across various learning activities, particularly during macroscopic properties, symbolic representations, and graphical representations. There is some Interest in real-world applications and problem-solving, but overall interest in deeper conceptual understanding remains low to moderate. Students show limited willingness to volunteer, collaborate, or contribute to discussions, suggesting a lack of confidence and initiative. Students demonstrate basic skills in relating experiences and calculations but struggle to connect microscopic and macroscopic concepts effectively. While students show a foundational understanding of prior knowledge, confidence in discussing microscopic concepts and readiness for mathematical representations is low.

Table 10. Summary of observation check list

N	Targeted area	Standard of observed area
1.	Engagement Level:	84.5%
2.	Interest in Conceptual Understanding:	85.75%
3.	Motivation to Participate:	93.5%
4.	Cognitive Development Indicators	85%
5.	Readiness to Learn:	83.75%

From observations of experimental group students fourth and fifth week; the way they react to context based instructional process during tutorial class adjusted only for EG was filled twice a week were analyzed as follows.

There were an overall positive trend in student engagement, interest, motivation, cognitive development, and readiness to learn through context based instruction during tutorial class over the weeks. Engagement level observed and the results shows 84.5 % of the students have engaged in different activities of gas laws at each conceptual level that demonstrated in the contextualized class. 85.43% average percentage of students observed when they give positive responses to problems and the eagerness to engage in discussions throughout these weeks as they have learned (Cents-Boonstra *et al.*, 2021; Tshering *et al.*, 2024).

93.75 % of students were show strong motivation to do any conceptual level activities of gas laws in their tutorial classes. Their willingness to volunteer for class presentations and collaborate highlights not only confidence but also a proactive approach to learning. This level of motivation is key to fostering an interactive classroom atmosphere where students are likely to strive for excellence (Rawung, 2016).

An average of 85% of observed student's exhibit solid cognitive development when relating concepts with practical experiences. Most participants connect theoretical knowledge with real-world applications, reflecting their ability to analyze, evaluate, and synthesize information effectively. This cognitive engagement is crucial for critical thinking skills and holistic learning (Khan and Ghosh, 2021; Hanham *et al.*, 2023).

Above 85% of observed for their readiness to learn may suggest that while most students are willing to engage with new content, there may still be some hesitance or lack of confidence regarding foundational knowledge. This can indicate a need for reinforcement in prior knowledge to enhance readiness for new concepts. It may also reflect areas where students feel they need more preparation before fully participating in discussions or activities.

4.4. Questionnaires

Table: 11. Results of questionnaires responses

No	Questionnaires	Yes	No
1	Does learning gas laws through CBA engage you?	83.8%	16.2%
2	Does this method (CBA) relate your learning with your prior knowledge or real-world practical situation?	94.6%	5.4
3	Do you feel more active in your participation when using this method?	94.6%	5.4
4	Does CBA help you think critically?	89.2%	10.8
5	Does CBA improve your English-speaking skills compared to other learning methods?	89.2%	10.8
6	Does the CBA class allow you to discuss your learning with your classmates?	94.6%	5.4
7	Do you feel you retain information learned in CBA for a longer time?	94.6%	5.4
8	Does CBA improve your interaction with your teacher?	97.3%	2.7
9	Does CBA encourage you to use the library and other information sources more frequently?	91.9%	7.1

The quantitative data collected through questionnaires to assess attitude of participants toward CBA on the concepts of gas laws analysis, shows majority of participants had positive attitudes.

The first questionnaire was to assess the engagement of students learning gas laws through CBA. The results indicated that majority of participants (N=31; 83.8%) being engaged by this method. This results of questionnaires were consistent with research studies conducted at Maleysia by which 75% of students strongly agreed to the effects of contextualized materials (Sharif *et al.,* 2021; Tadesse *et al.,* 2024).

#Item 2; was provided to determine whether the CBA relate students' learning to their prior knowledge or real-world practical situations. Majority of respondents 94.6% (N=35) gave yes responses which shows they believe learning through the CBA effectively connects with their prior knowledge and real-world applications (Ababu Demissie, 2020). This high percentage suggests that students find the CBA relevant and beneficial for contextualizing their learning.

#Item 3. To know the effect of CBA on student participation were majority of respondents (94.6%) affirmed their active participation by their yes response. This findings reveal that 94.6% of students were active in their participation when engaged in the CBA method (Tadesse *et al.*, 2024). This suggests that the CBA enhances student involvement, promoting more dynamic learning environment.

#Item 4. Asked to assess effectiveness of CBA on the students' critical thinking abilities. The majority of respondents (89.2%) commented that context based approach to teach gas laws enhances critical thinking of students. This results consistence with research conducted at Ohio State University, USA entitled with applications of physics education teaching (PhET) simulation (Correia *et al.*, 2019).

#Item 5. Was to evaluate the impact of the CBA on students' English-speaking skills. Majority of students (89.2%) commented as CBA enhances their English-speaking skills (Blackie, 2022).

#Item 6. Conducted to assess whether the CBA facilitates opportunities for students to discuss their learning with classmates. The results indicate a strong majority of students (94.6%) believe that the CBA class allows them to engage in discussions about their learning with their peers. This was to affirm item #1 and reveals similar results (Tadesse *et al.*, 2024).

#Item 7. Was to evaluate whether students retain information learned through the CBA for a longer period. 94.6% of student's responses yes; which suggests that students perceive the CBA as an effective instructional method that promotes long-term memory retention of subject matter. This findings were supported by literatures (Brusilovsky and Millán, 2007; Gijbels *et al.*, 2014).

Item 8. A survey aimed at assessing the impact of the CBA on student-teacher interaction. The results show an overwhelmingly positive perception among students, with 97.3% stating that the CBA enhances their interaction with their teacher. Such findings imply that CBA fosters a collaborative and communicative atmosphere, which is essential for effective learning and teaching, this findings were supported by previous studies (Bilgin *et al.*, 2015; Stolk *et al.*, 2012).

#Item 9. A survey evaluating the effect of the CBA on students' utilization of library and other information sources. The findings reveal that a significant majority of students (91.9%)

believe that the CBA encourages them to utilize library and other information sources. This impressive percentage indicates that CBA is effective in promoting resource-based learning, which is essential for developing research skills and critical thinking abilities in students (Agarwal *et al.*, 2011).

In conclusion, the findings from this study overwhelmingly support the effectiveness of the Context-Based Approach (CBA) in teaching gas laws. These findings strongly suggest that the CBA is a valuable pedagogical approach for improving student learning outcomes in science education (Correia, *et al.*, 2019; Ababu Demissie, 2020).

4.5. Analysis of Interview Responses of Experimental Group

To gather relevant information on the effects of context based instructional approach on the gas law concept to know attitudes of students towards the instructional process; 10 students from experimental group was interviewed. The validity of the instruments was enhanced by the use of interviews, which probe students' response to open-ended questions and confirmed that what had been written reflected their opinions about the tutorials. The selected treatment group students were interviewed by the following questions.

1. Out of conventional / traditional instructional process and contextualized instructional process, which one was help full for your conceptual understanding of gas laws? Why? explain your ideas____________________________
2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions___________________
3. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions________________________

For the first question, almost all EG group students gave their appreciation on the way they learned gas law chemistry concept with context based approach using experimental activity. It is evident from respondents' response; they have positive attitude/ appreciated the way they completed the tutorial class of gas law at different concept level with experiential approach.

One student responded that:

> *"I didn't think the lessons we are learning at our level could be demonstrated in practice. We were looking at it from far. Now the one we were waiting for it is realized*

and we saw it. I blamed our teacher for not teaching us in this way till date. he answered question by question."

Other students gave unique response for the first questions as:

It is a CBA. "There is still no one teach us, but now I proved by CBA that education is with us," he replied.

The other respondents answered the first question as:

My choice is CBA, "I was thought before that it is impossible to show chemistry experimentally at school level. Now I have observed, as it is possible locally. This method should continue for us," said.

The next students gave

"My choice is context-based teaching methodology, because, I heard that; chemistry is an action-based subject but *no one showed us. I have actually seen the experiment. What school tell us the presentation for yourself that you do not have, let's continue in this way from now on, since we haven't stopped learning, let's learn in this way, this method has shown us a practical lesson and inspired us".*

For the second questions most of students commented that CBA helped them to develop a deeper understanding of gas laws. They were able to relate abstract concepts to concrete examples from their daily lives, making the learning process more meaningful and engaging. One students responded the second questions as:

"*I also felt very unhappy about it, but I understood as there are many experimental activities around us. I learned from Boyle's law experiment how gases compress* and *exp*and *over time or occupy a larger space. However, I used to get tired of standing for long periods during the experiment because I did not like it. That's all I can say,"***.**

Another female student responded the second questions as:

*"I found something good from this method. I practiced how to show the relationship between changes, temperature, and pressure using graphs. I used to study alone. Since I have a child, it was not convenient for me to meet with friends to study together. Since I started learning with this new method, I have been discussing and working with students without getting tired. This method has connected me with the students. It has opened a way for me to work and discuss to gether" she concluded***.**

There is unique responses; one student comments the next.

