Context-Based Instructional Approaches and Students' Scientific Reasoning Skills, Conceptual Understanding and Epistemological Beliefs in Biology

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This is to certify that the dissertation prepared by Wuleta Ketema entitled: *Context-Based Instructional Approaches and Students' Scientific Reasoning Skills, Conceptual Understanding and Epistemological Beliefs in Biology* and submitted for the fulfillment of the requirements for the Degree of Doctor of Philosophy in Biology Education compiles with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Declaration

I hereby declare that the dissertation I have submitted is entirely unique to me and has never before been presented at Addis Ababa University or any other university. Except where appropriate reference is made, the dissertation does not, to the best of my knowledge and belief, contain any previously published or written work by another author.

Wuleta Ketema Abebe

Date ___________________________

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Abstract

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The main purpose of this study was to investigate the effect of a context-based Relating, Experiencing, Applying, Cooperating, and Transferring (REACT) instructional strategy on students' scientific reasoning skills, conceptual understanding, and epistemological beliefs on heredity concepts. In this study, a mixed-methods approach and a convergent embedded experimental design were used. One hundred thirty-one tenth grade students took part in the study. Both quantitative and qualitative data were collected. Three schools and three intact classes were selected randomly from each school. Treatment groups 1, 2, and comparison groups were assigned randomly to each school. Treatment group 1 received a context-based REACT instructional strategy; treatment group 2 received conventional instruction integrated with context-based activities; and conventional instruction was used alone to teach heredity concepts in the comparison group for six weeks. All groups received pre- and post-tests of the genetics conceptual understanding test, scientific reasoning skill test, and epistemological beliefs questionnaire. During the intervention, classroom observations and, after the intervention, semi-structured interviews were conducted. The quantitative data were analyzed using multivariate analysis of variance (MANOVA) and analysis of variance (ANOVA), while narrative analysis was used to analyze the qualitative data. The MANOVA results showed that *there were significant mean score differences between treatment group 2 and the other two groups in favor of treatment group 2 in both conceptual understanding and scientific reasoning skills. Nevertheless, there was no significant difference between treatment group 1 and the comparison group in both variables. The observation and interview results supported these findings. The one-way ANOVA result also showed that there were significant mean score differences between the groups in favor of the treatment groups when it came to epistemological beliefs. However, there was no significant difference between treatment groups 1 and 2. This suggests that, compared to conventional instruction, the context-based instructional strategy had a positive effect on students' epistemological belief shifts toward expertise. In conclusion, this study found that integrating context-based activities with conventional instruction has more effect on three variables than context-based REACT strategy and conventional instruction alone.*

Key words: context-based instruction, conceptual understanding, scientific reasoning, epistemological beliefs, heredity

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List of Acronyms

CBA	Context-Based Approach
CG	Comparison Group
EBQ	Epistemological Belief Questionnaire
EGSECE	Ethiopian General Secondary Education Certificate Examination
GCUT	Genetics Conceptual Understanding
NRC	National Research Council
OECD	Organization for Economic Cooperation and Development
Qual	Qualitative
QUAN	Quantitative
REACT	Relate, Experience, Apply, Cooperate and Transfer
SRST	Scientific Reasoning Skill Test
TG	Treatment Group
TIMSS	Trends in International Mathematics and Science Study

List of Publications

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CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Scientific literacy coined in literature with different meanings (Holbrook & Rannikmae, 2009). Adhering to the definition of National Research Council (NRC) (1996), scientific literacy is the capacity to apply scientific methods and ideas in decision-making on a personal level and to engage in dialogue on scientific matters that impact society. It enhances the ability to think critically, solve socio-science problems imaginatively, collaborate with others in teams, and use technology efficiently (Kapici et al., 2017).

The aim of science education in schools is to develop students scientific literacy (Avargil et al., 2011; Cabbar & Şenel, 2020). In today's world, where science has a significant role and power in the economic and social development of countries, the value that people give to science is also important (Aydin-ceran, 2021). In that case, the scientific literacy level of the whole population has long been a focus of attention for researchers because of its direct impact on many aspects of our lives (Renouard & Mazabraud, 2018).

In relation, the main aim of biology education is to develop students understanding of an integrative biological systems (Nehm, 2018). Biological systems are subject to various probabilistic interactions within and across scales (such as molecular, cell, organism, and ecological). Nehm (2018) defines biological patterns and processes as “a multiplicity of causal factors combined with probabilism in the sequence of events” across scales. Biology has a wide range of applications, such as protecting the planet and conserving nature. To cultivate such understanding and skills among students, enhancing scientific literacy through curricular reform, faculty development, and teaching and learning research is vital (Dirks & Knight, 2016).

Similarly, our understanding of the intricate underlying mechanics of genetic events has been enhanced by the advancements in genetic research over the past several decades. Personalized medicine, gene therapy, genetically modified crops, forensics, and genetic screening are just a few of the topics that knowledge developed in research labs is influencing citizen decision-making (Haskel-Ittah et al., 2020). Therefore, it is widely acknowledged that understanding genetics is an essential part of becoming literate in the sciences (Haskel-Ittah et al., 2020).

Given importance of scientific literacy, institutions, researchers, and science teachers should work to achieve it. Scientific literacy requires an understanding of real-world situations. In that case, the focus of science education in the 21st century has evolved from "what we know" to "how we know and why we believe". The OECD scenarios for the future of schooling report has stated that “In a complex and quickly changing world, this might require the reorganization of formal and informal learning environments and reimagining education content and delivery.” In an aging world, these changes are likely to apply not only to basic education but also to lifelong learning (OECD, 2020). In a rapidly evolving world, the ability to anticipate and prepare for future skill requirements is increasingly important. Moreover, enhancing students’ understanding of science is fundamental to cope up with the rapidly changing world (Bendixen, 2016; OECD, 2020).

However, many school curricula contains accumulated facts, do not focus on developing scientific literacy, and it is not situated in context and culture of the society (Linn et al., 2016). This makes student learning overloaded and problematic (Linn et al., 2016). The American Association for the Advancement of Science (AAAS) (1997) claims that many science classrooms implement a “curriculum that prioritizes the ability to memorize terms, algorithms, and generalizations and hinders the acquisition of understanding." Such attitudes often lead to shallow learning, where information is kept only for its use in a test and where there is little effort to build a consistent account of the domain. The focus on the dominance of subject knowledge in the curriculum implies that school science will keep struggling with an overloaded curriculum (Kind & Osborne, 2016).

Since context is viewed as a secondary topic in schools, many secondary school students around the world are uninterested in science (King, 2016). Additionally, they felt that the curriculum's topics had little to do with their daily lives. Regarding pedagogy, outmoded methods continue to be used in science classrooms where the emphasis is on knowledge memorization (King, 2016).

The ideological assumption that scientific knowledge systems are universal was challenged by Otulaja and Ogunniyi (2017). The authors reported that African science education curriculum is reflecting Western knowledge constructions without fully integrating indigenous knowledge systems. According to Ziegler and Lehner (2017), the dominance of Western science results in a kind of closed system of methods, goals, and paradigms that only and persistently reproduces itself.

This is the reality in most African countries, including Ethiopia. The Ethiopian science curriculum is fact accumulated and imported from westerns without incorporating the indigenous knowledge (MoE, 2018). The curriculum's content, how to contextualize and make it relevant for children, was not thoroughly researched (Meskerem, 2017). Learners do not have an answer for the question why they are learning a given topic. Hence, the curriculum has no or little relevance in students' everyday life (MoE, 2018).

Furthermore, the Ethiopian curriculum, according to Joshi and Verspoor (2013), is not addressing the needs of students who are not pursuing higher education, and it seems that the general secondary level's overburdened, challenging, and academically rigorous curriculum is a significant factor in the use of inadequate instruction and low student performance. The curriculum is content centered, not learner centered.

Studies reported that student learning outcomes are very poor, in fact, on a declining trend, and most secondary and preparatory students do not have the expected knowledge, attitudes, and skills (MoE, 2009; MoE, 2018). The students are seen as lacking the necessary competence and skills to enter work after completing 10 and 12 grades (MoE, 2018). This might be due to limitations in the Ethiopian curriculum’s ability to identify actual issues and then provide workable solutions. Instead of addressing the practical realities of the nation, more effort is put into topics that lean toward speculative theories and unrealistic ideas (Solomon & Aschale, 2019). Typically, instruction places more of an emphasis on academic subjects than it does on the development of cognitive skills (Solomon & Aschale, 2019).

Furthermore, science teachers in Ethiopia commonly practice conventional instruction (MoE, 2018; Joshi &Verspoor, 2013; Meskerem, 2017). However, it has been argued that conventional instruction does not show positive effects on the development of students’ scientific literacy (Avargil et al., 2011; Kapici et al., 2017; Cabbar & Şenel, 2020). To this end, it might be necessary to address the problems of overload, inappropriate topics, and learning gaps in the curriculum. Besides, it is necessary to change the mode of instruction to develop scientific literacy.

In that case, it is argued that situating science learning in the context and culture of the society might be important. Science and culture are inextricably linked, and isolating science from a society's culture may lead to an incorrect understanding of science, leading to negative attitudes toward science (Kapici et al., 2017).

According to Avargil et al. (2011), learning that is ingrained in a context and integrated into daily life is more durable, and it will boost students' scientific literacy (Gilbert, 2006). This leads to favor the context-based learning approach for 21st century science education (Aydin-ceran, 2021). By placing science concepts in situations that are relevant to everyday life, context-based techniques provide a fresh way to engage students in science (De Jong, 2008). When science is taught in context, students perceive the content to be more relevant (Bennett et al., 2005). The context based instructional approach helps students relate the situations they encounter in their daily lives to the content in the classroom.

Hence, the focus of the present thesis is to investigate the effect of context-based teaching approaches on conceptual understanding, scientific reasoning and epistemic belief as part of scientific literacy. The literature discusses the lack of context-based learning in Ethiopian biology education. It also states that there is no research that connects context-based learning with conceptual understanding, epistemological beliefs, and scientific reasoning in Ethiopia and that the current study aims to fill this research and practice gaps. The thesis uses a context-based curriculum that links genetics concepts with students’ everyday life experiences in grade 10 and employs the REACT strategies of relating, experiencing, applying, cooperating, and transferring. The study implements context based approaches (REACT strategy and the integration of context based activities and conventional instruction) and conventional instruction, and compares their effect on the mentioned variables.

1.2. Context of the Study

Ethiopia's education system is undergoing numerous reforms as one means of becoming a low-middle income nation by 2025. In relation, Strategic Policy for National Science, Technology and Mathematics Education (STME) (Ministry of

Education, 2017) provides more emphasis to science and mathematics education (MoE, 2010). For example, in higher education institution, the distribution of disciplines was 70% for natural science (mainly engineering and agriculture) and 30% for social science. However, recently it is changed to 55% for natural science discipline and 45% for social science discipline (Dawit, 2022).

Constructivist based learner centered approach gets emphasis in the 1994 Ethiopian education and training policy (MoE, 2009). The policy clearly indicated that curriculum development and textbooks should be prepared based on current sound pedagogical and psychological principles (MoE, 1994). The learner centered approach also gets emphasis on syllabi of courses at different levels (MoE, 2009). Active learning and a competency based approach in general get concern in the curriculum framework.

As the curriculum framework of the country, biology aims to enable students to understand issues affecting people as individuals and the interaction of people with society and with the environment (MoE, 2009). The curriculum framework is mainly competency–based; competency is taken as the capacity of learners' to apply knowledge, skills, attitudes and values in independent, practical and meaningful ways.

However, there are major drawbacks in the present curriculum, notably a lack of relevance of some of the content, problems in the assumed methodology of teaching, as well as difficulties in the implementation of continuous assessment. The research findings also indicate that contents of textbooks, which follow the subject syllabuses in the curriculum are highly overloaded and often conceptually too advanced (MoE, 1994; MoE, 2009; MoE, 2018). Moreover, although the policy advocates a student-centred approach, the teaching learning materials do not promote this method (Meskerem, 2017; Solomon & Aschale, 2019).

The structure of the current Ethiopian education system is 6-2-4, 6 years of primary education and 2 years upper primary education and 4 years of secondary education. There is a certification examination for completion of primary education and secondary education. After completing secondary education, students join either universities or technical and vocational training colleges (MoE, 2018).

In Ethiopia, Science is given to primary school students (grades 1- 6) with different subject names, such as environmental education and general science. ‘Environmental education’ is taught in grades 1-6, with concepts from biology, chemistry, geography, history, and physics. The subject is taught in the local languages until 6th grades. From grades 7-8 students learn ‘general science, which includes biology, chemistry, and physics using English language. Starting from grade nine, biology is offered as an independent compulsory subject until the end of grade 10. After completing 10th grade, students choose between two options: Science and social studies. Biology is then assigned as a separate subject to those students who choose to study science in grades 11 and 12. The topic of genetics is included in biology subjects at 10th and 12th grades.

1.3 Statement of the problem

As noted before, the Ethiopian educational system's curriculum is poor in quality and relevance. It is too theoretical, difficult, and bulky, which leaves little room for reflection and deep learning. It also fails to adequately prepare students for the workforce (MoE, 2018). The curriculum does not teach pupils "what to do," "how to do," or "what they need to do." Unlike the Ethiopian education policy promoting learner-centered instructions, the curriculum is content-led and overloaded. It does not endorse the implementation of active learning methods in the classroom (Joshi & Verspoor 2013).

One of the subjects in Ethiopia's educational system is biology. Teaching biological science requires instructional strategies that enable students to comprehend biology and use what they learn in daily life. There is a critical need to identify efficient learner centered teaching strategies that enable students apply biological knowledge to their daily lives. However, studies reported that the majority of science teachers employ a teacher-centered approach to instruction (Meskerem, 2017). The majority of students felt that biology in particular and science in general were challenging subjects (Alsumait, 2015; Çimer, 2012). This might be due to overly theoretical education (teacher-centered), which makes the subjects abstract and dull, and the poor academic performance of students (Oli, 2014). The drawback of the educational system, especially the nature of curriculum and manner of instruction can be attributed to the students' lack of conceptual understanding and poor performance in their achievements (Joshi & Verspoor, 2013; Meskerem, 2017; MoE, 2018).

The majority of Ethiopian pupils are unable to meet the core learning requirements set by the Ministry of Education. Three national learning assessments were conducted in Ethiopia between 2010 and 2017. The results fall short of what the students are expected to achieve, a minimum passing mark of 50% for each subject (MoE, 1994). When compared to the required minimum of 50%, the mean result of biology in Grade 10 is 38.33%. The average biology score in Grade 12 was found to be 50.01%, which is nearly the minimum required of 50%. In five subjects achievement results, more than half of grade 10 students were at lower level in their proficiency (MoE, 2017).