"I look at it with a positive attitude. I am a married woman and I am busy in household chores. Usually, I did not come back to school for tutorial programs. I did

not even come on the first day. From the next day, however, I discussed with my husband and asked him to cover my afterschool works. I made some rearrangements because I don't want to miss the tutorial class given with this approach".

Another student responded the last open-ended questions as next:

"*My overall perspective on this teaching method is very positive. Since the day we began learning chemistry, I have not missed this tutorial class for a single day. I traveled a long distance to attend it. I have to stay around the school until then without having lunch to attend the tutorial. Even now, I am focused on this learning experience, because, as I believe that the practical demonstrations, we attended are valuable. Therefore, I hope that this approach should continue in the same way in the future."*

The analysis of the interview responses revealed, the majority of students expressed positive views of CBA except two students gave negative response. These findings highlight the importance of CBA, strong preferences of CBA, appreciated the hands-on nature of CBA, as it allowed them to connect theoretical concepts with real-world experiences.

Additionally, they expressed that CBA helped them to develop a deeper understanding; able to relate abstract concepts to concrete examples, as they found it enjoyable, motivating, engaging and meaningful process. Generally, many students expressed a desire for more CBA instruction in other science subjects. This is in-line with other studies conducted in other areas (Rivera and Sanchez, 2020; Tutal, 2023).

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. Summary

This document presents a study that evaluated the effectiveness of a Context-Based Approach (CBA) in teaching gas laws (Boyle's, Charles', and Gay-Lussac's laws) to grade 9 students. The study used a variety of research instruments, including pretests, posttests, interviews, questionnaires, and retention test to assess students' understanding and achievement across different conceptual levels: macroscopic, microscopic, symbolic representation, and graphical representation. To analyze the quantitative data SPSS-27 was used.

The analysis of the pretest results showed no significant differences in prior knowledge between the control group (CG) and experimental group (EG). However, the posttest results indicated that the experimental group significantly outperformed the control group in macro, micro, symbolic and graphical representation of conceptual understanding. In addition, effectiveness of cognitive retention of EG; were also investigated through EGPOT and EGRT scores. The questionnaires and interviews highlighted students' positive engagement, critical thinking enhancement, and improved interaction with teachers through the CBA method.

The experimental group students reported high levels of engagement, relevance to prior knowledge, active participation, and a tendency to use the library more frequently when learning through CBA. The study concludes that the Context-Based Approach is an effective instructional strategy for enhancing students' understanding of gas laws at different conceptual level of macro, micro, symbolic and graphical representational levels.

The findings have important implications for curriculum development, teacher professional development, and future research. Educators are encouraged to integrate more context-based learning activities that connect gas laws to real-world scenarios, and to explore additional instructional strategies to improve students' understanding of symbolic representations of gas laws.

5.2. Conclusion

This research investigated the effectiveness of context-based approaches (CBA) in teaching gas laws (Boyle’s, Charles’, and Gay-Lussac’s laws) to grade 9 students at Ejersa Goro

Secondary School. It addressed the challenges students faced in understanding these concepts, from under-resourced backgrounds, and evaluated the effect of CBA on students' academic achievements and attitudes towards learning the concepts. The study found that CBA significantly improved students' understanding and achievement at each conceptual level (macro, micro, symbolic and graphical representation). The experimental group also showed a positive attitude toward CBA. The data gathered through close-ended type questionnaires and Semi Structured Interview indicated that students have positive attitudes towards context-based approach. Besides, the findings of the study revealed that in the approach significantly improved students' engagement, participation, and fostered a more interactive and create conducive learning environment as evidenced by the positive feedback from students. Overall findings of the study portray CBA is a more effective instructional method than traditional teaching in enhancing students' understanding and facilitate life-long learning.

5.3. Recommendation

Further Research: Additional studies should be conducted to explore the long-term effects of CBA on various scientific concepts and across different educational contexts, to validate and expand upon these findings.

Should be applied to teach through chemical concepts.

Should be applied to teach through chemical concepts.

Curriculum developers may better design Context-based approach for the gas laws concepts in secondary school chemistry.

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7. APPENDICES

A1: PRETEST

HARAMAYA UNIVERSITY

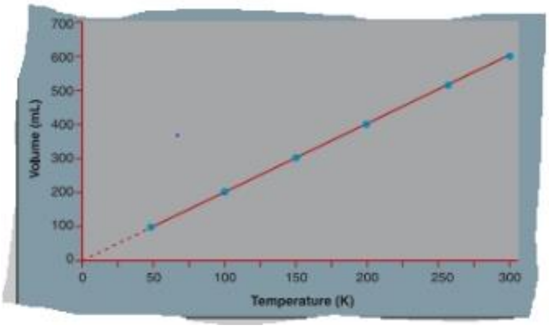
POSTGRAGUATE PROGRAM DIRECTORATE

ITEMS HAVE BEEN USED FOR PRETEST IN CONCEPTS OF GAS LAWS ACHIEVEMENT TEST

Time allowed 30’

DIRECTION: CHOOSE THE BEST ANSWER FROM THE GIVEN ALTERNATIVE AND ENCIRCLE YOUR OWN CHOICE

1. When pressure of a gas increased the volume of a gas will become lower, and then what will happen to the gaseous particles in the container? A. Possess low kinetic energy B. relax further apart C. will come close to each other D. No feasible change on particles of gases.
2. What will happen to the volume of a gas if pressure is increased at constant temperature?
   A. Remains constant C. Cannot be determined
   B. Volume will be increased D. volume will be decreased
3. W/c of the following gas laws can be represented by PV=K?
   A. Charles’ law B. Boyles’ law C. Gay-Lussac’s law D. Graham’s law
4. If a balloon is partially filled with air to 10 ml at room temperature placed in boiling water its volume will be increased, what will happen to the gaseous particles inside a balloon? A. go further apart B. Possess low kinetic energy C. completely disappeared
5. What will happen to the volume of a balloon, if you place air-filled balloon on boiling water? A. increases B. decreases C. remains as it is D. Cannot be determined
6. If certain amount of gas molecules occupies 10 ml volume at 300 K temperature exposed to 500 K temperature the new volume will be _____
   A.16.6 ml B. 166 ml C. 1.66 ml D. 1660 ml
7. Based on the following figures what do you understand regarding the relationship between volume and temperatures?
   A. direct relation B. inverse relation C. Have equal values D. have no relations



8. If the temperature of a gas having constant volume in a sealed containers increased what will happen to the pressure of a gases?

   A. Increased B. decreased C. have no changes D. Un defined

9. What will happen to the gaseous particles in a rigid volume, if temperature and pressures are simultaneously decreased?

   A. Kinetic energy of gases will be reduced
   B. Gaseous particles strike with a wall of container highly.
   C. There is high probability of particles collisions.
   D. There is high motions of particles.

10. Heating a gas cylinder to 250 K raises its pressure to 2.0 atm. What was its initial temperature, assuming the gas started out at ambient pressure (1.0 atm)?

    A. 125K B. 100K C. 10K D. 12.5

A 2: LABORATORY MANUAL

Introduction: Boyle's Law states that, for a fixed amount of an ideal gas at a constant temperature, the pressure of the gas is inversely proportional to its volume. This means that if the volume of the gas decreases, its pressure increases, and vice versa, as long as the temperature remains constant. Boyle's gas law is the law, which deals with the relationship between volume and pressure, keeping temperature constant. As the pressure on a gas increases, the volume of the gas decreases because the gas particles are forced closer together. Conversely, as the pressure on a gas decreases, the gas volume increases because the gas particles can now move farther apart.

Boyle's law

Macroscopic properties of gases

Macroscopic properties can be defined as what can be seen, touched and smelt. It concerned tangible properties. In terms of Boyles gas laws volume of ag gas and its pressure is its macroscopic properties (Johnstone, 2000).

Experiment 1: Determining pressure – volume relation at constant temperature

Objective: Determining macroscopic properties of gas laws in terms volume vs pressure keeping temperature constant

Apparatus:100ml syringe, 50 ml syringe, 10 ml syringe

Weights (to apply pressure)

Procedure:

Use 100 ml syringe

1.Close the hole of syringe

2.Ensure the syringe is empty and the plunger is at the 100 mL at 10 ml mark.