The achievement of students in cohorts 2017 was found to be significantly lower than the 2013 assessment in every subject. This suggests that students' performance is declining with time (MoE, 2017). Tesfaye (2014) further affirmed that there is a very substantial reduction in educational quality across all grade levels. The content of most tests focuses on knowledge, and students performed better in the knowledge level though below average than understanding and application (MoE, 2017). However, knowing facts and principles does not mean that the students understand the concepts (Mills, 2016).

Studies have demonstrated that increasing one's scientific literacy does not always follow from mastering science content. For instance, in Bao et al. (2009) study students that performed better on knowledge test performed poorly on the science reasoning test. This implies that Ethiopian students might have low reasoning skills since they achieve below-standard in knowledge level tests. Besides, Mulugeta et al. (2021) confirm that Ethiopian science and mathematics teachers do not place a strong emphasis on scientific reasoning in their teaching.

In relation to epistemological beliefs, Ethiopian students hold naive beliefs. According to Mulugeta (2019), university students in Ethiopia tended to have less sophisticated views about knowledge and the process of knowing. This may indicate that these pupils are less impacted by contemporary conceptions of knowledge and the methods used to acquire it. This might be attributed to the traditional values that teachers and elders want students to uphold and to the idea that authoritative people should not be questioned.

Researchers found a correlation between the majority of students' having consistently low conceptual understanding and scientific reasoning and teachers' incapability to use effective teaching strategies (Joshi & Verspoor, 2013). This suggests that students' academic success is a reflection of the effectiveness of their teachers. Teachers' levels of knowledge and expertise in using an appropriate learner-centered methodology in science classes in Ethiopia is very low (Joshi & Verspoor, 2013; Meskerem, 2017). Teachers lack the skills necessary to integrate contexts and students everyday life in their teaching (Gebeyaw et al., 2021; Meskerem, 2017). Students in Ethiopia come from a culture that has various traditional views about knowledge and the educational process. Additionally, the community has a long history of recognizing leaders in the classroom, especially in religious institutions. But teachers did not understand how cultural and societal elements have an impact on scientific knowledge and how it develops over time (i.e., with ambiguity). This demonstrates the apparent failure of Ethiopian schools' attempts to raise student involvement, meaningful learning, and epistemic notions (Oli, 2014).

Academics contend that, regardless of the method employed to deliver it, science education should center on context and culture (Bennett et al., 2007; Gilberts et al., 2011). Science education, regardless of technique, is said to benefit from contextualization and cultural relevance (Bennett et al., 2007; Gilberts et al., 2011). Besides, literature informed us that there was a lack of research on factors related to changes in epistemologies and reasoning skills using different active learning methods (Basu et al., 2017; Ding & Mollohan, 2015). Furthermore, research on the benefits of active learning techniques on students' comprehension, epistemological perspectives, and reasoning when learning biology found to be inconclusive. Some studies reported null effect of active learning methods on students believes (e.g., Floro, 2014; Beumer, 2019) other studies reported positive effects (e.g. Jeffery et al., 2016; Connell et al., 2016; Hoskins & Gottesman, 2018; Westerlund and Chapman, 2017). Based on these contradiction previous studies suggested that evaluating students' beliefs in classes that cover a larger array of teaching methods (Madsen et al., 2015), various active-learning methodologies' influence on students' beliefs (Cleveland et al., 2017), exploring ways of teaching to improve epistemological beliefs (Igwebuike &

Oribhabor, 2016; Beumer, 2019) are important directions for further research. Given this, it seems logical to look into how a context-based approach affects students' understanding, scientific reasoning, and epistemological beliefs in various cultural contexts.

Additionally, studies have shown that students' comprehension of scientific ideas either hampered or facilitated their capacity for reasoning (Duncan & Reiser, 2007). These investigations show a connection between conceptual knowledge and scientific reasoning that is visible, but the exact nature of this connection is yet unknown. It is therefore necessary to conduct an empirical investigation to examine the connection between conceptual knowledge, scientific reasoning, and epistemological belief. .

In summary, globally and nationally, the following problems are identified. 1. There is a dearth of researches on the effects of a context based approach on epistemological beliefs, scientific reasoning, and conceptual understanding in biology; 2. Students' poor performance in the variables listed; 3.Dominance of the traditional (transmission) method of teaching at all levels of education in Ethiopia; 4. Lack of relevance and quality of the curriculum; 5. Deterioration of students' epistemological beliefs towards science and considering science subjects as hard, difficult, abstract and boring; this leads to poor student learning, and 6. Inconsistence of study results in progressing epistemological beliefs using different active learning methods. In that case, the researcher aimed to implement context-based approach and to see its impact on their scientific reasoning, conceptual understanding and epistemological beliefs.

1.4 Objectives of the study

The main objective of this study was to investigate the effect of a context based REACT instructional strategy on students’ scientific reasoning skills, conceptual understanding, and epistemological beliefs compared to conventional instruction in biology. The following particular objectives and research questions were developed to help achieve this goal:

The specific objectives were:

1. To compare students' in the two treatment groups and one comparison group on their ability for scientific reasoning.
2. To explore the level of scientific reasoning skills of students after the intervention of context-based instruction and conventional instruction.
3. To compare how well students in the two treatment groups and the comparison group understood the concepts of heredity.
4. To examine students' epistemological beliefs among the two treatments and one comparison groups.
5. To determine the relationship among scientific reasoning skills, conceptual understanding and epistemological beliefs about heredity concepts of students after the intervention.
6. To investigate how scientific reasoning skills, epistemological beliefs and understandings of biology concepts of treatment group students are developed.

1.5 Research questions

The study's research questions were:

1. How do the two treatments and comparison groups differ in terms of their post-intervention scientific reasoning abilities?
2. How well does the level of scientific reasoning of students in the two treatment groups and the comparison group differ?

3. How do the two treatments and comparison groups differ in terms of their conceptual understanding of hereditary concepts?
4. How do the two treatment groups and the comparison groups differ in terms of their epistemological beliefs?
5. How do students' conceptual knowledge, scientific reasoning abilities, and epistemological beliefs relate to one another in context-based learning?
6. How scientific reasoning skills, understanding of biology concepts and epistemological beliefs of students are developed during treatment period?

1.6. Significance of the study

The result of this study would provide both practical and theoretical evidence. In the Ethiopian context, research into the causes and remedies for deteriorating quality is now highly essential. Though little has been done by way of systematic investigation into the causes, quite a few researchers have attributed the inability of the education system to bolster students' learning to different reasons. The wealth of research literature, on the other hand, criticizes overloaded and concept-led curricula, which makes students dissatisfied and disengaged while learning science. A curriculum that integrates everyday contexts with school science aids in the development of scientific concepts. Students' social or personal experiences were incorporated to enhance their biology learning in order to integrate concepts with context.

This study's objective was to improve students’ learning including better conceptual understanding of the biology content they were learning. It also has implications for changing the prevalent teaching and learning culture in schools. It also moves toward the desired quality of biology education at the school level. As a result, trained teachers in this study play critical roles in the development of their students; they gain experience in how they can help their students develop the abilities of linking the concept of learning with its application in a social context, particularly in daily life events.

The study might have practical significance for instructional improvement that calls for curriculum contextualization at the school level, including in existing CPD programs and teacher education reform that trains at the College of Teacher Education and the university. Finally, its implication goes to teachers, curriculum developers, policymakers, and all education-related bodies.

Even if scientific concepts are universally applicable, the learning of biology concepts is influenced by the society's specific context and culture. According to De Jong (2008), science concept learning can vary depending on the context. As a result, by using personal and societal practice in Ethiopia as a context, this adds to the body of literature supporting the efficacy of a context-based approach.

Furthermore, there was a modest improvement in the integrated method compared to the solely context-based strategy. Therefore, the study's findings are valuable in that they encourage teachers to experiment with integrated teaching methods in their classrooms as a substitute for traditional teaching methods that are either quick or too slow (contextual). On the other hand, they can be used within a given time frame. Similarly, the literature confirms that the development of epistemological beliefs and scientific reasoning takes a long time. In contrast, the result of this study showed that the EB and SR showed the start of development within six weeks of context-based intervention, even if they did not reach the maximum level.

Additionally, it is anticipated that the present study will contribute to the literature with its findings by resolving the methodological issues raised in the literature, as studies that examine the effectiveness of context-based instructional approaches are thought to be few in number and to have some methodological issues (Taasoobshirazi & Carr, 2008). This study also uses a holistic approach to see the effect of context-based instruction on the development of students' understanding, reasoning, and beliefs over time rather than studying each variable separately. In addition, this study used a mixed research approach to get in-depth data about the intervention and development of dependent variables rather than a quasi-experimental approach.

1.7 Delimitation of the study

This research was restricted to one unit (genetics) of grade ten biology textbook. The literature has shown that, among other topics in biology, genetics are difficult to teach and learn. Developing a conceptual understanding of heredity topics in this first introduction promotes learning specific genetics concepts in subsequent education; thus, grade ten is the first to introduce genetics terms. Secondary schools at Debreberhan in Amhara Region as one regional state of Ethiopia served as the setting for this investigation. Only three nearby public schools are allowed to use it. The variables also delimit scientific reasoning skill, conceptual understanding, and epistemological beliefs. The reason to focus on those variables is due to the scarcity of literature in relation to the development of those variables using a context-based approach, especially in the biology discipline. In terms of instruction, both conventional teaching techniques and a context-based approach using the REACT strategy were employed.

1.8 Operational Definitions

Epistemological beliefs: beliefs of students regarding the nature and organization of biological knowledge, the source of that knowledge, how it refers to the outside world, and how they solve problems.

Scientific reasoning: both formally (using scientific concepts and evidence) and informally (Based on their daily lives) reasoning.

Conceptual understanding: is a student's capacity to link various concepts and justify their decisions, as judged by the results of the genetic conceptual understanding test.

A context-based approach: content that is based on the actual day-to-day experiences of students in their specific environment.

Conventional instruction: relates to the actual methods of instruction used in classrooms, namely lectures and discussions. A lecture followed by a demonstration or a lecture followed by a discussion in class.

CHAPTER TWO: LITERATURE REVIEW

Introduction

In the section that follows, the researcher tries to illustrate both the theoretical underpinnings and key research constructs. The literature is primarily concerned with how context-based approaches are used in science instruction and how they affect students' conceptual understanding of science and biology as well as their views on epistemology and scientific reasoning. The conceptual underpinning of the investigation is also explained using this body of literature.

2.1 Theoretical Perspectives

The general "blueprint" for the dissertation's research is provided by the theoretical framework. It provides the framework to outline your overall philosophy, epistemology, methodological approach, and analytical approach to the dissertation (Grant & Osanloo, 2014). It also serves as the basis for developing and sustaining the study. a framework for study that relies on a formal theory and is created by using an accepted, comprehensive explanation of specific occurrences and relationships. The chosen theory (or theories), the concepts and definitions of that theory that are relevant to the topic, and the plan for exploring the issue are all parts of the theoretical framework. According to Grant and Osanloo (2014) empirical definition, a theory cannot be employed or produced for the dissertation unless it is appropriate, logically construed, well-understood, and aligns with the research issue.

Distinct learning theories make distinct assumptions about how students learn, including assumptions about knowledge, student learning, evaluation, and the instructional approaches that result from specific worldviews. Despite the wide variety of learning theories, there are only three main categories: behaviorist, cognitive constructivist, and social constructivist. There is no one perfect or appropriate theory for a dissertation, according to Grant and Osanloo (2014) argument. The researcher must make the decision and provide a clear reason for it in order to ensure that the theory chosen is in accordance with and supports the structure of the study's objective, research questions, significance, and design. In order to organize the dissertation, the researcher must select a theory. In this section, each type of learning theory is briefly introduced. Ormrod (2012) puts detailed explanation about each learning theory in relation to human learning. The following section discusses in short by taking the idea from this book.

2.1.1 Behaviorism

The most successful behaviorist teaching methods have been used in subjects where there is a "correct" solution or subject matter that is simple to learn and memorize. The late 19th and early 20th centuries saw the beginning and the dominance of methodological behaviorism. The focus of behaviorists was on behavior and events that could be objectively seen and measured. They said that since it is impossible to objectively see or measure what occurs in the mind, scientific theories should only take apparent indicators like stimulus-response sequences into account. According to behaviorists, knowledge is a set of behaviors. According to Skinner, "knowledge is action, or at least rules for action," as opposed to using information to guide our actions. It is a group of primarily mechanical, passive responses to outside stimuli. Behaviorists also believed that learning is primarily the transmission of the proper response to a given stimulus from instructor to learner, utilizing ongoing positive reinforcement and short, incremental sequences of tasks. Without rewards, learned reactions will quickly become extinct. This is because learners will keep changing their behavior until they receive some kind of positive reinforcement.

Behaviorist teaching methods commonly employ so-called "skill and drill" exercises to offer the consistent repetition necessary for the successful reinforcement of response patterns. Other techniques include guided practice, routine content reviews, and question (stimulus) and answer (response) frameworks in which questions are progressively more challenging. Additionally, a crucial element of behaviorist teaching methods is typically the use of positive reinforcement, such as verbal praise, good grades, and awards. Behaviorists measure the degree of learning by using methods that assess overt behavior, such as test performance. The most successful behaviorist teaching methods have been used in subjects where there is a "correct" solution or subject matter that is simple to learn. For instance, behaviorist approaches have succeeded in teaching organized material like facts and formulas, scientific ideas, and vocabulary from other languages. In the case of this study students who have naïve epistemological beliefs see knowledge as certain, comes from certain authorities and learning is an accumulation of facts.

Because the positivistic view is so deeply engrained in West-European society, the majority of secondary and university textbooks support the positivistic approach by providing biological content without examining its applicability in contexts. The notion is provided without discussing the circumstances surrounding its discovery, even if scientists who did propose novel biological hypotheses as the outcome of empirical research are referenced (Van & Boersma, 2018). The idea behind the term "context of discovery" as a whole is that the truth about biological items is revealed. There must be convincing justifications for selecting an alternative epistemological approach given that the majority of biologists and biological educators have received positivistic education. Since constructivism has gained widespread popularity in recent years, it has been assumed that knowledge building is an individual process.

Positivism and behaviorism serve as the intellectual underpinning and guiding principle of the teacher-centered teaching strategy, claim de la Sablonnière et al. (2009). For many years, teacher-centered instruction and behaviorist learning theory dominated scientific education. Other than helping them memorize facts, this teaching approach didn't do anything to aid students in grasping science topics. This issue spurred researchers worldwide to look for novel learning theories and associated teaching. Due to their disliking of behaviorism's tight emphasis on observable behavior, educational psychologists like Jean Piaget and William Perry sought an approach to learning theory that paid greater attention to what went on "within the learner's head." Constructivism emerged as a learning theory as a result.

2.1.2. Cognitive Constructivism

The purpose of cognitive teaching strategies is to enable students to incorporate new knowledge into their body of knowledge and to modify their preexisting conceptual framework to take that knowledge into account. They developed a cognitive technique that prioritized internal thought above outward behavior. The majority of cognitive theories agree that knowledge is composed of processes that act on propositions and other symbolic mental representations. Learning is defined as the active generation of knowledge by learners based on their pre-existing cognitive structures. Knowledge is composed of active mental systems with specific purposes that are derived from earlier learning experiences. Every learner interprets their experiences and information in light of their underlying knowledge, present cognitive stage, cultural background, personal history, and other factors. These components aid students in selecting and reshaping new content as well as organizing their past knowledge. Understanding the learner's preexisting intellectual framework is crucial in order to understand the learning process because learning is based on a person's stage of cognitive development.

Therefore, learning is a process of active discovery in which knowledge is actively created, according to cognitivists. The teacher has no need to continuously drill students with knowledge or to force them to learn through the application of well calculated rewards and penalties. Instead, cognitive education techniques assist students in fusing new knowledge with prior knowledge and in adapting their existing intellectual framework to take into account the new knowledge. Teaching strategies that promote active uptake and application of new material are therefore given more weight. Teachers must therefore take the student's prior knowledge into account when developing curricula and choosing how to present, arrange, and organize new material. For example, allowing students to explain new material in their own terms can aid in their assimilation by challenging them to utilize their own language to communicate the new concepts. Similar to how assigning pupils sets of questions to structure their reading enables them to tie it to earlier knowledge by emphasizing key passages and to accommodate new material by providing it with a clear organizational framework. Given that learning is mostly self-motivated within the cognitivist paradigm, cognitivists have also advocated teaching methods that encourage students to monitor their own learning. For instance, using study guides and ungraded exams enables students to monitor their own learning progress.

Jean Piaget

The chief advocate of cognitivism was Swiss child psychologist Jean Piaget. Piaget rejected the idea that learning was just memorization of previously learned material. Instead, he contended that learning is an active process that entails responding to reality in a number of steps, during which time students actively construct knowledge by creating and honing their own ideas about how the world works. The explanation of the mechanisms by which cognitive development occurs using equilibration principles and an explanation of the four main stages of cognitive development that children go through are the two main parts of Piaget's theory.

The main assumption of Piaget's theory, the principle of equilibration, holds that all cognitive growth, including both intellectual and affective development, moves in the direction of gradually more complex and stable levels of organization. Equilibration occurs as a result of the adaptation process, which entails integrating new knowledge into pre-existing cognitive structures and accommodating that knowledge by constructing new cognitive structures. For instance, students who already have some of the mental models needed to solve time-rate-distance problems in math will also already have some of those models. However, they will need to modify their existing models to make room for the newly acquired information in order to solve the new type of problem. Thus, by incorporating new knowledge into pre-existing cognitive structures, learners adapt and develop.

Children's cognitive development happens in four main stages, according to Piaget. During the first two years of life, children go through a sensory-motor stage where they change from cognitive structures dominated by instinctual drives and unexamined emotions to more ordered systems of concrete concepts, unexamined emotions, and their early external affective fixations. At this age, children's outlook is predominantly egocentric since they lack the capacity to take other people's perspectives into account.

The second stage of development lasts from the age of two to seven. Children begin to interpret the world via language. They are taught how to work with numbers and sort things according to different standards. Children's developing linguistic skills open the way to increased socialization of behavior and interpersonal contact. Between the ages of seven and twelve, children begin to understand logic, but they are only able to apply it to concrete things like events and objects.

Adolescence is when children enter the formal operational stage, which they remain in for the rest of their lives. As they grow emotionally and intellectually, children are able to undertake abstract intellectual operations. They learn to develop and test abstract hypotheses without using actual physical items. Most importantly, children learn to respect both their own and other people's opinions. The last two stages—concrete operational and formal operational—are important because these are when more complex reasoning abilities, as previously indicated, start to emerge. Individuals that operate in the real world are dependent on real-world events and are unable to form hypotheses based on those events. Formal operational thinking is attained by those who can create and test hypotheses, or who employ hypothetico-deductive reasoning.

The table (Table: 1) below summarizes stage of development and its description. From the 1950s to the 1970s, Piaget's hypothesis was embraced by the majority of people. The notion had a big impact on following theories of cognitive development, even though it isn't as frequently accepted anymore. For instance, assimilation and accommodation are two forms of adaptation that are still commonly acknowledged.

Table 1. Piaget’s stages of cognitive development adopted from (Ormrod, 2012).

Stage and age range	General description
Sensory-motor Stage (birth until about 2 years old)	Schemes primarily entail perceptions and behaviors. Children’s understandings of the world are based largely on their physical interactions with it.
Preoperational Stage (2 until about 6 or 7 years old)	Many schemes now have a symbolic quality, in that children can think and talk about things beyond their immediate experience. Children begin to reason about events, although not always in ways that are “logical” by adult standards.
Concrete Operations Stage (6 or 7 until about 11 or 12 years old)	Children acquire cognitive structures that enable them to reason in logical, adult like ways about concrete, reality-based situations. They also realize that their own perspectives are not necessarily shared by others.
Formal Operations Stage (11 or 12 through adulthood)	Children can now think logically about abstract, hypothetical, and contrary-to-fact situations. They acquire many capabilities essential for advanced reasoning in mathematics and science.

2.1.3. Social Constructivism

Social constructivism, a subset of cognitive constructivism, emphasizes the collaborative nature of many learning experiences. Lev Vygotsky founded the movement for social constructivism. Despite the fact that he was a cognitivist, Vygotsky disagreed with Piaget and Perry when they asserted that learning could be divorced from its social environment. This applies to all cognitive functions, including idea generation, logical memory, and purposeful attention. Real connections between people form the basis of all higher functions. Every cognitive process originates from social interactions and must thus be seen as a byproduct of such interactions. According to Vygotsky (1978), every function that contributes to a child's cultural development "appears twice," first on the social level between people (inter-psychological) and then on the personal level within the child (intra-psychological). This holds true for all cognitive processes, including concept creation, logical memory, and intentionally directed attention. All higher functions are built on the foundation of real connections between people.

The Vygotsky developed socio-cultural perspective, which is grounded in pragmatism, places an emphasis on the importance of culture and language and maintains that knowledge is formed via interactions between people. Socio-cultural theory is concerned with how cultural attitudes and ideas influence education and learning, as well as how adults and peers influence individual learning. Learning is social, knowledge is experience-based and produced by the learners, and all aspects of an individual, such as societal and cultural views, are interconnected. These are some of the key characteristics of both the social constructivist and socio-cultural perspectives. Important aspects of context based learning in relation to social constructivists are the ideas of teaching based on experiences and content related to everyday life, as well as the purposes of teaching and the importance of reflection which is relevant to this study.

Cognitivists like Piaget and Perry contend that when students engage with outside stimuli, they actively produce knowledge. According to Vygotsky, language and culture are significant factors in the evolution of the mind. According to Vygotsky, language and culture are crucial for a person's intellectual growth as well as how they view the world. Humans can overcome the fundamental limitations of their visual field by imposing culturally defined sense and meaning on the universe. Language and culture serve as the frames through which people perceive, express, and understand reality. According to Vygotsky, language and the conceptual frameworks it conveys are primarily social phenomena. Vygotsky believed that, as a result, human cognitive systems are essentially socially constructed. Knowledge is not only created; it is co-constructed.

Lessons that encourage scientific reasoning, according to Adey and Csapo (2012), offer several chances for social construction. In other words, they support kids in having meaningful conversations with one another, putting forward and supporting views, and respectfully challenging others. High-quality conversation, modeled and facilitated by the teacher, defines a lively classroom. Students who are merely a few steps ahead of their peers may be quite effective in helping the others since they think similarly to their classmates and are aware of the impediments to comprehension.

Piaget had been unable to grasp how collaborative learning works. Vygotsky distinguished two phases of development: When a student is capable of resolving problems on their own, they have reached the developmental stage at which they are genuinely developed. The "zone of proximal development" (ZPD) refers to the amount of growth that a pupil is capable of making with the assistance of teachers or in collaboration with peers. A learner may solve problems and grasp material at their level of potential development, which is higher than their level of actual development. This level is where learning takes place. It is made up of cognitive structures that are still forming, but they can only do so with others' assistance or in concert with them. In the case of this study, teachers in treatment group help students to relate the given experience based activities with the concept of heredity because students perform the given activity without knowing the reason behind by their own.

Numerous ramifications of Vygotsky's theory exist for educational practice. For instance, when students learn the fundamental cognitive skills required for a variety of tasks and academic fields, they may think more clearly. A real-life scenario was one of the effective learning tools for science from a social constructivist standpoint that may help students understand the concepts of the subject matter being studied. Utilizing learner experience to support students' learning is one technique to reflect a real-life scenario (Janssen & Fred, 2014). Constructivism claimed that learning can happen when students tie new knowledge to their pre-existing knowledge, and CBLA concurs by recommending using familiar and appropriate situations from daily life in the establishment of relations (Ultay & Ultay, 2014).

Numerous studies have shown that communities are capable of producing indigenous knowledge that is distinct from formal scientific knowledge and that knowledge building may also be viewed at the level of the community of practice (Lave, 1988). These results corroborated those in physics education, which showed that physical knowledge is created in both scientific and non-scientific situations. The activity in which knowledge is applied functionally is referred to as the context, and according to sociocultural theory, various contexts can give concepts diverse meanings. This viewpoint has significant ramifications for biology instruction since it suggests that conceptual growth cannot be limited to a single accurate interpretation of a notion. If use in several contexts is the goal, concepts should be re-contextualized, which involves adapting their meaning to a new environment, to avoid these outcomes (Van & Boersma, 2018).

If we believe that students will "own" the acquired knowledge and if we perceive biology learning as a personal production rather than a transmission process, then the most active student-centered learning methodologies should be taken into account. One instance of how a more student-centered approach may conflict with teachers' attitudes in a more traditional way of instruction is the idea that teaching biology should be based on lectures (McComas et al., 2020). Any ideas can be examined as potential interactions between the three poles of the KVP model, scientific knowledge (K), values (V), and social practices (P). Any ideas can be examined as potential interactions between the three poles of the KVP model, scientific knowledge (K), values (V), and social practices (P). In the KVP model, any conception(C) can be analyzed as a possible interaction between the three poles of K (knowledge), V (values), and P (social Practices) (Clément, 2006).

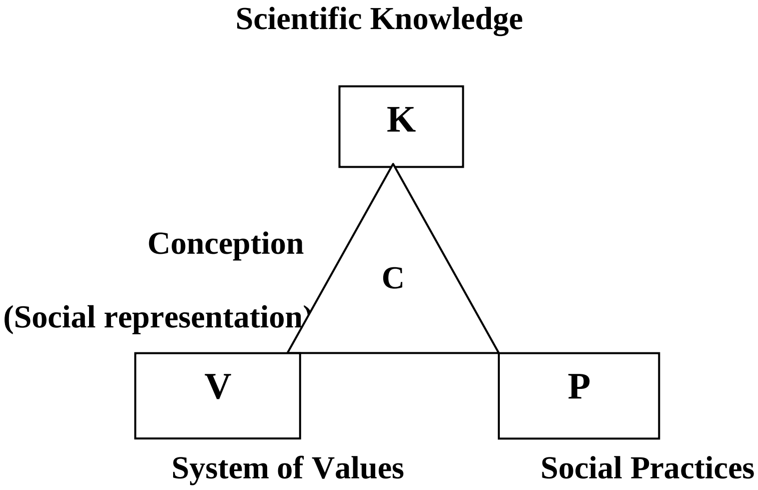

Figure 1. The KVP model (Clément, 2006).

According to Clément (2006), the didactic transposition delay (DTD) in biology education research is a measurement of the time it takes between the publication of a new scientific concept and its inclusion in teaching (in textbooks, curricula, or syllabi). It should come as no surprise that scientific information is frequently updated, sometimes in significant ways, yet typically what is taught changes very slowly, with delays varying from nation to country. Because of this, measuring and interpreting DTD may be a useful method for examining the socio-cultural and economic influences on the subject matter of biology education globally (McComas et al., 2020). For example, the topic of human origins has recently been banned in some nations (like Lebanon) and is not yet covered in the textbooks of others (like Algeria). Important brand-new biological ideas like transposons, brain epigenesis, and epigenetics have not yet been included in secondary school curricula in a number of nations. Another difficulty is that some of the concepts taught may be out of date. DTD can therefore be a valuable indicator of the socio-cultural influences on what is covered in biology schools worldwide (McComas et al., 2020).

The concept of learner-centered, active learning is gaining support in the research literature as an empirically supported teaching style that best supports students' learning in the modern day (Bao & Koenig, 2019). It comes from the constructivist school of thought on learning, which emphasizes that knowledge must be actively constructed by the student and that the instructor should operate more as a facilitator than as a supplier of information. The constructivist viewpoint suggests that learner-centered education typically places an emphasis on active engagement and inquiry-style teaching-learning approaches in which the students can successfully create their understanding while being guided by the teacher. In the same way the context based approach is a type of learner centered approach that gives space for learners to construct their knowledge based on their previous experience.

The importance of constructivism for the use of contexts in teaching has been emphasized by researchers (Gilbert, 2006; Sunar, 2013). According to constructivists, students build their own knowledge by engaging in experiences, reflecting on those experiences in light of existing knowledge, and applying that knowledge to new circumstances by connecting the new information to their earlier concepts and experiences (Sunar, 2013). Context-based techniques offer students meaningful learning experiences to acquire these higher-order thinking skills by using the students' real-world as the beginning point for presenting scientific ideas, providing a constructivist perspective. Learning being "situative" or "tied to a specific context and situation" is one of the hallmarks of constructivist learning, according to Sunar (2013). According to Bennett et al. (2005), learning will not be meaningful until it is separated from the physical and social environment in which it is created. In other words, situatedness relates specifically to being a component of the activity, setting, and culture in which knowledge is produced (Taasoobshirazi & Carr, 2008). Accordingly, one of the instructional models based on situated learning that immerses students in real-world settings and encourages them to use authentic learning strategies is similar to the context-based instruction (Sunar, 2013; Taasoobshirazi & Carr, 2008). Additionally, context is not separate from the activities people engage in using their own items. As with context-based instruction, cognitive apprenticeship is an application of activity theory to classroom practice with the goal of guiding and supporting students as they solve problems (Sunar, 2013).

The active process of developing explanations, inferences, and predictions concerning genetic phenomena is referred to in this work as epistemological beliefs, conceptual understanding, and reasoning. Knowing the structures, functions, and interactions of the entities involved in these occurrences is what is meant by the term "understanding" (reasoning about a phenomenon thus makes use of understandings of it). In this study in order to maximize their learning in treatment group teacher introduces the concept of chromosome, DNA and genes to relate their experience with the given activity based on real world. As Vygotsky’s explain when kids communicate about their experiences, they learn and remember more in both REACT strategy and context based approach to the conventional strategy give space for students to explain their experience even though the time was different. Almost as soon as they start speaking, kids start talking about their experiences. Teachers and parents should participate in the process: Talking with kids about shared experiences helps kids understand their experiences in ways that are appropriate for their culture and improves their recollections of what they saw and did. According to the social constructivist idea, kids should have access to experiences that are quite similar to what they would find as adults. Children who participate in group learning activities can acquire cognitive techniques. Children are likely to internalize the procedures they initially utilize in social contact, leading them to use those processes autonomously later on, according to Vygotsky.