3.Then push dawn the pestle slowly by recording volumes of syringe at each 20 cm volume until the pestle do not go further.

4.Use 50 ml syringe and press dawn by an interval of 10 ml

5.Repeat the above steps with 10 ml syringe and press with the interval of 2 ml

6. Record your observation carefully using tabulated form.

Observation

What change do you observed on volume of a gas as pressure is increased?

Questions: Discuss on the following questions and reflect your conclusion?

1.What was happened to the volume of a gas as pressure increased?

2.From the above three experimental procedures is there any different based on the relation of pressure and volume?

3.What was the relationship between volume and pressure?

Microscopic properties of gases in terms of pressure versus volume

Introduction: during experimental activity of Boyle's Law states that, for a fixed amount of an ideal gas at a constant temperature, the pressure of the gas is inversely proportional to its volume. This means that if the volume of the gas decreases, its pressure increases, and vice versa, as long as the temperature remains constant. This implies as pressure increased gaseous particles will come close to each other and be compressed.

Experiment:2. Determining microscopic properties of gases according to Boyles law

Objective: Determining microscopic properties of gases in terms of pressure- volume relation at constant temperature.

Apparatus: glass syringe, plastic syringe, balloon

Using cotton

Procedures.

1. Setup the experimental procedures
2. Remove the piston
3. Insert the cotton
4. Back the piston and adjust the volume of a syringe on fixed 90 ml or 40 ml for 50 ml syringe
5. Press down the piston through fixed volume of a syringe and record the volume
6. Critically observe what is happening in the syringe.

Questions

1. What is happening to the cotton inside the syringe as you press dawn the pistle?
2. Assuming cotton represented gas particles in the syringe describe properties of gases in terms of cotton at particulate level.
3. Discuss with your group member and reflect your conclusion

USE PARTIALLY AIR FILLED BALLOON

Repeat the above experimental procedures by inserting partially air filled small balloon in each of syringes.

Observation

What did you observe from the experiment?

Questions

4. What change did you observed when pestle pushed down?
5. What happened to the balloon in the syringe?
6. Explain changes on the balloon assuming as a gas particle?

SYMBOLIC REPRESENTATIONAL LEVEL

Objective: Implementing Boyles gas laws at symbolic conceptual level.

Activity: based on your previous experimental score solve the following problems.

1. As you press dawn the pestle of a syringe from initial 100 ml to 80 ml, 60 ml, 40ml and 20 ml by how much pressures increased?
2. If 1atm pressure was applied on 50ml gas containing plastic syringe what pressure was required to compress gases to 10 ml volume keeping temperature constant?
3. When you press 10nl volume of syringe containing air from 10ml to different interval of volume as 8 ml, 6ml, 4 ml, and 2 ml assuming initial pressure is 760mmHg (1 atm) by what factor you increased the pressure of a gases to decrease volume to 2 ml?

GRAPHICAL REPRESENTATION LEVEL

Based on your record from previous experimental activity sketch the graph on x-y axis.

EXPERIMENT CHARLES GAS LAWS

Experiment2.1. Charles gas laws at macro level

Objective: Investigating behavior of gases at macro level based on relationship between volume and temperature keeping pressure constant.

Apparatus: heat source, beaker, ice water, thermometer, tap water, glass syringe of 100 ml

Procedure:

1. Arrange 5 beakers of 500 ml by assigning 1-ice water, 22-cold water, 3-tap water, 4-hot water, 5- boiled water
2. . Add each type of water to each corresponding beaker
3. Measure temperature of each beakers using thermometer and record it using tabulated forms.
4. Remove the piston glass syringe and brush with oil.
5. Close the lower end holes of glass syringe tightly and turn back the piston to the syringe.
6. Adjust volumes of a syringe at room temperature to a fixed point by pressing a piston until further movements a piston is impossible, record this points of volumes.
7. Insert adjusted volumes of syringes in to each temperature measured waters in five beakers.
8. Record what you have observed son the volumes of glass syringes from adjusted volumes.

Questions:

1. Is there any change on volumes of the syringe in different measured temperatures when you inserted?
2. In which types water volumes of a glass syringe reduced, in boiling water or in ice water? Why?
3. Based on your observations determine the relationship between temperature and volumes keeping pressure constant.

Which conditions favors' a gas to occupy large volumes/spaces of a gases, high temperature or low temperatures?

Experiment:2.2. Determining Charles laws at micro level

A. Using balloon and boiling water

Objectives: determining behaviors of gases at micro level behalf of volumes and temperatures keeping pressure constant.

Apparatus: hot water, partially air blown balloon.

Procedure:

1. Blow air partially to the balloon.
2. Insert a balloon in tap water, then in cold water, then in the boiled water. Finally turn back to the cold water.
3. Observe the changes on the volumes of a gases in the space of the balloon.

Questions.

1. What will happen to the motions of a gas in the in the balloon when you insert a balloon in cold water and in the boiling water?
2. In which cases gas molecules in the balloon go far apart ?

B. Using a glass syringe of 100 ml

Procedure:

1. Arrange 4 beakers of 100 ml by assigning 1-ice water, 2-tap water, 3-hot water, 4-boiling water
2. Add 50 ml of each water in to beakers
3. Measure temperature of water
4. Remove the piston from the glass syringe and close the holes of the lower part of syringe.
5. Blow an air partially to the balloon and insert into the syringe.
6. Adjust volumes of a syringe in to the level of the balloon.
7. Insert the glass syringe in to each beakers containing different water temperature.
8. Critically observe the changes on the balloon and record your observations.

Questions.

a. What was happen to the volumes of a balloon in the glass when you inserted in the ice water?
b. Assuming air filled balloon as gas particles explain the kinetic energy of a gas particles in the syringe.
c. What difference did you observed when you inserted glass syringe containing air filled balloon in ice water and boiling water behalf of volumes, motion of a gas, and its kinetic energy?
d. In which beakers you recorded highest volumes and highest KE?

1. Using air filled balloon

1. blow an air in to a balloon and filled partially
2. Ice water, tap water, and boiled water were prepared by assigning number 1,2,3, respectively
3. Measure temperature of each beakers
4. Initial volumes of air-filled balloon was measured using meter its circumstance.
5. Partially air filled balloon were inserted in in each beakers and stayed for 5 minutes
6. Change in circumstance of a balloon I each beakers' temperatures of each beakers containing water was measured and recorded as

Volume in circumstance						
T in k						

Questions.

1. In w/c beakers circumstances of a balloon is reduced? Why/?
2. Are the particles of a gases closed to each other or went far apart when size of a balloon decreased?
3. Based on your observations what was the effects of temperature on motion of gas particles?

EXPERIMENT: GAY-LUSSAC'S GAS LAWS

Experiment 3.1. Determining behavior of gases at macro level according to Gay-Lussac's laws

A. Using water container

Objectives: investigating effects of temperatures on pressure of a gases keeping volume of a gases constant.

Apparatus: one-liter water container, balloon, source of heat, boiled water, thermometer

Procedure:

1. Heat water until its temperature reach above 70ºC.
2. Remove original close of empty water container and substitute by partially air-filled balloon.
3. Insert empty water container covered with partially air-filled balloon in hot water.
4. Critically observe what happened.

Questions.

1. What was the relationship between pressure and temperature based on what you have observed?
2. What happened to the balloon that you have use to close the container? Why?
3. What difference you observed on the containers closed by air-filled balloon when it inserted in hot water and when it was in room temperature?
4. What effect of temperature you observed on pressure of gases?

Experiment 3.2. Gay-Lussac's gas laws at micro level

A. using fire and water

Objective: investigating behavior of gases at micro level keeping volume constant according to Gay-Lussac's gas laws.

Apparatus: beaker, lighter, alcohol, colorizer, water, trough

Experimental procedures:

1. Pour water into trough
2. Add a little color to change the shape of the water a little
3. Drop few alcohols in a beaker
4. Light a paper flame and drop it into the beaker in which the alcohol has been sprayed and turn the mouth down and bend it down into the water in the trough.
5. Critically observe what have been happened.

Activity:

Based on your observations discuss on the following questions and present to the class.

1. what happened to the fire in the beaker?
2. do you see rising level of water above the level of water after fire is extinguished?
3. What happened to the volume of gases in the beaker?
4. What happened to the particles of gases in the beaker?

B. Using a partially air filled small balloon inserted in water container connected by plasters above boiling water separated by chambers.