The objective is to keep schools connected to society and daily life, to sum up. Focusing on the experiences and interests that each student has in their daily lives is the first step in context-based education. The constructivist method offers significant advantages for context-based teaching (Bennett et al., 2005; Gilbert, 2006). The majority of studies on context-based learning discuss the social constructivist theory of learning (Gilbert, 2006; Parchmann et al., 2006). This investigation focuses on biology training that takes into account students' practical knowledge. The core of this approach is the contextualization of a delegated biology curriculum, where the curriculum is interpreted and applied in ways that integrate the concept of biology with actual local conditions. Students find meaning in the learning process by making connections between the concept and the events or activities they encounter in their daily life in the local context. The social and socio-cultural constructivist learning theory was employed by the researcher to guide the current study since learning takes place in the social, cultural, and local context that students draw upon for their day-to-day experiences.

2.2 Conventional instruction in science teaching and learner performances

In his dissertation work, Kazeni (2012) summarizes the literature on conventional instruction in science and the following conclusions were drawn.

- The conventional methods of teaching science frequently give students the impression that learning about science consists of memorizing a list of abstract facts with no room for dialogue, which gives the subject an unappealing air of difficulty.

- They might not encourage hands-on and mind-on activities, which are crucial for the development of higher-order thinking skills;
- They might not always relate science lessons to learners' real-life experiences, which could make the study of sciences seem irrelevant and uninteresting to learners. All of these factors could prevent them from preserving young people's sense of wonderment about the natural world.

In certain cases, conventional (traditional) methods of science instruction seem to be moderately successful in raising students' achievement levels. It is necessary to determine whether using context-based science teaching techniques would be more beneficial than what is currently done in the majority of traditional (conventional) classrooms. These techniques tend to place more emphasis on connecting science learning with learners' real-world experiences. It is crucial to assess the relative effectiveness of conventional teaching techniques and a context-based approach in order to enhance learners' performance in terms of comprehension, reasoning, and epistemological perspectives.

2.3. Context based science learning

Prioritizing the development of 21st century abilities in scientific instruction will force students to make sense of reality and perceive science as a tool for applying it to real-world circumstances. From this vantage point, governments are redesigning science curricula and practices in an effort to, as much as possible, bridge the gap between science and real life by using settings from real-world situations.

A learning-teaching strategy known as the contextual approach bases instruction on the need to know (Pilot & Bulte, 2006) and seeks to mold the learning experience around circumstances students are likely to encounter in their daily lives. Gilbert et al. (2011) claim that students' understanding of the subject matter is mediated by the situation in which they are learning it. Learning cannot be divorced from its environment. Learning is influenced by the learner and the content, as well as the circumstance (Aydin-Ceran, 2021).

Studies have shown that context-based learning is effective at piqueing students' attention, making scientific classes more enjoyable, stressing the importance of knowledge acquisition in order to interpret context, and connecting science to students' everyday lives. Gilbert (2006) argues that a Life-Based Approach should be used in science courses in order to build students' science literacy and high-level thinking skills as well as to solve difficulties that arise throughout the teaching process in order to support this situation.

Context is the fundamental organizational framework that serves as the foundation of the life-based learning strategy and the skeleton of the educational process. According to Aydin-Ceran (2021), instruction starts with a context that the student is already familiar with from their sociocultural environment. The effectiveness of the procedures is then increased by applying the newly learnt concepts to additional situations. Concepts are then taught within this context. According to Gilbert (2006), the educational model that incorporates the context's meaning should be such that it effectively addresses the pertinent curriculum and societal issues. Students "need to know" the background in order to comprehend the scientific phenomena they are studying (Pilot & Bulte, 2006; Gilbert, 2006; Gilbert et al., 2011). To answer issues raised by the context, pupils "need to know" the concepts and guiding ideas. The "need to know" encourages pupils to participate fully in their educational process (Aydin-Ceran, 2021).

2.3.1 Definition of context in science education

Different scholars define the term context in connection with science education and there was no a single definition for it. The verb "contexere" in Latin, which meaning "to weave together," is the source of the name. This suggests that there must also be a relationship between the context and the environment it exists in. The verb "contexere" in Latin, which meaning "to weave together," is the source of the name. This implies that the context and the environment it surrounds must also interact (Vos, 2014). This interplay between the setting and a student's learning occurs in science education. Gilbert (Gilbert, 2006) defines context's role in education as the circumstances that allow a new scenario placed within a broader point of view a coherent meaning. According to Bennett et al. (2006) and Pilot and Bulte (2006), a "context" can also be a theme, issue, tale, topic, circumstance, practice, experience, application, and problem.

Contexts are characterized as situations that help students understand concepts such as laws, rules, and other laws. By considering that contexts can also be thought of as strategies for helping students give meaning to laboratory exercises in the classroom, this definition can be expanded (De Jong, 2008). In its broadest sense, context, according to Bennett et al. (2006), may relate to the social and cultural setting in which the student, teacher, and institution are located or, more specifically, may refer to the application of a scientific theory. There are two basic sorts of contexts for science education globally, each with a different definition. These are the science-technology-society (STS) approach and the context-based approach. The name STS is predominantly used in North America, despite the fact that the context-based approach is well-liked in European countries (Bennett et al., 2007a). A context-based approach is what Bennett and her colleagues characterize as:

“Context-based techniques are methods used in science instruction where the development of scientific concepts is started from the settings and applications of science. Contrast this with more conventional methods, which first discuss scientific concepts before examining applications (Bennett et al., 2007*; p. 348).*

The term "context" in pedagogical science practices in the Netherlands refers to a setting that has been chosen and adapted for educational aims both inside and outside of the classroom since a context is often thought of as a circumstance (Van & Boersma, 2018). Given that "context" is a pedagogical concept, it follows that if students are required to apply a concept in a context, they must complete an assignment at school as opposed to in a setting outside of it. This viewpoint does not explain why concepts might have different meanings depending on the situation. A context is described by De Jong (2008), as a social practice or a laboratory activity. These activities are goal-oriented and involve a series of actions being performed with an object by all of the participants, not just one particular subject.

Following Gilbert (2006) analysis of the context meaning, three definitions of “context” should be taken into account and related when developing a context-based strategy like ChiK (Parchmann et al., 2006):

● Context as information *(content)*. The underlying concepts that can be applied to address such challenges must be connected with the applicable contexts from which questions are formed in the creation of instructional modules. Other competencies, such as the study and presentation of necessary results or experimental investigations to produce such outcomes, are included in the design of the teacher's and students' activities.

● *Context as a learning stimulus*. For learning to be successful, learning settings must pique students' innate mental interests.

● *Context provides a foundation for knowledge and skill development and application in a specific situation.* Particularly when it comes to the transfer of learning results from one unit to another, the (social) development of competences in the classroom needs to be encouraged and improved. Context was conceived of in this study as a framework for the placed application of knowledge and competences. Therefore, context was crucial to aiding pupils' understanding.

All context-based science education initiatives often aim to raise students' interest, attitude, and motivation by making the study of scientific topics more relevant through the use of meaningful contexts. The need-to-know principle is the most efficient way to apply scientific ideas to the real world and achieve this relevance. This approach begins with the introduction of a familiar context, which will alert the student to the need for conceptual knowledge in order to comprehend the specific problem (Pilot & Bulte, 2006). Context-led science courses aim to address the problems with conventional science education by lowering the boundaries between academic science and real-world settings. By emphasizing the link between social issues and scientific knowledge, they also raise the social and cultural significance of science for students (Benneth & Lubben, 2011).

Contexts in a context-based approach might come from various origins. For instance, De Jong (2008), recognized four domains—the personal, the social and societal, the domain of professional practice, and the domain of science and technology—as the sources of contexts. In the context of the learner's own specific domain, make a connection between science and chemistry and their own lives. By elaborating on science/chemistry and its relevance in social issues, the social and societal domain settings allude to preparing students for their roles as responsible citizens. Situations in the area of professional practice are pertinent to the future careers of students as professionals in public or private settings. The setting within the science and technology sector helps students develop their technical and scientific literacy based on scientific advances and discoveries. It will finally become obvious that a specific context can come from more than one domain. This demonstrated that there is no clear distinction between those context domains and that it is possible to explain various concepts using more than one domain. For instance, both the personal and the social and societal domains might influence the context of food consumption. In the same way, both personal and societal domains can be used in trait inheritance.

The location of the main events, the behavioral environment, the language used, and extra-situational background information are the four distinct characteristics of an educational context (Gilbert et al., 2011). According to these features, a context is a central event that is embedded in a cultural environment. Additionally, the environment must be relevant to the student's regular activities. Learning activities provide a behavioral environment that encourages dialogue among the students. The specific language is a situational characteristic that promotes the development of proper scientific language usage. Coherence of the specific language is provided by the behavioral environment, which is related to the appropriate context of the main event. According to Kazeni and Onwu (2013), learners' extra-situational background knowledge should be connected to key events.

2.3.2 The importance of context

By incorporating the social aspects that are covered by group learning activities, integrating out-of-school environments, and applying learning outcomes outside of the classroom (for example, by participating in meetings and decision-making processes), the tasks and units should enable students to integrate their own ideas and activities. Biology science instruction should be integrated into instructional methods in a way that supports students' competence growth. Context-based teaching and learning refers to the delivery of biological information to learners in a way that allows them to connect it to their everyday experiences and that opens up scientific application areas (Elster, 2010).

Contexts' functions can change depending on how they are presented in a lesson and how they relate to other ideas. De Jong (2008) provided contexts in three different ways (Table 2). Contexts typically follow concepts in many conventional context-based methodologies. Contexts serve two purposes frequently in this teaching. First, situations are offered as examples of previously taught concepts, particularly in the case of abstract notions. Second, contexts are provided so that students can put their knowledge of a subject into practice. This may result in a concept's present meaning changing or getting a new meaning added to it. Contexts come before concepts in several more recent context-based methodologies. Two additional functions of contexts are frequently highlighted in this teaching. First, contexts are introduced as the foundation or justification for teaching concepts. Second, these contexts can increase motivation for learning new ideas in addition to serving as an orientation tool. In some of the most modern context based methodologies, contexts not only come before concepts but also follow those concepts with (other) contexts. The four context-related functions are united in this teaching sequence.

Table 2 Context-based approaches and functions of contexts

Teaching approach	**Order of presentation**	**Function of context**
Traditional	Contexts follow concepts	Illustration, Application
More modern	Contexts precede concepts	Orientation, Motivation
Recent	Contexts precede concepts and (other) contexts adhere to them	Each of the aforementioned actions

2.3.3 Models for the development and implementation of context based curriculum

Four models were put forth by Gilbert et al. (2011) for the creation of context-based curriculum. According to the first paradigm, a setting that instantly applies a notion is only given as an example after an abstract concept has been understood. In the second paradigm, context is used to connect a concept to its applications. Due to the text's cyclical structure, numerous examples are provided multiple times in order to apply previously revealed principles and introduce new concepts. When scientific concepts are connected to stories by a person's own mental activity, the third model gives context. The person is highly valued in this paradigm. In the fourth model, instruction occurs while teachers and students collaborate to find a solution to a problem that arises in their immediate community. Incorporating contexts into science education and allowing it to address societal concerns are made possible, in the authors' opinion, most successfully by the fourth technique (Gilbert et al., 2011). This proposal inspired the researchers to compare the effectiveness of the fourth model to conventional training and conventional education paired with a context-based approach (model 2). Due to the prevalence of transmission teaching in Ethiopia, we chose the second model to serve as a transitional model between conventional education and a fully context-based approach (model 4). Science education can address societal concerns by including settings, according to the author, who claims that courses developed under the fourth model do so most successfully (Gilbert, 2006; Gilbert et al., 2011; Vos, 2014).

According to Gilberts' definitions of the models of context, model four is used in this study because it is anticipated to more closely meet the requirements of a successful context based approach than the other models when employing the REACT technique as a teaching strategy. On the other hand, model two also used for treatment group two as a transition mechanism from fully conventional to fully context based approaches.

2.3.4 Roots and history of context based approach

The use of contexts and applications of science as a tool to enhance scientific thinking has been one of the most prominent themes in the development of science curricula over the past three decades. There are probably significant and "partially hidden" historical roots behind the idea of incorporating science teaching and learning scenarios that are real and meaningful to the students. These occasionally include movements and customs from the local area. For instance, the development of context-based education in the Netherlands (as in Taconis et al., 2016) appears to have been influenced by Freudenthal's work from the late 1960s, which passionately campaigned for connecting math education to real-world problems. The huge secondary physics education campaign known as "Learn Physics Package Development" and the first official context-based project both originated in the Netherlands many years ago (Alfred & Kaulu, 2018). Identical concepts have existed in other nations, and beginning in the 1970s, they began to be thoroughly investigated in a number of nations.

In Germany, CHEMIE imKontext, Biologie imKontext, and Physik imKontext were developed, similar to SATIS and Salters' Science and Chemistry in England, Wales and PLON Physics in the Netherlands, CHEMCOM in the USA, LORST in Canada, and CHEMCOM in the USA (Parchmann et al., 2006; Taconis et al., 2016). This type of curriculum served to help pupils realize how the lessons and their everyday lives are related. From elementary through tertiary schooling, it was appropriate. There have been a few minor context-based projects in secondary science education in Africa. Examples include the Lessons project and the Linking School Science to Industry and Technology (LISSIT) initiatives in Swaziland, as well as the Basic Education into Rural Development (BEIRD) project in Uganda (Kazeni, 2012). The short-term programs have a general background for science education as their main focus.

According to Vos (2014), imKontext courses were developed in Germany in response to criticism of the country's secondary scientific education system. These courses aimed to boost students' interest in and attitudes toward learning science as well as facilitate the transfer of knowledge. According to Vos (2014), rather than merely regurgitating facts, teachers should encourage their students to use their scientific knowledge in a variety of settings outside of the classroom. The common goals of context-based techniques include affective, behavioral, and cognitive. Additionally, it is hoped that if students are more engaged and inspired by their learning experiences, this would lead to better retention of scientific concepts (Taconis et al., 2016). The results of the TIMMS and PISA tests, which are standard tests administered in most countries, have recently received increased attention from educational systems. Additionally, it has been discovered that the curriculum and exam outcomes have a positive link (Ültay & Ültay, 2014). Context-driven challenges or subjects should be taken into consideration while designing the curriculum because assessments often incorporate real-world problems.

2.3.5 A rationale for context-based learning in science education

Many context based learning initiatives had theoretical as well as practical launching points. The practical portion was based on the widespread acceptance of the unsatisfactory outcomes of science education, notably in terms of student engagement and motivation to pursue careers in STEM (Bennett et al., 2007a). Discussions regarding how to structure educational experiences to account for the expanding understanding of constructivism were included in the theoretical input (Sevian et al., 2018). If the pre-knowledge of learners is to be taken into account, the learning environment, particularly the learning activities, should make linkages between students' prior experiences and the subject to be taught. It should be easier to position or contextualize the subject if it is specifically connected to events outside of the classroom. By enabling students to apply classroom knowledge to pertinent themes in the real world, contexts should enable students to experience competence and social embeddedness both within and outside of the classroom. CBL can, and already is, theoretically grounded (Pilot & Bulte, 2006).

According to several publications, one of the main reasons for the development of context-based science teaching was student dissatisfaction and boredom with the way science is taught in traditional concept-led courses (Bennett et al., 2007; Gilbert et al., 2011; Parchmann et al., 2006; Pilot & Bulte, 2006; Vos, 2014). The vast majority of the abstract concepts taught in science classes are drawn from theoretical applications of science that have little to no practical application to students' daily lives (Gilbert, 2006). Students sometimes complain that their science classes are too theoretically challenging and have little real-world application. Students frequently view school science as being unfeminine, difficult, authoritarian, abstract, theoretical, fact-oriented, and fact-overloaded, with little room for fantasy, creativity, enjoyment, or curiosity, according to Taconis et al. (2016), who compiled findings from a number of authors.

As students are inundated with disparate information and formulas that seem to have no connection to their daily lives, researchers have found that it is becoming harder for schools to justify the science content they teach in the classroom (Brist, 2012). Furthermore, because this unrelated knowledge is of no utility to pupils, it is often memorized for a test and then quickly forgotten. Giamellaro (2014) further suggested that it is essential to assist students in contextualizing their science learning if they are to advance from rote memorization to an integrated, practical understanding that will benefit them outside the confines of the classroom. When science is taught conventionally, learners are not given the opportunity to make the connection between science education and their everyday experiences. Make students feel as though science education is unimportant and unpopular. Lead to discrepancies between what professors teach and what students want: Avoid encouraging higher-order cognitive abilities. Encourage students to think they can solve problems and decide based on their needs and daily experiences, but don't let them. According to Janssen and Fred (2014), there are issues with the curriculum related to a lack of relevance, a lack of coherence, and an overabundance of biological topics. In an effort to overcome the challenges connected with science instruction in schools, context-based teaching methodologies have been developed in the last few decades. Use of a context-based teaching approach as an alternative to more conventional forms of science teaching is one potential way to boost the number of students interested in studying science at a higher level and to further make science learning more interesting for students (King, 2012).

When South Korea, one of the top performing nations in the PISA science literacy dimension, is looked at, it is found that the general framework of the program emphasizes "to use the ability to determine the basic rules of science and scientific nature in solving problems in daily life and to develop a scientific behavior to solve problems in daily life" (Aydin-ceran, 2021). Students are successful in exams, but they are unaware of how much science and mathematics are relevant to their lives, according to the Hong Kong PISA research, which is why they changed the science curriculum with a new reform despite being the second in "science success" in the world in 2012 and the third in 2018 (Aydin-ceran, 2021).

As a result of the contextual learning philosophy of science for science literacy based on PISA research on 21st century abilities, many countries have revised their curricula. For instance, Hungary revised its 2020 Physics Education Curriculum (for primary and secondary education). The new NCC2020's development priorities and learning objectives for physics have been created to facilitate the adoption of modern instructional techniques including phenomenon-based, active, and context-based learning. Its goal was to develop a curriculum that would provide Hungarian students access to current information and the chance to hone crucial 21st-century abilities including teamwork, communication, creativity, and critical thinking (Aydin-ceran, 2021). In today's schools that educate the skills of tomorrow, the notion that "knowledge is meaningful if it works in real life" (Aydin-ceran, 2021) should be taught.

Kelly (1980), quoted by UNESCO (2014), has emphasized the significance of viewing biology curriculum in connection to addressing individual and social needs. One of the biggest obstacles in biological education, according to Kelly, is creating a biosocial synthesis that is credible and has a legitimate position in the curriculum. Biological science has frequently been more successful in developing the affective dimension of biological education in terms of translating affective goals into efficient teaching strategies when it has been incorporated into a more comprehensive curriculum context, such as that of environmental education, health education, or personal and social education. Rather than developing teaching programs solely based on the internal logic of the subject, it is now necessary to place more emphasis on the individual's overall education and, as a result, on their individual and social needs. This has sharpened perceptions of the relevance of biological processes and concepts to the individual in such programs.

Since biology conceptions are frequently much harder for pupils to understand, intuition and culture have a significant influence on the concept. Traditional instruction is rarely effective because the basic misunderstandings are very hard to change (Özay Kose & Çam Tosun, 2015). Instead than being organized around established biological principles, the context is based on biology-related challenges that affect the community. Biology lessons are taught to students in real-world situations. Context-based learning environments are being created in a number of countries in an effort to revive scientific education and create crucial learning environments that will satisfy the many needs of students, society, and science. Using context-based techniques, Gilbert et al. (2011), for instance, describe five issues with science education that can be resolved:

(1) Many separate facts and ideas of various importance are included in the curriculum in order to provide pupils a conceptual overview of the science or sciences they are studying. A consequence of this accumulation of scientific knowledge has a great impact on students learning which hampers the acceleration of learning in this rapidly evolving technological environment.

(2) The curriculum's content is dispersed, making it difficult for pupils to create a useful "mental map" because there is incoherence both inside and between the conceptualizations they have developed. The emphasis placed on teaching pupils curriculum knowledge regardless of whether they can make connections among and between the disparate facts leads to confusion and is not intended to help students create mental models for understanding the idea.

(3) Students frequently struggle to apply their information in contexts other than the one in which it was first learned. It's possible that how students approach difficulties is how their teacher instructed them. Therefore, when the issue presentations vary, students regrettably frequently fail to solve questions using the same concepts. Students are unable to see how problems relate to their current or future daily lives. Gilbert (2006) interprets this result as a lack of application of chemical knowledge to real-world circumstances.

(4) Too frequently, the material taught lacks application to students' daily lives. Since many students do not find science relevant to them, the majority of students would not choose science as an elective course unless it was obligatory. Additionally, they are unable to understand why they must master a particular subject.

(5) Uncertainty over the benefits of having pupils study science. The traditional emphasis of science curricula has been the cumulative development of propositional knowledge to comprehend the next science course, the proper explanation of the world, and using the right processes to produce reliable knowledge as the foundation for more advanced study of science (Gilbert, 2006). When the main objective is the formation of scientific literacy, this combination of emphases is, however, increasingly considered as an inadequate base for such study pupils who will not continue studying the subject.

By offering learning that is presented inside a context that is anticipated to be meaningful to the students, Gilbert et al. (2011) claim that context-based courses avoid these issues. According to Janssen and Fred, (2014), students' participation in the context(s) is anticipated to validate their learning and progress in formal science. Context-based instruction typically consists of three components. These are method, context, and fundamental knowledge. Context in instruction aids in examining the subject's circumstance and presenting it from many angles and relationships. Students will no longer find the subject to be abstract, and connections between the subject and everyday life will become apparent. Not merely diverse facets of the subject are to be revealed. Determining the fundamental area knowledge—basic concept details, guiding principles, and frameworks for generalization—is equally crucial. When basic information is taught in a variety of scenarios, examples, and connections with the help of contexts, students are aided in learning from a wider and related context. Additionally, it is believed that doing this will encourage students to think about new concepts, problems, and phenomena, to work on them, and to propose methods for solving them.

Today's biology education is largely disconnected from daily life. This could be the cause of the students finding biology instruction boring and challenging (Stanisavljević et al., 2016). To effectively enhance learning, it is important to integrate instruction and daily life to a greater extent. De Jong (2008) asserts that using a meaningful environment for teaching and learning is one strategy for overcoming the isolation of the curriculum. A more upbeat outlook and a better comprehension of chemistry were encouraged by the adoption of contexts (De Jong, 2008). The main objectives of science education should be accomplished through context-based instruction, including relating science to daily life and teaching scientific principles and procedures by resolving practical issues (Avargil et al., 2011). This helps kids learn science in a meaningful way and helps bridge education gaps (Ultay & Calik, 2012). Therefore, in order for students to fully benefit from their biology courses, teachers are encouraged to use a context-based approach. Context-based scientific education has been shown to boost students' motivation and enjoyment, according to much stronger research (Bennett et al., 2007; Pilot & Bulte, 2006; Parchmann et al., 2006). While Brist (2012) used context-based learning to perform action research, the research's findings showed that attitudes marginally deteriorated following the modification.

2.3.6 Previous research on context based approach

There is a lot more proof that context-based scientific education improves students' interest, motivation, and attitudes than there is for its impact on learning outcomes like understanding (Bennett et al., 2007; Pilot & Bulte, 2006; Parchmann et al., 2006). The way these subjects are taught as well as student motivation and passion in science classrooms are affected by the use of the need-to-know idea.

According to Bennett et al. (2005) in their review paper, context based instructional activities encouraged students to work autonomously, which boosted their confidence. The experiments by Pilot and Bulte (2006) also showed the impact of context based chemistry instruction on the growth of motivation and interest. Reginaning-Charysma et al. (2018) discovered that the context had a favorable impact on the learner's interest in the information related to the immune system. According to Reginaning-Charysma et al. (2018), there was a content, context, and pedagogy mismatch that made it challenging for teachers and students to develop higher order thinking, particularly problem solving and scientific reasoning skills. Brist (2012) carried out action research, and the findings showed that following the change, attitudes, confidence, and performance all marginally decreased using context-based intervention.

Another thematic review also made by Ultay and Ultay (2014) on 32 context based approach in physics. They have also found different results from positive change to no change after intervention. Out of 32 investigations, five concluded that contexts boost students' achievement, and three discovered some evidence of better motivation and interest in physics. Three studies, however, found no distinction between students' achievement as measured by the contexts and the content. The findings and conclusions of the studies indicate that there are no adverse effects on students' attitudes or academic performance; however some studies' findings did not indicate any beneficial benefits on students. Accordingly, a context-based approach to education cannot guarantee a solution to systemic problems, but it can make them easier to resolve (Ultay & Ultay, 2014). One study that was included in the evaluation also demonstrated that PLON students did not learn as well as students in traditional courses. However, three studies likewise revealed no distinction between context-based classes' success rates or problem-solving abilities and those of control classes.

By stimulating students' assumptions, which serve as the foundation for meaningful learning, context-based education is anticipated to increase students' knowledge (Abd-Raub et al., 2015; Janssen & Fred, 2014). As a result, through social contact with their classmates and teachers, the students will combine the new information they have learned with what they already know to generate new knowledge in their minds (Abd-Raub et al., 2015). The use of a context-based education strategy, in which teachers adjust to the learning and evaluation needs of their students, is appropriate for students with a variety of talents, interests, experiences, and cultural backgrounds. Students who explore contextual learning will not only comprehend the lesson's material but also look for support for it in contexts relevant to their daily lives (Abd-Raub et al., 2015).

According to Stanisavljević et al. (2016), there was a statistically significant difference in how well the treatment group performed on the post test evaluation of knowledge, scoring highly on both individual ranks and the exam as a whole. Studies have also shown that biology lessons are more effective when they are related to the prior experience that students have gained in real-world settings. Giamellaro (2014) provides an account of the fundamental contextualization procedures that take place during science immersion excursions and the subsequent student learning in high school ecology classrooms (n=67) and teachers. He made the following claims: (1) These immersion experiences were connected with significant learning; and (2) There was a positive relationship between the degree of contextualization and the degree of learning (Giamellaro, 2014). However, this study's primary data source was student self-reports of their educational experiences. The data indicated a definite association between contextualization and the growth of scientific knowledge, but it is unknown what criteria must be met for this relationship to exist and how closely they must align for the relationship to be successful.

According to Kazeni and Onwu (2013), using a context-based teaching strategy improved students' performance in genetics, higher-order thinking abilities including problem solving and decision-making, and attitudes toward life sciences more effectively than using a traditional teaching strategy. The teaching method or strategy used to deliver the instruction was not indicated. Additionally, context-based methodology boosts academic accomplishment and attitudes toward biology, as demonstrated by Özay Kose and Çam Tosun (2015). Additionally, their qualitative study reveals that context-based teaching methods facilitate student understanding, learning, and memory.

In recent year Cabbar and Şenel (2020) reviewed 19 experimental studies conducted in Turkey in relation to context based biology learning through content analysis. The research's evaluated data demonstrated that applications developed using the context-based learning strategy typically had a beneficial impact on academic success, attitude, and motivation. In this evaluation, two research findings indicated that the approach had negative effects on students and that not all subjects had the same level of accomplishment. This indicates that the method has various effects on various themes and subjects. Some discoveries in all of the context-based environmental research have a positive impact on achievement and attitude. Some studies on persistence showed encouraging results, while others found no differences. The effectiveness of a context based approach to comprehending was not clearly demonstrated by this review's findings.

The type of curriculum is a hindrance or facilitator for applying student centered method of teaching. Research findings testified that, the content led and overloaded curriculum not endorse the implementation of active learning methods in the classroom. Connell et al. (2016) believe that condensing content to specific learning targets allowed students to process less breadth of content for significant learning gains of students in their introductory biology course. Unburdening the curriculum was a crucial part of the process of reforming the undergraduate biology course over a number of years in stages, and Connell et al. (2016) believe that curriculum unburdening was a key component. Ding and Mollohan (2015) also reason out the type of curriculum designed may a cause for deterioration of students' epistemological beliefs after they learn it. As Joshi and Verspoor (2013) mentioned, among other pressing problems, the overloaded curriculum nature in Ethiopia is accounted for the implementation of unsuccessful instruction, which is also one of the consequences for student's poor performance in considered variables. The majority of research studies in Ethiopia concentrate on the style of pedagogy, and it was shown that most teachers employed a teacher-centered way of instruction while ignoring national policies about education and training (Meskerem, 2017).

Making scientific topics that students are studying relatable to their lives is one of the issues teachers commonly face. Why should I learn this subject? Some students may wonder, "When will I apply this knowledge to my everyday life?" and instructors struggle to explain why a certain subject has to be taught or learned (Meskerem, 2017; Sunar, 2013). Teachers themselves are not willing to exercise the relevance of curriculum in their research and they expect unreasonable demonstrate qualities and dispositions in their teaching (Meskerem, 2017). Because of an overstuffed curriculum, students struggle to grasp how what they study in scientific classrooms relates to their daily lives. These findings indicate that Ethiopian schools appear to have failed in their attempts to enhance scientific teaching, learning, and student achievement (Oli, 2014). They only are aware of the fact that each course will lead them to the following phase of their academic career (Pilot & Bulte, 2006).