Activity of Gay-Lussac's law gas behavior at symbolic and graphical representation level

Gay-Lussac's gas laws at symbolic level:

Context based activity:

1. based on definition of Gay-Lussac's law; fill the following tables using Gay-Lussac's formula of $P/T= K$ or $P_1/T_1=P_2/T_2$.

A. If 100ml volumes of gas in a glass syringe at 25^0C and 1 atm inserted in a water of different temperature of 10 ^{0}C, 40^0C, 60^0C, 80^0C, 90^0C, 100^0C; then calculate the pressure of a gas at each temperature?

B. insert your answers in the table below?

C. use the kelvin temperatures

Temperatures in ^{0}C	10^0C	25^0C	40^0C	60^0C	80^0C	90^0C	100^0C
Temperature in K	283	298.73	313.73	333.73	353.73	363.73	373.73
Pressure in atm	0.95 atm	1 atm	1.05	1.12	1.20	1.22	1.25

2. based on previous questions draw the graph of temperature Vs pressure on the coordinate number line?

A3: INSTRUCTIONAL PLAN FOR CBA

Experiment:1

Objective: investigating behaviors of gases at macro level behalf of P v_s V at constant temperature

A. Using 100 ml glass syringe and 50 ml plastic syringe

Apparatus: Balloon, 100 ml glass syringe and 50 ml plastic syringe

Table 1. Context based instructional plan for concepts of Boyle's gas law at macro level.

No	Learning plan (1 hr)	Contextualized instruction	Context	Target
1	Determining Boyles' gas law at macro level	Using an experiment w/c shows when a piston of syringe is pushed down the volume of a syringe will be decreased	An experimental demonstration of plastic syringe	Showing inverse relationship between pressure v_s volume of a gas.

Similarity:

- pressing a piston dawn a syringe → is increasing pressure on volume of a gas
- syringe → volume of a gas

Instructional plan for the concept of Boyle gas laws behavior at micro level in term of Pressure versus Volume keeping temperature constant.

Objective: investigating Boyles' gas laws: Determining behavior of gas in terms of relationship between pressure v_s volume keeping temperature constant at particulate level

A. Using cotton and 100 ml glass syringe and 50 ml plastic syringe

Apparatus: cotton, 100 ml glass syringe and 50 ml plastic syringe

Table 2. Instructional plan for Boyles' gas laws

No	Learning plan 1 hr	Contextualized instruction	Context	Target
1.2	Behavior of gas at micro level in relation to pressure v_s volume at constant temperature	Experimentation to describe compression of gas particles	100 ml plastic syringe, cotton	Pressing down a piston of 10 ml plastic syringe containing cotton shrinks a cotton represents Compression of a gas to occupy small spaces and when we turn up a piston a cotton in a syringe was expanded w/c represents expansion of gas particles each gas particles go far apart.

Similarity: pressing down the piston →shows change in pressure to be increased

Shrinking of a cotton →compression of gas particles

Difference: a cotton → was not gas particles since gases were not visible.

B. Using 100 ml glass syringe and balloon

Apparatus: 100 ml glass syringe and partially air filled balloon

Table 3. Instructional plan for Boyles' gas laws at symbolic level

No	Learning plan 1 hr	Contextualized instruction	Context	Target
1.2	Behavior of gas at micro level in relation to pressure v_s volume at constant temperature	Experimentation to describe compression and expansion of gas particles.	partially air filled Balloon and glass syringe of 100 ml	Pressing down a piston shrinks a partially air filled balloon represents Compression of a gas to occupy small spaces and when we turn up a piston partially air filled balloon in a syringe was expanded w/c represents expansion of gas particles each gas particles go far apart.

Similarity: pressing down the piston →shows change in pressure to be increased

Shrinking of partially air filled balloon →compression of gas particles

Difference: partially air filled balloon → was not gas particles since gases were not visible.

Instructional plan for the concept of Boyles' gas law behavior at symbolic level and graphical representation level in terms of pressure versus volume keeping temperature constant.

Objectives: to investigate change in pressure v_s volume at constant temperature for initial and final conditions at concepts of symbolic level

Table 4. Learning plans for symbolic representations of Boyles' gas laws

No	Learning plans 2 hr	Context based instructions	Context	Target
1.3	Behaviors of gases at symbolic level graphical representation for Boyles' gas laws	At symbolic level based on experimentally recorded data of pressure v_s volume changes giving as $P_1V_1 = P_2V_2$ From tabulated records of experimental demonstrations pressure v_s volume using X-Y extrapolated graph showing relation between pressure and volumes	Giving problems in w/c initial volume, initial pressure and final pressure or final volume should be calculated Recorded data using tables	To connect calculated values of pressure and volumes with gaseous behaviors at macro and micro conceptual level Investigating inverse relation between pressure and volumes when one variables increased the other will be decreased

Similarity: given problems based on their experimental activity.

For each concepts of gas laws, the experiential instructional activity was conducted to contextualize instructional process in order to improve micro level, macro level, and symbolic representational level of gas law concepts to experimental group. As instructional activity completed for both experimental and control group, gas law based achievement test which includes all level of gas law concepts was demonstrated as posttest to evaluate achievement of the students. All the items are objective type achievement test which contains 13 items. In order to minimize cheating and sharing of information's; each group were taking achievement test at the same time and Cheating with in a group was avoided by having a single seat and the examinee was oriented critically to keep each students seat independently. properly.

A4: POSTTEST

HARAMAYA UNIVERSITY
POSTGRADUATE PROGRAM DIRECTORATE
ITEMS HAVE BEEN USE FOR POSTTEST IN CONCEPT OF GAS LAW ACHIEVEMENT TEST.

Time allowed 30'

DIRECTIONS: CHOOSE THE BEST ANSWER FROM THE GIVEN ALTERNATIVE AND WRITE YOUR OWN CHOICE ON THE PROVIDED SPACE.

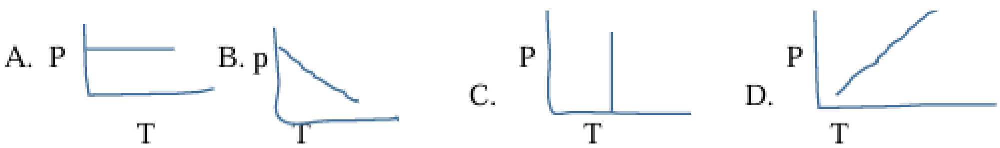
1. How do gas particles respond to an increase in volume keeping temperature constant? A. Increase in kinetic energy and increase in pressure B. Decrease in kinetic energy and decrease in pressure C. Increase in kinetic energy and decrease in pressure. D. Decrease in kinetic energy and increase in pressure

2. If the temperature of a gas remains constant but pressure is decreased the volume of a gas will A. Increase B. decrease C. remain the same D. cannot be determined

4. What will happen to the particles of gases in containers closed with partially filled air balloon, which drew off when it is entered in boiling water? A. Possess high kinetic energy B. exert low pressure C. creates low kinetic energy D. No change on gases

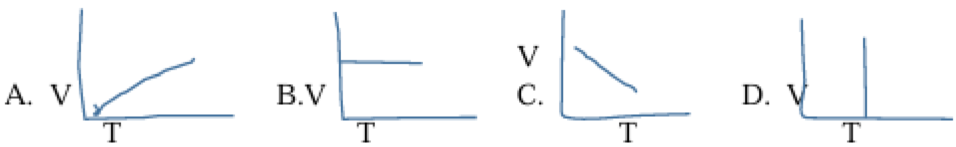
5. Keeping pressure constant at what temperature volume of a gases be decreased? A. If temperature Increased B. if temperature Decreased C. if temperature stay the same D. at higher temperature

6. Which of the following graphic representations shows the relationship between pressure vs temperature keeping volume constant?



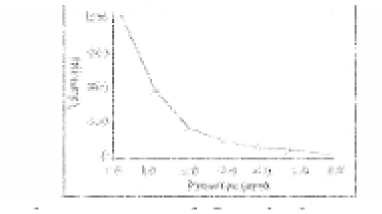
7.If pressure of a gas increased and its volume remains constant what will happen to its temperature? A. Increase B. decrease C. Remain the same D. unknown

8.Best Graphic representations of the following data of pressure vs temperature according to Charles law



9. 1L of gas at 273k, at what temperature in kelvin (k) the gas can occupy 4L keeping pressure constant. A. 1000 B. 1111 C. 1092 D. 1019

10. Based on the following volume vs pressure plotted graph determine the relationship between V and P?



A. directly proportional B. inversely proportional C.at the beginning pressure is very high D. volume increases progressively

11. An aerosol deodorant can have a pressure of 3 atm at 250C. what is pressure inside the can at a temperature of 8450C? A. 11.3 B. 113 atm C. 1.13 D. 1130

12. According to Charles law as temperature increases volume of a gas will be increased keeping pressure constant. Then what will happen to particles of gases? A. Kinetic energy of gases will be increased B. Amount of gases will be increased C. Gaseous particles will come close to each other D. Motions of gaseous particles in the container will be constant as temperature increased.