Similar findings were made in Ethiopia, where teachers were found to be unable to give students the chance to engage in context-based inquiries or understand how culture and society shape knowledge development. This problem may be brought on by instructors' conceivable incapacity to address contextual teaching and learning in the classroom employing inquiry and experimentation methodologies (Gebeyaw et al., 2021). When engaging in such context-related investigation and experimental activities, teachers are expected to respect the cultural values of the students and society. When engaging in such context-related investigation and experimental activities, teachers are expected to respect the cultural values of the students and society. The overall results show that in upper primary science classrooms, teachers are unable to provide students with the opportunity to undertake inquiries and to comprehend that knowledge is always undergoing change and is influenced by culture and society (i.e. uncertainty) (Gebeyaw et al., 2021).

Students can connect a novel concept with its application and take a deeper approach to learning when they learn scientific concepts in the context of everyday life. It is predicted that context-based learning will motivate kids more and inspire a love of nature in them. Ultay and Calik (2012) support students in developing positive attitudes toward science and the scientific worldview in addition to making learning simpler (Bennett et al., 2006; Wieringa et al., 2011). In general, a context-based strategy may be the most effective way to motivate students, maintain their attention, foster critical thinking, help them comprehend biology concepts, and foster the development of ideas about the nature of science. Despite these benefits, there is little effort made in Ethiopia to make learning contextually relevant, and as a result, pupils do not find meaning or relevance in what they study. According to academics, science education should be focused on context and culture, regardless of the technique used to convey it (Bennett et al., 2006; Gilbert et al., 2011). In other words, either examples must be given or students must be directed to these instances in order for students to make links between biology and the actual world.

Conclusive results have not been obtained from the context-based strategies outlined above. This discrepancy may be brought on by a lack of connection between contexts and pertinent concepts in students' and teachers' perceptions as well as in the actual sort of education used. The necessity of using and enhancing context-based instruction is highlighted by this circumstance (De Jong, 2008; Kazeni & Onwu, 2013). According to what I have read, there has not been any research connecting context-based approaches with scientific reasoning abilities, epistemological beliefs, or conceptual understandings of biology ideas. In Ethiopia, no research has been done on the use of context based learning in biology instruction. I need to contribute few for biology learning based on the opportunity in our social practices whether the practices are good or bad.

2.4 Epistemology

Science is the establishment for steps forward in the modern world and has a significant role in every aspect of our daily lives. Teaching pupils to think like biologists is one of the objectives of educating future biologists. This mindset can encompass viewpoints towards intellectual capacities (such as thinking, problem-solving skills, and a biology grasp beyond memorizing) and epistemological beliefs (Beumer, 2019). Philosophers of science, historians of science, scientists, and science teachers all have diverse definitions of what science is. The term "nature of science" refers to the nature of scientific knowledge, according to research literature (Lederman et al., 2014). Researchers like Hofer and Pintrich (1997) have suggested that epistemic views might be viewed as an investigation into people's conceptions of the nature of knowledge and the nature of knowing. They distinguish four components of epistemic beliefs: justification of knowing (assessment of knowledge claims), source of knowledge (authority), structure for knowledge expansion, and guarantee of knowledge (stability). According to the biological science handbook, a student's nature-of-science mental model should serve as the support structure from which all other science-related learning will hang. However, pupils are prone to having inadequate mental models when it comes to the nature of science (National science teachers, 2009). In this research, epistemological beliefs were defined as student beliefs about biology and about learning biology.

We all have views about what "knowledge" and "learning" are as humans who constantly acquire new things, and these concepts are commonly referred to as epistemic beliefs (Ormrod, 2012). Schommer (1990) originally categorized epistemic beliefs into five broad types. The certainty of knowledge: whether knowledge is a fluid, changing phenomena that will continue to change through time or knowledge is remain constant over time, unchanging, and unalterable "truth"; *The knowledge's structure and simplicity:* Whether knowledge consists of a body of distinct, unrelated facts or a body of intricate, interconnected concepts; *The source of knowledge*: The standards for determining truth affirm the origin of information, whether it comes from learners themselves or from outside sources (such as a teacher or other authoritative figure): whether a statement is taken at face value when uttered by a person of authority or when it is logically evaluated in light of the available facts; *The speed of learning*: Whether knowledge is acquired quickly, if at all (in which case, knowledge is acquired in an all-or-nothing fashion), or slowly over time (in which case, knowledge is acquired in a partial manner), and Learning ability varies depending on whether a person's potential for learning is fixed at birth (i.e., inherited) or whether it may be developed through time with the use of better methods (Hofer & Pintrich, 1997; Schommer, 1990).

2.4.1 The Importance of Epistemological Beliefs in Education

One of the most significant cognitive factors that influence learning and teaching processes is epistemological beliefs. Students' academic progress is impacted by their epistemological views both directly and indirectly through how they approach learning. It is evident that knowledge is dynamic or ill-defined, which implies that knowledge from the 20th century may not be relevant today. Many science educators concur that students in the 21st century need to learn the sophisticated scientific thinking abilities required in this century. However, research has shown that experts and students have different perspectives on the nature of scientific knowledge. Because of this, increasing evidence suggests that epistemic beliefs may affect opinions about learning and education in general as well as in specific domains (Schommer-Aikins, 2004). In the recent years, educators have made numerous attempts to establish a connection between students’ epistemological ideas and their learning effectiveness. Therefore, how students view their education has a wide range of effects on how they learn and perform (Schommer-Aikins, 2004). The growth of "thinking like scientists," which is one of the crucial parts of learning, can also be hampered by students' naive and ingrained epistemologies (Hoskins & Gottesman, 2018). Instead, according to Schommer (1990), formed beliefs promote advanced learning and critical thinking (Schommer, 1990). In order to understand the epistemologies of highly specialized fields, discipline-based research in scientific education has been essential because these beliefs are context-dependent (Mollohan, 2015; Semsar et al., 2011). Similarly Basu et al. (2017) and Beumer (2019) claimed that conducting a research on the development of epistemic belief is an important input for biology learning.

Alsumait (2015) summarized the findings of a review of the literature and hypothesized that learners’ motivation, academic performance and success, self-regulated learning, thorough comprehension, learning approaches, test-preparation strategies, and other aspects of their learning are correlated with their thoughts and beliefs about what they learn (knowledge) and how they learn (knowing). The linkages between epistemological beliefs and all these different components of learning have attracted attention because they show how beliefs can be changed, can affect people's capacity for scientific thought, can be affected and developed during learning and growth phases. But how students' more sophisticated or expert-like scientific thinking, scientific epistemological viewpoints, or understanding of the nature of science grew remained a mystery (Hoskins & Gottesman, 2018).

In his book, Ormrod (2012) discussed in detail about effects of each epistemic beliefs on students' learning based on Schommer (1990) five categories. The specific implications that different views are likely to have on how they study and learn are as follows:

• Beliefs about the certainty of knowledge: When students believe that knowledge about a subject is a fixed, certain entity, they are more prone to make fast and maybe inaccurate inferences from the information presented to them. When students perceive knowledge as something that is constantly changing and does not always have definite right and wrong answers, they are more likely to enjoy cognitively challenging tasks, engage in meaningful and elaborative learning, read course material critically, undergo conceptual change when necessary, and recognize that some issues are contentious and difficult to resolve (Schommer-Aikins, 2004).

• Beliefs about the *simplicity and organization of knowledge*: Students who perceive knowledge as a collection of discrete facts are more likely to memorize information and hold to preexisting ideas. Furthermore, individuals tend to think that they "know" the material they are learning if they can recall the most basic definitions and facts. When students think of knowledge as a complex collection of interconnected ideas, they are more likely to engage in meaningful and elaborate learning as well as judge the effectiveness of their learning efforts based on how well they understand and can apply what they have learned (Hofer & Pintrich, 1997; Schommer-Aikins, 2004).

• *Beliefs regarding the source of knowledge:* Students who think that knowledge comes from outside the learner and is transmitted directly by authority people are likely to be rather passive learners when classes entail inquiry activities and class discussions instead of lectures. They may passively take in explanations without making an effort to define hazy ideas. Students are more likely to be cognitively engaged, link concepts, read and listen critically, try to make sense of information that appears to contradict one another, and go through a conceptual shift when they feel that knowledge is ultimately self-constructed (Schommer, 1994).

- *Beliefs about the standards for establishing truth:* If students believe that something is unquestionably true if it comes from an "expert" of some kind, they are more inclined to accept information from authoritative people without hesitation. However, people are more inclined to critically evaluate new information in light of the known evidence when they believe that the quality of ideas should be evaluated by their logic and scientific worth (as opposed to their source) (Schommer, 1990).

- *Beliefs regarding the speed of learning:* Students who believe learning occurs quickly and in an all-or-nothing manner are more likely to believe they have understood something before they have, possibly after just one reading of a textbook. Additionally, they have a higher propensity to give up easily after failing and to show their disappointment or indifference in their studies. Students who, on the other hand, think of learning as a continuous process that regularly necessitates time and effort are more likely to employ a variety of study methods and to persist until they have a firm grasp of the material (Schommer, 1990).

- *Beliefs regarding the nature of learning ability:* Students' perceptions of the nature of learning capacity are related to their persistence in learning. People are quite likely to give up on challenging assignments if they think that learning ability is a fixed trait. However, if people think they have control over their ability to learn, they will take part in a variety of learning activities to support their efforts and keep trying until they have mastered the subject (Schommer, 1994). According to Schommer (1994), students who believe that learning is frequently a lengthy, sluggish process and that material is complicated and ambiguous do better in class. Additionally, more advanced viewpoints on knowledge and education may arise from higher academic accomplishment (Schommer, 1994). Students will learn that learning involves acquiring an integrated and cohesive set of ideas, that even experts don't know everything about a topic, and that having a truly complete and accurate understanding of how the world works may ultimately be an unattainable goal as they progress past the basics and investigate the outer limits of a discipline, whether it be science, mathematics, history, literature, or another field.

Not just pupils, but some teachers too seem to hold nave views. According to some teachers' beliefs (Hofer & Pintrich, 1997; Schommer, 1994), learning consists of mindless memorization and repetition, and knowledge about a given subject is a fixed and well-defined entity that students must “absorb” in discrete bits and pieces. These ideas are probably going to have an impact on how teachers instruct and evaluate their students. In their lesson plans, classroom activities, assignments, and examinations, for instance, teachers who hold these attitudes are more likely to emphasize lower-level skills (Hofer & Pintrich, 1997).

To assist students' growth in scientific thinking abilities, innovative instructional strategies that lead them toward more mature epistemological beliefs may be required. The literature supports the idea that a quality education should cause students' opinions about experts to alter. If students receive a quality education, their beliefs regarding the subject matter and how it should be learned should be similar to or even closer to those of experts (Igwebuike & Oribhabor, 2016). It is crucial to refute this belief and demonstrate the importance of scientific thinking in all students' lives if science education is to be successful. When it comes down to it, scientific reasoning shouldn't be viewed as the only domain of "experts" (Hoskins &

Gottesman, 2018). Due to the contextual nature of these ideas, it has been essential for science education researchers to do discipline-based research in order to understand the epistemologies of more specialized fields (Ding & Mollohan, 2015; Mollohan, 2015; Semsar et al., 2011).

In summery the following chart showed the effect of epistemological beliefs in classroom teaching-learning processes.

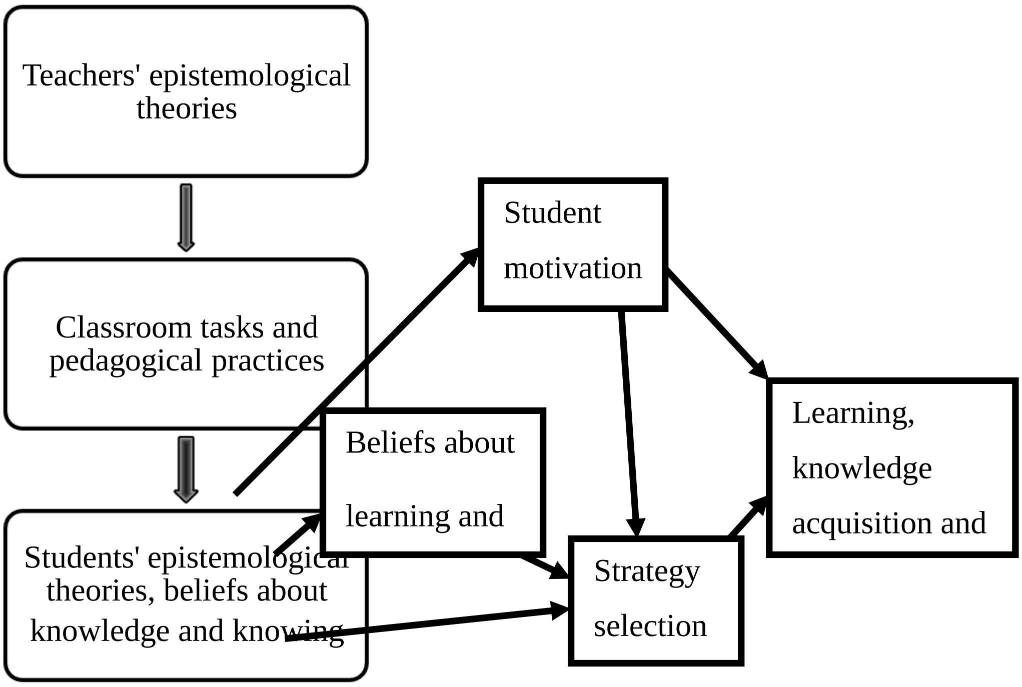

Figure 2. Working model of how epistemological theories influence classroom learning (Hofer, 2001).

2.4.2 The importance of epistemic views to biology learning

Epistemic views are domain-specific, according to prior research, and merit additional study in a variety of academic fields (Schommer-Aikins, 2004). For instance, Tsai (2006) found that high school students saw biological knowledge as being more tentative than knowledge of other science disciplines, such as physics, when examining high school students' epistemic beliefs. Shen et al. (2018) looked into the learning strategies of high school biology students in relation to their epistemic viewpoints and learning ideas. The findings showed that the 'Uncertainty' EVB negatively correlated with lower COLB, which in turn positively correlated with surface strategies, whereas the 'Justification' EVB positively correlated with higher COLB as 'Increase one's knowledge and understanding,' which in turn positively correlated with deep strategies.

Lin et al. (2012) also looked into how students' desire for learning science, ideas of how to learn science, and scientific epistemic views related to one another. They found that whereas "multiple sources" and "uncertainty" were negatively related to repeated conceptions, "development" and "justification" were positively connected to constructive conceptions. Additionally, it was discovered that students' conceptions and their learning goals were related. With rare exceptions, Basu et al. (2017) stated that the majority of students believed science to be a miracle that could only be accomplished by qualified scientists, engineers, or physicians. They came to the conclusion that learners' epistemic perspectives are connected to their biology learning. During their undergraduate careers, from the freshman to the senior years, students develop increasingly expert-like attitudes and ideas about biology, according to Hansen and Birol (2014) and Semsar et al. (2011). In contrast, Ding and Mollohan (2015) discovered the reverse. Those findings are contradictory in relation to whether the development of epistemic beliefs occurs in high school or at university. Therefore, in this study, the researcher tried to see the development of epistemic beliefs through context-based learning with high school students and contribute to the literature to resolve the debate.

Another scholar compare the epistemic beliefs of science majors with non-science majors and found that the science majors exhibited a higher percentage of expert-like response than did the non-science majors in all of the categories at pre-instruction (Mollohan, 2015). While the post-instruction results showed the reverse of this trend, with the non-science major class exhibiting a higher percentage of favorable responses than the science major class, in all categories except for “Enjoyment”. For the science majors’ course, a negative shift was detected in the overall result as well as in all of the categories. The negative shifts were all significant ($p < 0.001$), suggesting that the science students deteriorated toward more novice-like conceptions in their views about learning biology after a semester of instruction. Survey results also indicated that students in the intermediate level biology course showed slight though statistically insignificant improvement in their epistemologies about biology and learning biology during the semester. This showed that the number of courses taken may not have an effect on epistemological belief change rather curriculum and approach to teach.

Studies conducted on university students’ epistemological belief shift showed a mixed result towards science education. For instance, a study employing CLASS instruments to examine the epistemological beliefs of first-year students in introductory physics, chemistry, and biology revealed that as the semester went on, the students' epistemological beliefs shifted more toward those of a beginner (Adams et al., 2006; Barbera et al., 2008; Ding & Mollohan, 2015). The majority of research utilizing CLASS-Bio in majors-level courses has likewise discovered that first-year biology majors' epistemological beliefs deteriorate in the semester after introductory biology education (Ding & Mollohan, 2015; Hansen & Birol, 2014). Students' epistemic ideas about biology and science in a non-majors course were interestingly either consistent or even enhanced (Ding & Mollohan, 2015). In contrast, expert shifts in physics were observed utilizing modeling of scientific practice and the

Physics for Everyday Thinking (PET) curriculum, which promotes students' consideration of the nature of science in particular (Madsen et al., 2015).

Expert shifts in physics have been observed utilizing modeling of scientific practice and the Physics for Everyday Thinking (PET) curriculum, which promotes students' consideration of the nature of science in particular (Madsen et al., 2015). According to Madsen et al. (2015)'s review, physics majors acquire expert-like perspectives during their K–12 education. On the other hand, studies of biology students found that they entered their first year of college with epistemological beliefs and views that were more akin to those of novices (Semsar et al., 2011; Hansen & Birol, 2014; Ding & Mollohan, 2015; Igwebuike & Oribhabor, 2016). There were no a research conducted on biology at high school using CLASS-Bio instrument to investigate their epistemological beliefs using the context-based learning. There was also a debate whether epistemic beliefs are developed (Hansen & Birol, 2014; Lin et al., 2012; Semsar et al., 2011) or not (Mollohan, 2015). This variation may occur due to variation in curriculum and instruction process. Therefore, in this research, the author tried to see the development of epistemic beliefs using CLASS-Bio through context-based learning and contribute to the literature to resolve the debate.

A growing corpus of research in biology has examined the impact of active learning techniques on students' epistemological beliefs, even when the findings were incongruous. For instance, a research in a large enrolment introductory biology course revealed no difference between an active learning classroom and a more lecture-based classroom in terms of a shift in epistemological ideas (Floro, 2014). Changes in expert or beginner perspectives over the first semester of biology instruction are not significant overall or for any category, according to Beumer (2019) team-based learning study. There is evidence from biology research that active learning and belief are positively correlated. As an illustration, a lab that used guided inquiry revealed a rise in epistemological beliefs during the course of the assessment (Jeffery et al., 2016). Additionally, it has been discovered that elevating student-centered pedagogies strengthens pupils' epistemological convictions (Connell et al., 2016). In a recent study, (Hoskins & Gottesman, 2018) found that using the CREATE curriculum in an introductory biology course resulted in more knowledgeable student epistemological beliefs. CREATE stands for Consider, Read, Create and Analyze Hypotheses, Analyze and Interpret Data. Accordingly Westerlund and Chapman (2017) demonstrated that there were significant shifts in student epistemological beliefs towards more positive and expert-like views in a newly designed summer genetics course.

In the domains of science, physics, and chemistry, a sizable number of context-based intervention studies on motivation and general attitudes have been published. Bennett et al. (2005) and Özay Kose and Çam Tosun (2015) pointed out that there hasn't been much study on context-based biology instruction globally. Özay Kose and Çam Tosun (2015) investigation of students' enjoyment of context based learning revealed a notable improvement. On the other hand, according to their review, Cabbar and Şenel (2020) argued that there was no statistically significant difference between the pre-test and post-test averages of the students' general biology course Epistemological beliefs Scale scores after the context-based approach intervention.

Students from Ethiopia come from a culture that has various traditional views about knowledge and the educational process. The common saying "One destined to know masters in forty days; one destined to toil masters in forty years" can be approximately translated as "One destined to know masters in forty days; one destined to toil masters in forty years." reflects the strong traditional conviction held by the culture that learning ability is associated with fortune. Society, on the other hand, likewise firmly believes that learning is only possible through persistent effort and hard labor. Slow learners are encouraged by their teachers in Ethiopia's traditional education to put in their best efforts and not give up. Additionally, the community has a long history of valuing leaders in the classroom, especially in religious institutions. Traditionally, instructors and elders expected students to learn everything they were imparting to them. More individuals continue to hold the conventional view that knowledge originates from authorities or experts, even if this traditional belief is being questioned by many as a result of the advent of contemporary educational philosophies these days (Mulugeta, 2019).

Ethiopia is a bilingual, multicultural nation, and its context and culture are unique from those of other countries. However, there hasn't yet been any empirical study on how students' epistemological ideas are affected by context, students' experiences, and activities centered on culture in the teaching-learning environment (De Jong, 2008). Bennett et al. (2007) and King (2012) found that context based teaching and learning had a favorable impact on affective aspects in science education. The teaching model used to execute the curricular materials or the types of situations (De Jong, 2008; Gilbert, 2006) cited as the reasons for variable results (Kazeni & Onwu, 2013).

This study sought to ascertain whether or not context-based learning intervention improved the epistemological beliefs of high school pupils or not. It also explores any disparities between students who engaged in context-based learning and those who did not. To reach this goal, a context based intervention material was developed and implement through REACT strategy and by combining context based learning with conventional strategy in practice to promote fundamental aspects like adequate conceptions concerning the nature of biological learning and knowledge in biology.

2.5 Scientific Reasoning

Making meaning of observations, events, and processes involves reasoning, a process used both formally in academic contexts and informally in ordinary life. Scientific reasoning (SR) in the process of producing scientific knowledge through evidence-based reasoning (Schen, 2007). Reasoning is a way to infer and make conclusions about natural phenomena from any given information (Lawson, 2004). In order to distinguish it from formal reasoning, scientific reasoning is defined in the literature as reasoning that has direct influence on or is utilized during different types of scientific inquiries (Zimmerman, 2000). Scientific inquiry and scientific reasoning are essential for enabling the successful management of real-world issues in professions outside of the classroom as science has continued to become crucial to contemporary society (Han, 2013). Additionally, he contended that a thorough appreciation of the nature of scientific reasoning necessitates extensive scientific knowledge.

Scientific reasoning skills are central not just for future scientists but also in today’s knowledge-based society (Jufri et al., 2016). The research findings support the consensus of the science education community on the need for K-12 students to develop an adequate level of scientific reasoning skill along with a solid foundation of content knowledge. Basic scientific reasoning skills are of increasing importance to people for making informed decisions in their everyday lives and for participation in socio - scientific debates in the global era (Engelmann et al., 2016). Fostering scientific reasoning is therefore highly relevant for science education and lifelong learning from elementary through college level of education to enable science students to successfully handle open-ended real world tasks in future career (Bao, et al., 2009; Engelmann et al., 2016; Jufri et al., 2016). Scientific reasoning skills are the tools that allow one to obtain new knowledge and think critically (Han, 2013). He also argued that scientific reasoning is important for everyday decision-making and problem-solving. For example, ratio skills are used in determining solutions. Inductive reasoning is used whenever a conclusion is made from limited observations and information. Causal reasoning and probability are used in predicting weather and assessing insurance rates among many other things. Hypothetical deductive reasoning skills are used in everyday problem-solving (Han, 2013).

Cognitive skills like reasoning and critical thinking are linked to scientific reasoning. Additionally, scientific reasoning can be taught and strengthened through training with regard to its long-term effects on students' academic accomplishment (Adey & Csapo, 2012; Bao, et al., 2009). The development of scientific reasoning must necessarily be a slow, organic process in which the students construct the reasoning on their own (Adey & Csapo, 2012). This is true for the development of any sort of reasoning. The requirement for a workforce equipped for the twenty-first century is emphasized in educational reforms across the globe; as a result, students are expected to learn advanced transferable thinking abilities in addition to science knowledge (National Research Council (NRC), 1996). Students will be more equipped to manage unique, open-ended circumstances and create their own investigations to address scientific, engineering, and social issues in the real world as a result of the development of these skills (Bao, et al., 2009).

2.5.1 Previous research related with scientific reasoning

International testing over the past few decades has shown that students in many countries do not possess the conceptual scientific knowledge necessary to develop arguments based on scientific evidence, nor do they possess the scientific reasoning abilities necessary to do so (OECD, 2010). To increase student aptitude, the Organization for Economic Co-operation and Development (OECD) suggests using authentic approaches, such as model-based learning. Globally, students could gain from specialized training that focuses on enhancing their capacity for scientific reasoning. According to Stammen et al. (2018), there is a correlation between improvements in conceptual scientific knowledge and the growth of students' scientific reasoning abilities. Therefore, in order for students to succeed in subsequent science courses, it is crucial that science teachers concentrate on authentic activities that allow students to build their scientific reasoning skills.

Scientific reasoning and scientific inquiry go hand in hand, according to the literature (Bao, et al., 2009; Bao & Koenig, 2019; Fischer et al., 2014; Han, 2013; Jufri et al., 2016; Piraksa et al., 2014; Yanto et al., 2019). Inquiry-based science instruction can help students develop their scientific reasoning skills. Although these abilities are cultivated through activities in the classroom, students do not naturally acquire them, and a rigorous scientific education is insufficient. Students learn higher-order scientific reasoning skills differently depending on how they are taught than on what they are taught (Bao, et al., 2009). Even when implemented rigorously, the current approach to STEM education has minimal effect on students' ability to build scientific reasoning skills (Bao, et al., 2009). Because the predominant methodology places more emphasis on recall and practicum. This situation demonstrates how critical it is to use scientific reasoning while teaching. As a result, thinking is not a natural skill; rather, it develops as a result of many different circumstances, including the curriculum and teaching strategies employed by teachers.

The cognitive component of skills for the twenty-first century, which is heavily stressed, includes scientific reasoning (SR). Students' critical thinking, open-ended problem-solving capabilities, and decision-making abilities can all be enhanced through the development of scientific reasoning abilities (Bao & Koenig, 2019). This demonstrates how curricular goals that emphasize scientific reasoning are compatible with learning other skills, such as conceptual thinking, which are parallel with and interdependent upon one another. This demonstrates how curricular goals that emphasize scientific reasoning are compatible with learning other skills, such as conceptual thinking, which are parallel with and interdependent upon one another. Strong argumentators require a broad and deep understanding of the subject matter in order to recognize pertinent and important facts. Strong reasoning abilities, on the other hand, also help people link ideas. The research (Schen, 2007; Zimmerman, 2005; Zohar & Nemet, 2002) that shows those people who are characterized as having advanced reasoning skills also have stronger conceptual knowledge implies this. However, multiple actual studies showed that learning the sciences does not always translate into more sound scientific reasoning. For instance, Bao et al. (2009) contrasted the scientific reasoning and physics knowledge of university students from China and the United States. They discovered that whereas Chinese students performed similarly to their American counterparts on the science reasoning test, they performed significantly better on the science knowledge test.

Saad et al. (2017) used a survey design to assess students' levels of scientific reasoning in biology based on SSI due to students' inability to respond to questions about scientific issues that pertain to their daily lives, such as the environment, medicine, health, and genetic engineering, in Malaysia's TIMMS and PISA results. They showed that students' achievement is still low or medium and that they lack the ability to connect scientific ideas to socioscientific problems. According to them, the discussion of SSI needs to be prioritized in order to produce excellent students in reasoning, particularly in making reflections, strategies, and approaches, so that students can not only find solutions to problems and make decisions, but can also put them into practice in their daily lives. Students enter universities after completing their high school education through transmission teaching, and in Thailand, most university students have unscientific ways of thinking (Piraksa et al., 2014).

To determine the profile of Indonesian junior high school students' capacities for scientific reasoning, Yediarani et al. (2019) conducted a descriptive quantitative cross-sectional survey design study with the same aim. 1146 students from 15 schools with varying levels of accreditation served as the study's sample population. The Lawson Classroom Test of Scientific Reasoning (LCTSR) from 2000 was used as a tool for gathering data. According to Piaget's theory of child development, junior high school students have started to transition into the formal operation stage. A youngster has mastered complicated brain processes that involve both concrete and abstract notions at this time. According to the study's findings, 100% of the sample is still using extremely basic and low-level scientific reasoning. This demonstrates how poorly kids have been able to reason about complex concepts. In general, those children did not exhibit any formal or transitional reasoning abilities. Based on the findings of this study, researchers recommended emphasizing pedagogies and curriculum frameworks that support students' capacity for scientific thinking.

The learning method, which is still focused on developing low-order thinking abilities, and the absence of scientific reasoning tasks appear to be the root causes of the poor performance. As a result, high school graduates still have limited cognitive abilities (Yanto et al., 2019). This process begins with teacher preparation at a teacher education college. If the student teacher's capacity for reasoning is inadequate, it follows that their approach to teaching will be inadequate should they choose to pursue a career in education (Jufri et al., 2016). Jufri et al. (2016) also proposed that the fundamental goal of teaching and learning at every stage of the curriculum, from the basic to the tertiary level, should be the development of students' reasoning abilities rather than concentrating more on the growth of their mathematical and scientific literacy. This demonstrates the need for innovative teaching strategies, particularly in the teaching of science, in order to improve students' learning, including their capacity for scientific reasoning.

In their 2019 study, Yanto et al. employed a quasi-experimental pre-test post-test non-equivalent control group design to examine how much students' scientific reasoning abilities improved when using the alternative technique. The purpose of the study was to evaluate how well the three types of inquiry—structured, guided, and free inquiry—worked. The research sample consisted of 76 students from the biology education study program at the state Islamic University of Sunan Kalijaga in Yogyakarta, Indonesia. According to the study's findings, the three stages of inquiry were superior to the traditional approach in terms of helping students develop their analytical, evaluative, and creative skills in scientific reasoning.