13. 13. A 0.20 ml CO_2 is bubbled in a cake batter at 27 0C. In the oven it gets heated to 1770C, keeping pressure constant, what is its new volume? A. 0.30 ml B. 0.2 ml C. 0.6 ml D. 0.4 ml

A5: CHECK LIST FOR CLASS ROOM OBSERVATION

CHECK LIST FOR CLASS ROOM OBSERVATION OF GRADE 9 STUDENTS IN 2015

Table 7. 1 Checklist for classroom observation

N	**Target of observations**	**Week 1:CG**				**Week1: EG**			
		Standard of observation							
1	**Engagement Level**	1	2	3	4	1	2	3	4
1.1	Engagement during macroscopic properties		x					x	
1.2	Curiosity during microscopic concepts			x				x	
1.3	Enthusiasm for symbolic representation		x					x	
1.4	Focus during graphical representations			x				x	
2	**Interest in Conceptual Understanding**								
2.1	Interest in real-world applications		x					x	
2.2	Insights on microscopic interpretations			x				x	
2.3	Eagerness for problem-solving			x				x	
2.4	Discussion on how construct graphical representation of gas laws				x				x
3	**Motivation to Participate**								
3.1	Volunteering to present classes at any time				x				x
3.2	Collaboration on microscopic concepts				x				x
3.3	Initiative in solving formulas			x					x
3.4	Contribution to graphical discussions			x					x
4	**Cognitive Development Indicators**								
4.1	Relating macroscopic behavior to experiences			x				x	
4.2	Connecting microscopic and macroscopic			x				x	
4.3	Accuracy in calculations		x				x		
4.4	Analysis of graphical relationships			x				x	
5	**Readiness to Learn**								
5.1	Understanding of prior knowledge		x					x	
5.2	Confidence in microscopic discussions			x				x	
5.3	Readiness for mathematical representations			x				x	
5.4	Practicing graphical representation		x					x	

		Standard of observation							
N	Target of observations	Week 4				Week4			
1	**Engagement Level**	1	2	3	4	1	2	3	4
1.1	Engagement during macroscopic properties				x				x
1.2	Curiosity during microscopic concepts			x				x	
1.3	Enthusiasm for symbolic representation				x				x
1.4	Focus during graphical representations			x					x
2	**Interest in Conceptual Understanding**								
2.1	Interest in real-world applications				x				x
2.2	Insights on microscopic interpretations			x				x	
2.3	Eagerness for problem-solving			x				x	
2.4	Discussion on how construct graphical representation of gas laws				x				x

3	**Motivation to Participate**								
3.1	Volunteering to present classes at any time				x				x
3.2	Collaboration on microscopic concepts				x				x
3.3	Initiative in solving formulas			x					x
3.4	Contribution to graphical discussions			x					x
4	**Cognitive Development Indicators**								
4.1	Relating macroscopic behavior to experiences			x				x	
4.2	Connecting microscopic and macroscopic				x			x	
4.3	Accuracy in calculations			x			x		
4.4	Analysis of graphical relationships			x				x	
5	**Readiness to Learn**								
5.1	Understanding of prior knowledge				x			x	
5.2	Confidence in microscopic discussions				x			x	
5.3	Readiness for mathematical representations				x			x	
5.4	Practicing graphical representation				x			x	

		Standard of observation							
N	Target of observations	Week 5				Week5			
1	**Engagement Level**	1	2	3	4	1	2	3	4
1.1	Engagement during macroscopic properties				x			x	
1.2	Curiosity during microscopic concepts			x				x	
1.3	Enthusiasm for symbolic representation				x			x	
1.4	Focus during graphical representations				x			x	
2	**Interest in Conceptual Understanding**								
2.1	Interest in real-world applications				x			x	
2.2	Insights on microscopic interpretations			x				x	
2.3	Eagerness for problem-solving			x				x	
2.4	Discussion on how construct graphical representation of gas laws				x				x
3	**Motivation to Participate**								
3.1	Volunteering to present classes at any time				x				x
3.2	Collaboration on microscopic concepts				x				x
3.3	Initiative in solving formulas			x					x
3.4	Contribution to graphical discussions			x					x
4	**Cognitive Development Indicators**								
4.1	Relating macroscopic behavior to experiences			x				x	
4.2	Connecting microscopic and macroscopic				x			x	
4.3	Accuracy in calculations				x		x		
4.4	Analysis of graphical relationships			x				x	
5	**Readiness to Learn**								
5.1	Understanding of prior knowledge				x			x	
5.2	Confidence in microscopic discussions			x				x	
5.3	Readiness for mathematical representations			x				x	
5.4	Practicing graphical representation				x			x	

A6: INTERVIEW QUESTIONS
HARAMAYA UNIVERSITY
POSTGRAGUATE PROGRAM DIRECTORATE
INTERVIEW QUESTIONS

Good morning dear, student my name is ___________ I come from Haramaya University Natural and Computational science college department of chemistry to investigate the effect of CBA on the concept of gas laws on grade 9 students' Achievement and Attitude. Then, I would like to stay with me some minutes and give your genuine responses to my interview questions.

Open Ended Interview

2. Out of conventional / traditional instructional process and contextualized instructional process, which one was help full for your conceptual understanding of gas laws? Why? explain your ideas____________________________
3. Explain what you gain from context-based approach of connecting science with your environment? Explain your opinions___________________
4. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions________________________

A7: RESPONSES OF INTERVIEW QUESTIONS

Interviewer:1 Out of conventional/ traditional instructional process and contextualized instructional process which one was help full for your conceptual understanding of gas laws? Why? explain your ideas_

Student-1: *"For me, CBA (Context-Based Approach) is important. The reason for this is that this teaching method helps me distinguish the different levels of concepts regarding gases. For example, I have gained a deeper understanding of What type of change can be observed in the volume of a gas when pressure is increased,* and *how does increasing temperature affect the particles of gas?* and *other concepts as well"*

Interviewer:2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions___________________

Student1: started by saying that *"I have learned a lot from the Context-Based Approach (CBA). From the topic of gas laws, I have observed the relationships* and *effects that can be seen when the temperature is held constant, as illustrated by Boyle's Law, as well as the relationships that exist in conjunction with temperature, as described by Charles's Law. We have also looked at the behaviors of gases by using cold water* and *boiled water in this context. He replied that we have actually done a graph showing this relationship* and *practiced the graph. The biggest thing I found is that the topic of gas law is around us".*

Interviewer:3. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions

Student-1 *"I have a very distinct perspective on the teaching method. This teaching approach has given me great hope in my learning. Therefore, I want this teaching method to not only be limited to the topic of gas laws but to continue in this manner. I also hope it expands to all areas of science education. This is how I conclude my thoughts"*

Interviewer:1. Out of conventional/ traditional instructional process and contextualized instructional process which one was help full for your conceptual understanding of gas laws? Why? explain your ideas_

Student-2. *"My choice is the Context-Based Approach (CBA). The reason I chose CBA is that this teaching method connects the theory we have learned with practical experiences we have observed. This approach has taught us about our environment. It has linked our learning to our daily lives."*

Interviewer:2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions___________________

Student2. "*I have gained a good understanding. What I had previously learned theoretically* *has now been reinforced by what I have seen with my own eyes. This has been very beneficial in my learning experience."*

Interviewer:3. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions?

Student2. "*My overall perspective on this teaching method is very positive. Since the day we began learning chemistry, I haven't missed a single day. I travel a long distance from the countryside to attend school,* and *to participate in afternoon classes, I have to stay around the school until then without having lunch. Even now, I am focused on this learning experience, as I believe that the practical demonstrations we engage in are valuable. Therefore, I hope that this approach continues in the same way in the future."*

Interviewer:1. Out of conventional / traditional instructional process and contextualized instructional process, which one was help full for your conceptual understanding of gas laws? Why? Explain your ideas_

Student3. *"I choose the Context-Based Approach (CBA). This method has taught me a lot. If you remember, you mentioned that water* and *salt can be separated through vaporization. Your explanation helped me underst*and *that chemistry is all around us. Even now, we are using a thermometer to measure temperature,* and *we have practically placed it in hot water to see how it works* and *how the heat increases."*

Interviewer:2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions____________________

Student3: *"This teaching method has transformed me. It has allowed me to differentiate between the boiling points of water at high altitude* and *at sea level. Previously, I only knew that water boils quickly at sea level. Now, I have learned that the boiling point of water has a relationship with pressure boils quickly at higher altitude."*

Interviewer:3. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions?

Student3. *This method is very beautiful. I like it, so I hope it continues."*

Interviewer:1. Out of conventional/ traditional instructional process and contextualized instructional process which one was help full for your conceptual understanding of gas laws? Why? explain your ideas_

Student4: *"I choose the Context-Based Approach (CBA). This method has taught me more than just theory; there is nothing more satisfying than seeing practical experiments. Until now, I have not seen a single experiment in our school conducted in this way. If we had learned in this manner from the beginning, we would not have fallen behind*."

Interviewer:2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions___________________

Student4: *"I found something good from this method. I practiced how to show the relationship between changes, temperature,* and *pressure using graphs. I used to study alone. Since I am a wife* and *have a child, it was not convenient for me to meet with friends to study together. Even in the classroom, I was preoccupied with thoughts about my child* and *my home. Since I started learning with this new method, I have been discussing* and *working with students without getting tired. This method has connected me with the students. It has opened a way for me to work* and *discuss together" she concluded***.**

Interviewer:3. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions?

Student4. *I look at it with a positive attitude. I am a wife personally. I wasn't usually comfortable coming back afternoon for tutoring. I didn't even come on the first day. From the next day, however, I discussed my household chores with my husb*and and *had him help me. I made this sacrifice because I liked this teaching method. She replied that she wishes we could always learn like this.*

Interviewer:1. Out of conventional/ traditional instructional process and contextualized instructional process which one was help full for your conceptual understanding of gas laws? Why? explain your ideas_____________

Student5

this student has a different opinion. *"No, I'd rather be the same. My reason is, I live by helping my family. I don't feel comfortable coming back after noon. Secondly, I don't like st*and*ing* and *doing things because this method requires st*and*ing* and *doing things. I'd rather be told verbally than told to do it by h*and, and *I've attended this tutorial class many times. Because I heard that attendance would be held, I was there."*

Interviewer:2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions___________________

Student5: "*I also felt very unhappy about it, but I understood as there are many experimental activities around us. I learned from Boyle's law experiment how gases compress* and *exp*and *over time or occupy a larger space. However, I used to get tired of st*and*ing for long periods during the experiment because I didn't like it. That's all I can say," he said***.**

Interviewer:3. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions?

Student5: *it's good for someone who can st*and *up* and *not be late."*

Interviewer:1. Out of conventional/ traditional instructional process and contextualized instructional process which one was help full for your conceptual understanding of gas laws? Why? explain your ideas_

Student6: He replied*, CBA.*

"I didn't think the lessons we are learning at our level could be demonstrated in practice. we were looking at it from afar. now the one we were waiting for in the distance sprouted by us, we actually saw it. I blamed our teacher for not teaching us in this way till date. he answered question by question.

Interviewer:2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions____________________

Student6: *"what we have learned by this method; Boyles gas law, Charles gas law, Gay-Lussac's gas law. We have drawn their graphs based on the data we have recorded by ourselves* and *given them to our teacher. We have measured the temperature".*

Interviewer:3. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions?

Student6: *I say, it should continue.*

Interviewer:1. Out of conventional/ traditional instructional process and contextualized instructional process which one was help full for your conceptual understanding of gas laws? Why? explain your ideas_

Student7: *"It's a CBA. There is still no one to teach us, but now I proved by CBA that education is with us," he replied.*

Interviewer:2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions____________________

Student7: *"this teaching method made us work closely together on questions. It strengthened our relationship a lot"*

Interviewer:3. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions?

Student7: He replied*, "It would be great if we could always learn like this. It's very beautiful"*

Interviewer:1. Out of conventional/ traditional instructional process and contextualized instructional process which one was help full for your conceptual understanding of gas laws? Why? explain your ideas_

Student8*: "My choice is an action-based teaching methodology, I used to think that education is only written on paper. Now that it is down to earth, I have seen the trial, so I ask it to continue for us"; said.*

Interviewer: 2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions___________________

Student8. "*We have illustrated the relationship between temperature* and *pressure".*

Interviewer: 3. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions?

Student8*"This method is so beautiful that let's continue."*

Interviewer: 1. Out of conventional/ traditional instructional process and contextualized instructional process which one was help full for your conceptual understanding of gas laws? Why? explain your ideas_

Student9: Another student answered the first question. *"My choice is context-based teaching methodology" explaining her reason for choosing CBA, "chemistry is an action-based education* and *we started reading the same thing from paper in the lower grades. no one showed us one day. but now I have actually seen the experiment. what school tell us the presentation for yourself that you don't have. let's continue in this way from now on, since we haven't stopped learning, let's learn in this way, this method has shown us a practical lesson* and *inspired us," she replied.*

Interviewer: 2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions___________________

Student9: "*from this CBA method, according to the gas law, whether mass* and *pressure have an inverse relationship if we do not change the temperature,* and *whether mass* and *temperature have a directional relationship; from which I have derived thoroughly that this is Charles gas law. If we had always studied this way, we would have scored well."*

Interviewer: 3. What is your general attitude towards the CBA learning approach on the concepts of GL? Please explain your opinions?

Student9: *"The action-oriented teaching method is very beautiful* and *let us continue."*

Interviewer: 1. Out of conventional/ traditional instructional process and contextualized instructional process which one was help full for your conceptual understanding of gas laws? Why? explain your ideas

Student10

"I choose CBA. The reason I chose this is because we learned the topic of gas laws by connecting it with tangible things we see around us. For example, when we play soccer in

the hot sun, we see that the ball expands more than before. This relates to Gay-Lussac's law, which shows the relationship between temperature and *pressure. We gained insights like this," he replied.*

Interviewer: 2. Explain what you gain from CBA of connecting science with your environment? Explain your opinions____________________

Student10

we have gained a better understanding of gas law

A8: QUESTIONNAIRES

1. Does learning gas laws through CBA engage you? yes ☐ No. ☐
2. Does this method (CBA) relate your learning with your prior knowledge or real-world practical situation? yes ☐ No.
3. Do you feel more active in your participation when using this method? yes ☐ No. ☐
4. Does CBA help you think critically? yes ☐ No. ☐
5. Does CBA improve your English-speaking skills compared to other learning methods?" yes ☐ No. ☐
6. Does the CBA class allow you to discuss your learning with your class mates? yes ☐ No. ☐
7. "Do you feel you retain information learned in CBA for a longer time?"
8. Does CBA improve your interaction with your teacher? yes ☐ No. ☐
9. Does CBA encourage you to use the library and other information sources more frequently? Yes ☐ No. ☐

A9. SCORE OF PRETEST FOR CG AND EG AT EACH CONCEPTUAL LEVEL

Table7. 1 Score of pretest for control group and experimental group

Conceptual level	Question items	Score of control group	Total number of student	%	Score of experimental group	Total number of students	%
Macroscopic level	2	10	35	28.57	11	37	29.7
	5	12	35	34.5	11	37	29.7
	8	10	35	28.57	9	37	24
	Av.	10.66		30.45	10.33		27.92
Microscopic level	1	8	35	22.8	2	37	5.4
	4	12	35	34.5	17	37	45.7
	9	10	35	28.6	14	37	37.8
	Av.	10		30.45	11		29.72
Symbolic representation level	3	35	14	40	11	37	29.7
	6	35	7	20	10	37	27.2
	10	35	12	34.2	13	37	35.1
	Av.		11	31.42	11		29.72
Graphical representation level	7	35	11	31.4	13	37	35
Av.	av		11	31.14		37	35

Table7. 2 Pretest score for control group

		macro				micro				Symbolic				graph	
ID	sex	2D	5A	8A		1C	4A	9A		3B	6A	10A		7A	
C1	M	C	C	D	0	A	D	A	2	B	D	C	1	C	0
C2	M	D	C	C	1	D	B	D	0	A	B	B	0	D	0
C3	M	A	A	B	1	C	B	C	1	D	C	A	0	D	1
C4	F	D	D	B	1	D	B	A	1	C	B	A	0	D	1
C5	F	D	A	D	1	D	A	C	1	C	B	A	1	A	1
C6	M	D	A	D	2	A	A	B	1	C	B	D	1	A	0
C7	F	C	B	A	1	D	A	B	1	B		B	1	C	0
C8	M	C	A	D	1	D	A	A	2	B	A	D	2	D	0
C9	F	C	C	C	0	A	D	D	0	A	D	B	0	B	0
C10	F	D	A	A	3	C	A	A	3	B	C	B	1	D	0
C11	M	D	D	A	2	C	D	A	2	A	B	B	0	D	0
C12	F	B	D	C	0	A	A	B	1	C	A	D	1	D	0
C13	M	A	C	B	0	C	A	D	2	B	A	B	2	C	0
C14	M	D	A	A	3	B	B	B	0	D	B	B	1	A	0
C15	M	B	A	B	1	D		D	0	D	D	C	1	A	0
C16	F	A	B	D	0	A	B	D	0	B	D	B	1	C	0
C17	M	B	C	D	0	C	C	C	1	D	D	C	0	C	0

C18	M	B	B	A	1	D	D	C	0	A	D	A	0	C	1
C19	M	D	A	A	3	C	A	C	2	B	B	A	2	A	1
C20	F	B	C	A	1	D	C	C	0	B	A	B	3	A	0
C21	M	B	A	C	1	D	C	A	1	D	A	A	1	D	1
C22	M	C	D	A	2	A	D	C	0	B	C	D	1	C	0
C23	M	B	B	D	0	D	B	C	0	A	D	B	1	A	0
C24	F	B	D	D	0	D	A	C	1	A	C	A	1	A	1
C25	F	A	C	B	0	C	D	A	2	D	B	A	1	A	1
C26	M	B	B	B	0	A	A	C	1	B	A	D	2	D	0
C27	M	C	A	C	2	B	A	C	1	B	D	D	1	C	0
C28	M	C	A	C	2	D	B	B	0	A	C	A	1	A	1
C29	F	D	B	D	1	A	C	A	1	B	B	A	1	C	1
C30	F	B	B	A	1	D	B	B	0	B	D	C	1	B	0
C31	M	C	D	C	1	A	B	D	0	A	C	D	0	B	0
C32	F	C	A	C	2	A	C	B	0	B	D	A	2	A	1
C33	F	A	C	C	0	B	C	C	0	A	B	B	0	C	0
C34	M	D	D	D	1	D	A	B	1	A	D	A	0	D	1
C35	M	B	B	A	1	D	D	C	0	C	D	D	1	A	0
		10	12	10		8	12	10		14	7	12		11	

Table7. 3 pretest score for EG

		macro				micro				Symbolic				graphica	
		2D	5A	8		1C	4A	9A		3	6A	10		7A	
E1	F	C	B	A	1	D	A	A	2	B	A	B	1	B	0
E2	M	C	C	A	1	D	B	C	0	C	C	B	1	A	1
E3	M	A	D	D	0		B	B	0	C	B	B	0	D	0
E4	M	D	A	B	2	D	B	A	1	A	B	C	1	A	1
E5	M	A	B	A	1	D	A	B	1	C	C	C	0	D	0
E6	M	B	A	A	2	C	B	A	2	D	D	B	0	D	0
E7	M	D	C	A	2	D	A	D	1	B	D	B	1	C	0
E8	F	D	A	B	2	B	D	A	1	D	C	A	1	B	0
E9	F	D	B	D	1	D	A	B	1	C	C	D	0	D	0
E10	M	B	A	B	1	D	A	A	2	D	A	D	0	B	0
E11	F	B	C	A	1	C	A	B	2	A	D	D	0	B	0
E12	M	D	B	A	2	D	D	A	1	C	B	D	1	A	1
E13	F	C	A	C	1	B	C	B	0	A	A	A	2	A	1
E14	F	C	B	A	1	D	D	C	0	C	C	A	2	A	1
E15	F	D	A	D	2	D	A	C	1	B	A	D	1	B	0
E16	M	B	B	B	0	D	B	D	0	C	D		0	B	0

E17	M	D	C	A	2	A	D	B	0	C	C	A	2	A	1
E18	F	B	D	D	0	D	A	C	1	A	C	D	0	D	0
E19	F	B	A	B	1	D	A	A	2	A	A	A	1	B	0
E20	M	C	A	A	2	D	A	D	1	B	A	C	1	A	1
E21	M	C	A	A	2	D	A	D	1	B	A	C	2	A	1
E22	M	B	B	B	0	B	A	A	2	B	D	B	1	B	0
E23	M	B	B	A	1	D	A	C	1	A	A	D	1	A	1
E24	F	D	C	B	1	B	A	A	2	C	C	A	2	A	1
E25	M	D	C	A	2	B	C	B	0	B	C	C	1	D	0
E26	M	D	B	A	2	B	C	B	0	B	B	B	1	B	0
E27	M	C	B	A	1	D	A	C	1	A	D	A	1	B	0
E28	M	B	C	A	1	D	D	A	1	B	D	D	1	C	0
E29	M	B	B	A	1	D	A	C	1	C	B	B	1	A	1
E30	F	B	D	B	0	A	A	A	2	D	C	C	1	A	1
E31	M	B	C	A	1	B	D	A	1	C	C	A	1	B	0
E32	M	B	D	B	0	B	C	A	1	B	B	A	2	B	0
E33	F	B	B	B	0	D	B	A	1	A	B	B	1	A	1
E34	M	B	A	B	1	B	B	C	0	A	A	A	1	B	0
E35	F	B	A	A	2	D	D	C	0	B	B	A	3	A	1
E36	M	D	B	B	1	D	C	B	0	A	A	A	2	A	1
E37	M	A	B	B	0	B	A	D	1	D	D	A	2	A	1
		11	11	9		2	17	14		11	10	13		13	

Table7. 4 Score of posttest for control group

		Macro level				Micro level					SYMBOLIC			GRAPHIC			
student ID	Sex	2 A	5 B	7 A		1 B	4 A	12 A		11 A	9 C	13 A		6 D	8 A	10 B	
C1	M	A	D	B	1	D	A	A	1	D	B	A	2	B	C	D	0
C2	M		A	C	0	D	A	C	0	D	A	A	1	C	B	D	0
C3	M	B	A	B	0	C	A	C	0	A	D	B	0	C	C	D	0
C4	F	D	D	C	0	A	A	D	0	B	B	D	0	B	D	A	0
C5	F		A	D	0	B	A	D	1	A	D	A	1	C	D	A	0
C6	M	B	A	B	0	C	B	C	0	C	D	C	0	B	A	C	1
C7	F	C	D	C	0	A	D	C	0	A	D	B	0	A	B	A	1
C8	M	D	C	D	0	D	A	D	0	D	D	A	1	D	A	A	2
C9	F	A	A	D	1	D	B	A	1	D	D	D	0	A	A	A	1

C10	F	A	A	A	2	C	A	C	1	C	B	C	1	A	B	D	0
C11	M	A	B	B	2	D	B	D	0	B	B	D	0	A	D	C	0
C12	F	B	B	C	1	B	A	D	1	A	A	B	1	B	D	C	0
C13	M	A	B	B	2	B	A	A	3	D	B	B	0	B	A	D	1
C14	M	B	C	A	1	D	A	B	1	C	B	B	0	C	A		1
C15	M	A	A	B	1	B	C	D	0	D	B	A	1	B	A	A	1
C16	F	A	B	C	2	C	C	A	1	A	B	B	0	D	A	D	1
C17	M	C	B	D	1	B	C	B	0	D	C	A	3	C	B	D	0
C18	M	A	A	A	2	D	C	D	0	A	B	C	0	B	A	A	2
C19	M	B	B	A	2	A	D	D	0	A	D	B	0	C	A	B	2
C20	F	B	B	B	1	B	B	C	1	C	C	D	1	C	B	A	0
C21	M	B	D	A	1	B	A	A	2	A	D	B	0	C	B	C	0
C22	M	C	D	A	1	A	C	B	0	A	C	C	1	B	B	A	0
C23	M	B	B	A	2	B	B	C	0	C	A	A	1	C	A	B	2
C24	F	A	A	B	1	C	D	A	1	A	D	B	0	D	A	C	2
C25	F	C	D	C	0	B	C	D	1	B	A	B	0	A	B	C	0
C26	M	A	B	C	2	B	B	D	0	D	A	A	2	B	C	D	0
C27	M	B	A	A	1	D	B	A	1	B	C	A	2	B	A	A	1
C28	M	D	D	C	0	B	C	B	1		C	A	2	C	D	D	0
C29	F	A	C	B	1	B	B	A	2	A	A	C	0	B	D	B	1
C30	F	C	D	B	0	A	D	B	0	D	A	B	0	C	B	C	0
C31	M	C	A	A	1	B	B	A	2	B	D	C	0	D	C	D	0
C32	F	B	C	C	0	B	B	D	0	B	A	B	1	A	C	B	1
C33	F	A	A	A	2	C	B	D	0	C	B	B	0	B	A	D	1
C34	M	A	A	A	2	B	D	A	1	C	B	B	0	B	C	A	0
C35	M	A	B	B	2	B	B	D	1	C	C	B	1	C	B	C	0
		14	10	11		15	11	10		9	6	10		3	13	4	

Table7. 5: Score of posttest of experimental group

		Macro level				Micro level				symbolic level				Graphical level			
student ID	sex	2A	5B	7A		1B	4A	12A		11A	9C	13A		6D	8A	10B	
E1	F	A	A	A	2	B	A	A	3	A	C	C	2	C	A	B	2
E2	M	A	D	A	2	B	A	D	2	A	D	B	1	A	B	B	1
E3	M	A	D	A	2	B	A	A	3	D	B	A	1	C	A	B	2
E4	M	B	B	A	2	D	A	A	2	A	D	A	2	C	B	A	0

E5	M	B	B	A	2	B	A	C	2	A	D	A	2	B	D	C	1
E6	M	D	B	B	1	B	C	D	1	A	B	D	1	B	A	A	1
E7	M	D	B	C	1	B	D	B	1	A	B	A	2	B	D	D	0
E8	F	A	A	A	2	B	A	A	3	C	D	A	1	D	A	D	2
E9	F	A	B	A	3	D	D	A	1	A	C		2	C	B	A	0
E10	M	B	D	A	1	D	A	A	2	A	B	A	2	C	A	A	1
E11	F	A	C	C	1	B	C	A	2	D	B	A	1	B	C	C	0
E12	M	A	A	B	1	B	A	C	2	B	C	B	1	A	A	B	2
E13	F	A	B	A	3	B	D	A	2	A	C	A	3	C	A	A	1
E14	F	A	B	A	3	B	A	A	3	A	C		2	C	A	A	1
E15	F	A	B	D	2	B	A	A	3	D	B	A	1	A	B	B	1
E16	M	A	A	A	2	D	A	C	1	A	C	A	3	C	A	D	1
E17	M	A	B	C	2	B	A	A	3	A	B	C	1	B	A	C	1
E18	F	B	D	A	1	B	C	B	1	C	B	C	0	C	A	B	2
E19	F	A	B	B	2	D	A	A	2	A	A	B	1	B	B	A	0
E20	M	A	A	A	2	C	A	A	2	B	D	B	1	B	C	A	1
E21	M	B	B	A	2	B	A	B	2	A	A	A	2	B	A	A	1
E22	M	A	B	D	2	B	A	C	2	A	A	A	2	B	A	B	2
E23	M	B	B	A	2	B	A	A	3	A	D	A	2	C	A	A	1
E24	F	A	A	A	2	B	B	A	2	C	B	A	1	A	C	A	0
E25	M	B	B	A	2	B	C	B	1	A	D	B	1	C	B	C	1
E26	M	A	D	D	1	B	A	C	2	A	C	A	3	B	B	B	1
E27	M	A	B	A	3	D	B	C	0	A	C	C	2	C	A	D	1
E28	M	A	D	D	1	B	A	C	2	A	B	A	2	B	B	B	1
E29	M	A	B	B	2	B	A	A	3	A	A	A	2	B	A	B	2
E30	F	A	A	A	2	B	B	A	2	A	C	C	2	B	B	B	1
E31	M	A	C	A	2	D	C	C	0	A	C	C	2	B	B	A	0
E32	M	A	B	A	3	B	B	C	1	D	B	D	0	C	A	C	1
E33	F	C	D	A	1	B	B	A	2	A	C	A	3	D	A	B	3
E34	M	B	B	A	2	B	A	A	3	A	C	A	3	D	A	B	3
E35	F	A	D	B	1	D	A	B	1	B	C	D	1	C	B	A	2
E36	M	B	B	A	2	A	B	B	0	D	B	C	0	C	B	C	2
E37	M	A	A	A	2	B	C	B	2	D	B	C	0	C	B	C	2
		25	19	25		27	21	19		23	13	1 5		3	1 9	1 3	

Table 7. 6 Score of retention test for experimental group only

	Macro level				Micro level				symbolic level				RTSEG graphical level			
	1A	2B	3A		7B	8A	9C		10C	11A	12B		4B	5C	6C	
E1	C	B	A	2	B	A	C	3	B	C	B	1	A	A	C	1
E2	B	A	A	1	C	B	C	1	B	B	B	1	B	B	C	2
E3	A	C	B	2	A	A	C	2	A	C	B	1	B	A	B	1
E4	A	B	C	2	C	B	A	0	A	A	A	1	B	B	A	1
E5	C	A	A	1	B	A	B	2	B	C	B	1	C	C	C	2
E6	B	B	A	2	B	A	C	2	A	A	C	1	C	C	A	1
E7	C	C	A	1	B	B	B	1	A	C	B	1	B	C	C	3
E8	A	A	A	2	A	C	C	1	A	A	C	1	C	C	C	2
E9	A	B	B	2	A	A	C	2	A	A	B	2	C	C	A	1
E10	A	B	B	2	A	A	C	2	A	A	B	2	A	A	C	1
E11	A	B	B	2	A	A	C	2	B	A	B	2	A	C	A	1
E12	A	B	B	2	A	A	C	2	A	A	B	2	B	B	A	1
E13	A	B	B	2	A	A	C	2	B	A	B	2	A	C	A	1
E14	A	B	B	2	A	A	C	2	C	A	B	3	B	B	C	2
E15	A	B	A	3	A	A	A	1	C	A	B	3	A	C	A	1
E16	B	A	A	2	B	B	C	2	C	A	A	2	A	B	C	1
E17	A	A	A	2	A	C	A	0	C	A	B	3	C	A	C	1
E18	A	C	B	1	B	A	C	3	B	B	B	1	A	A	B	0
E19	A	B	B	2	A	A	C	2	B	A	B	2	C	B	A	0
E20	A	A	A	2	C	A	C	2	A	A	B	2	C	A	A	0
E21	A	B	A	3	C	C	C	1	A	A	A	1	B	A	C	2
E22	B	A	A	1	C	B	C	1	C	A	A	2	D	B	C	1
E23	A	A	B	1	C	B	C	1	B	A	A	1	B	A	A	1
E24	B	B	C	1	B	A	B	2	A	B	A	0	A	B	C	1
E25	C	C	B	0	C	C	A	0	B	A	D	1	A	C	B	1
E26	A	B	B	2	A	A	C	2	B	A	B	2	B	C	A	2
E27	B	A	B	0	C	A	C	2	A	B	B	1	A	A	A	0
E28	A	A	B	1	B	A	C	3	B	A	A	1	B	A	C	2
	18	14	12		8	18	21		5	20	18		10	10	12	

A10: PICTURE OF PARTICIPANTS

Figure: 1. Wretest demonstration

Figure: 2 Pre experimental setup

Figure: 3. Demonstrating experimental activity by different group

Figure: 4 When students learn through CBA Boyles' gas law concept

Figure: 5 Setup preparation of Charles' Law

Figure: 6 Showing setup preparations of Gay-Lussac’s gas law concepts.

Figure: 7 An image showing students participation in CBI.

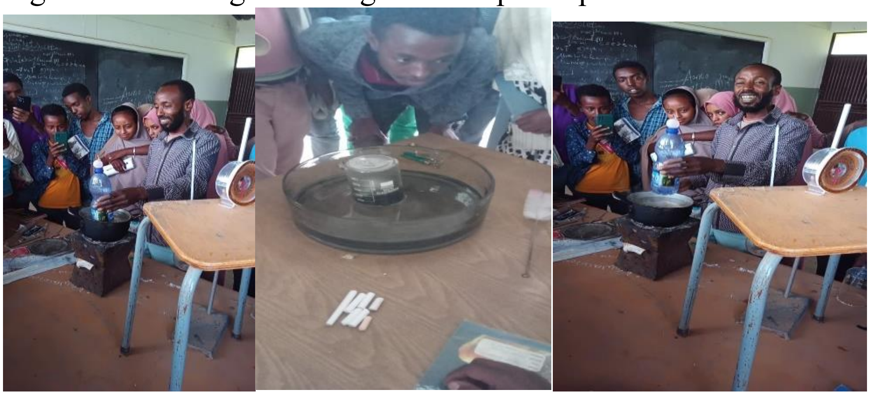


Figure: 8 Photos w/c shows students participations in experimental demonstrations of Gay-Lussac’s gas laws

Figure: 9 Students taking posttest