Regarding the development of scientific reasoning at different levels, Mollohan (2015) investigated undergraduate students’ scientific reasoning abilities by using multiple years and majors in a large-scale descriptive study. The specific questions addressed included the association between quantity of content learning (rank/year) and context of content learning (major) in relation to student scientific reasoning abilities. The results indicated that there was no relationship between scientific reasoning and cumulative GPA, epistemologies, number of undergraduate courses taken and standardized test score except for possibly a weak relationship between reasoning and cumulative GPA. Additionally he determined student epistemologies are related to student scientific reasoning abilities with a smaller sample of intermediate and upper-level biology students by using CLASS-Bio instrument and the LCTSR questionnaire.

Tsui and Treagust (2010) conducted research on the design and implementation of a two-tier multiple-choice test to evaluate students in grades 10 and 12 on their understanding of genetics based on reasoning. The diagnostic instrument's pretest and posttest versions were used with other methods in a case-based qualitative study on teaching and learning in three secondary schools in Western Australia to gauge students' understanding of genetics. The instrument's final version's Cronbach's alpha reliability was 0.75 and 0.64 for the pretest and posttest, respectively. To paint a fuller picture of how students perceived genetics in terms of scientific reasoning, this two-tiered diagnostic instrument was utilized in coincidence with other qualitative data-gathering methods. They discovered that 12th graders outperformed 10th graders on all types of reasoning. The two 10th graders' reasoning skills in schools 1 and 2 appeared to be in line with the diverse approaches their teachers took to teaching the topic and the different accents they gave to each subject's curriculum. From this research, one may conclude that using various pedagogies and curricula influences kids' capacity for thinking, leading to varied academic performance among their grade 10 students.

The instrument used by Tsui and Treagust (2010) to measure students' levels of reasoning ability was created and put into use. The two difficulty levels that are the focus of two-tier tests are: one is within generations (easier ones) and the other is between generations (difficult ones). Each asks a logical series of questions about a single organism, gradually progressing from straightforward to intricate kinds of inference. To scaffold student performance across more complicated issues, the components were thoughtfully ordered (**Table 3**).

Within Generations (easier) Monohybrid inheritance I (Cause to Effect): questions focus on Genotype to phenotype mapping: Students were asked to predict phenotypes from the given genotypes and information about an organism's genetics. Monohybrid inheritance III (Effect-to Cause): This category of questions focuses on phenotype-to-genotype mapping, where students are supposed to predict the genotypes of an organism based on the given phenotypes and information on the genetics of the organism.

Between Generations (harder) Monohybrid inheritances II (cause to effect): In this sort of question, students are asked to predict the genotypes and phenotypes of their children using information from two parents' genetics. Monohybrid inheritance IV (effect to cause): In this sort of questions, the phenotypes of a population of children are provided, and students are supposed to ascertain the underlying genetics of a novel trait.

Punnett squares (input/output reasoning) (Process reasoning) Type V and VI: Explain Punnett squares in terms of ploidy, or the development of haploid and diploid organisms, with a particular emphasis on (event reasoning) during the meiotic process. In this question, the genetic make-up of an organism and the outcomes of a single meiosis are provided, and students are asked to explain the meiotic processes that led to these outcomes. The question in type V reasoning asks, "How can information from DNA base sequence (genotype) be mapped to amino acid sequence in protein synthesis (phenotype)?" This needs the process of translation and transcription which is complex process and in Ethiopian curriculum first introduce at grade twelve. Because of this questions that measure type V reasoning were not included in this study. But type V reasoning needs explanation of the process of cell division types which is the main content of heredity unit of grade ten curriculums. Therefore, the present investigation comprised inquiries that probe human reasoning in regard to cell division. Hence the level and depth of the curriculum of Ethiopia and Australia is different, questions also modified in Ethiopian context except adopted question.

The curriculum is distinct in addition to the question kinds. The curriculum in the comparison classes consisted of traditional text-based instruction, teacher-led class activities, and a self-paced drill-and-practice workbook. According to Adey and Csapo (2012) the content of curriculum should be different depending on the cognitive development of students rather than overloading it by accumulation of abstract and complex facts is supported by the literature. There are two strategies to reduce the disparity between students' actual cognitive growth and the amount of abstraction, complexity, and organization of educational materials. Teaching materials need to be better adapted to students' psychological and developmental traits as one part of the answer. In order to promote students' progress, this calls for additional details on the real developmental stage of each student as well as tailored teaching strategies. Accelerating students' cognitive development is the other part of the approach, which will raise their level of thinking to that required by the learning assignments. Learning science presents a lot of effective options to hasten pupils' cognitive development, and research has demonstrated that some activities and exercises can boost development (Adey & Csapo, 2012). Based on this idea the activities were designed founded on the syllables of Ethiopia in order to facilitate students' reasoning by focusing on "how and why" questions instead of asking low level questions.

Students must relate the phenotypes given to the genotypes of the parents (effect to cause) when thinking at levels III and IV, either within or between generations. The mapping in Types III and IV is more difficult since it is not a one-to-one mapping, which means that more than one genotype may correlate to the same given phenotype, in contrast to Types I and II (cause-to-effect) mapping. Successful reasoners must use multiple antecedents to draw conclusions about the nature of inheritance, including whether it is dominant or recessive, and in more complex cases, whether it is autosomal or sex-linked. They must also use alternatives to help them reason about and solve problems. Each asks a logical series of questions about a single organism, gradually progressing from straightforward to intricate kinds of inference. According to Tsui and Treagust (2010), the items were thoughtfully ordered to scaffold student performance across progressively more difficult issues.

According to Tsui and Treagust (2010) review, the majority of secondary life science instruction does not go beyond cause-to-effect reasoning. This is typically done in the context of simple inheritance problems involving Punnett squares, though simple effect-to-cause problems involving pedigree analysis are also occasionally used. But they paid particular attention to the trickier effect-to-cause issues that call for higher order thinking and domain knowledge. One often requires some form of integrated propositional, analogical, and logical realms of knowledge to reason from consequences to causes.

Table 3 Six types of genetics reasoning adapted from Tsui and Treagust (2010)

Domain general dimension of reasoning

(Novice Expert)

Domain specific dimensions of reasoning

Complex

Simple

	Cause to effect reasoning	**Effect to cause reasoning**	**Process reasoning**
Between generation	**Monohybrid inheritance:** Mapping genotype to phenotype **(Type II)**	**Monohybrid inheritance:** Mapping phenotype to genotype **(Type IV)**	**Punnett squares (input/output reasoning):** Meiosis process (event reasoning) Mitosis process **(Type VI)**
With-in generation	Mapping genotype to phenotype **(Type I)**	Mapping phenotype to genotype **(Type III)**	Mapping information in DNA base sequence (genotype) to amino acid sequence in protein synthesis (phenotype) **(Type V)**

Analogical, probabilistic, and propositional reasoning were all used in this study. Students must use both domain general and domain specific information to reason out their response while using this type of reasoning. Analogical reasoning can be used when a student needs to tackle an issue that has a context similar to one they are already familiar with or contains a problem base they have already solved. By evaluating the current problem in the context of prior knowledge of a comparable circumstance, the learner should be able to find a solution. One of the fundamental methods for transferring and applying knowledge is analogical reasoning (Adey & Csapo, 2012). By comparing novel scientific events to established ones that are comparable, analogous thinking aids in understanding as well as knowledge application in new contexts. As a result, learning science provides many opportunities to enhance analogical reasoning (Adey & Csapo, 2012). The majority of scientific phenomena and everyday happenings are dependent on probability and require probabilistic reasoning. Probabilistic reasoning is necessary to comprehend these events and determine risks. Based on anticipated (or computed) likelihoods of future events and past events, probabilistic inferences are made (Adey & Csapo, 2012). Probability is required in this research's learning activities that ask for the use of punnet squares.

In their 2009 study of four classrooms of 16–18-year-old students taking anatomy and physiology courses, Zeidler et al. discovered that the treatment classes had much more instances of reflective thinking than the control classes did. These researchers came to the conclusion that familiarity and a sense of personal connection with the instructional environments resulted in higher level argumentation and reasoning as well as a more complex comprehension of epistemology. Although students in treatment groups displayed a general decrease in the number of conclusions made, the mean number of justifications per conclusion and the number of ideas expressed in conversational turns significantly increased, according to Zohar and Nemets' (2002) study of SSI treatments in the teaching of genetics. According to Zohar and Nemets' (2002), students increased the amount of biology knowledge they included in their arguments.

Teachers need to be adept at scientific reasoning skill since their classroom activities have a big impact on students' capacity to develop scientific reasoning. In a province of Ethiopia, Dawit (2022) examined the scientific reasoning abilities of teacher educators, schoolteachers, and prospective teachers. 140 primary school teachers, 116 prospective teachers, and 37 teacher educators took part in the study. To gather information, the Lawson's Test of Scientific Reasoning was used. The analysis of the data revealed that 86% of the participants were intuitive thinkers, indicating a generally low degree of reasoning ability. Group comparisons revealed that teacher educators had superior reasoning skills to school teachers, who in turn had superior skills to prospective teachers. While prospective teachers and classroom instructors were mostly found to be intuitive thinkers, teacher educators were found to be equally split between transitional and intuitive thinkers. Participants had the most trouble with hypothetico-deductive reasoning and variable control, two of the six components of scientific reasoning.

International research found that more countries shown relative strengths in recalling/recognizing, characterizing, and articulating scientific concepts than in applying scientific knowledge and reasoning (Bao et al., 2009; Osborne, 2013). It is crucial to promote the development of scientific reasoning skills in classrooms and teacher preparation programs in order to give future educators the chance to design their own resources that enable them to foster reasoning abilities in their students (Jufri et al., 2016). Jufri et al. (2016) suggest further investigation into how kids think about genetics using a larger sample of students from different educational levels, nationalities, and regions. Furthermore, they argue that, in order to help students develop concepts suitable for the biotechnology era, it is still pedagogically advantageous and motivating for them to learn scientific reasoning through examples from human genetics that can be explained using fundamental Mendelian principles.

The existing literature showed the low performance of students in scientific reasoning at every level of education from primary to tertiary. Researchers identified teaching methods and the overloaded curriculum as the main reasons for this failed and some suggests using realistic context to facilitate scientific reasoning (Adey & Csapo, 2012). On the other hand, Smith and Bitner discovered that the teaching methods used in their study (ChemCom, which focuses on chemistry in the community, and GenChem, which is a standard chemistry course) had little to no effect on the students' development of reasoning skills. The relationship between conceptual knowledge and scientific reasoning was also a topic of debate. This study is important to fill this gap by using context based approach as an intervention and by showing the correlation of scientific reasoning, epistemology and conceptual understanding.

2.6 Conceptual Understanding

Conceptual understanding is considered as learned something to understand the assumptions behind the concept, its implications, and its application (where appropriate) to new situations (Klymkowsky et al., 2010). According to Mills (2016), there are four key components of conceptual understanding: factual and procedural knowledge, information transfer, creating connections, and metacognition. Thus, acquiring factual or procedural information served as the foundation for conceptual comprehension. The mathematical literature made it clear that a solid foundation of factual and procedural knowledge is required for the student before conceptual understanding can occur according to Ross and Wilson (2012) as in (Mills, 2016). Factual knowledge was a condition for, but did not guarantee, conceptual understanding. Understanding is built on having some basic knowledge of facts, yet facts and methods cannot be kept apart.

According to Mills (2016) summary of several academic works, particularly those in the fields of science and mathematics, it is crucial to connect information in order to prevent facts and procedures from remaining in isolation. The student starts to make connections between the information as they gain more procedural and factual knowledge. A subject is more likely to be grasped the more knowledge is connected to other knowledge and the stronger these connections develop. When information is well integrated rather than remaining as isolated facts and procedures, retrieving information is made simpler and more effective. Transferring learning requires the ability to switch back and forth between theory and practice. Although they appear to be comparable, knowledge transmission and making connections are two distinct aspects of conceptual comprehension. Without links, knowledge transfer would not be feasible. However, knowledge transfer also includes using isolated facts or knowledge in a novel method or with a topic that was not previously known to the user. Making links between previously learned material and a new subject helps learners think creatively and reinforce connections.

According to Mills (2016), conceptual learning is the process through which pupils learned how to arrange knowledge into logical mental structures, increasing their thought processes and improving their conceptual understanding. The ability to access knowledge more easily and use it effectively increases as the learner organizes the material. As observed in the figure below conceptual understanding is a deep flexible and justifiable knowledge of the underlying biology concepts, skills and generalizations with rich connections, relationships as well as ability to use and apply it to different domains of biology within the environment.

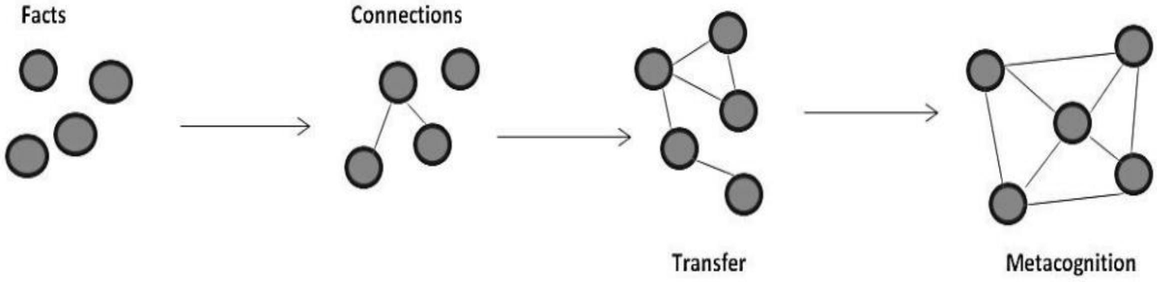

Figure 3 Dimensional matrix of conceptual understanding adopted from (Mills, 2016).

Another study, similar to Mills', demonstrated the cognitive abilities necessary for the growth of conceptual knowledge in science education by breaking it down into five steps. According to Schönborn and Anderson (2008), these include: 1) Memorize information about the concept mindfully as opposed to rote learning; 2) Integrate information about the concept with information about other related concepts to create sound explanatory frameworks; 3) Transfer and apply information about the concept to comprehend and resolve (novel) problems; 4) Reason analogically about the concept; and 5) Reason locally and globally about the concept (system thinking).

Numerous difficulties that students have when learning science and engineering have been highlighted in literature on learning and teaching. There is no question that "these challenges can pose serious barriers to learning and acquiring expertise in a discipline, and they have significant implications for instruction, especially if instructors are not aware of them" (Singer & Smith, 2013). A significant obstacle is having precise conceptual knowledge. Students hold false notions and attitudes about concepts that are important to every field. Possessing correct conceptual understanding is a major barrier. Students have incorrect beliefs and attitudes on ideas that are crucial to every field. They have enormous difficulties when trying to understand unseen and extremely small or extremely big spatial and temporal scales, such as those involved in understanding the interaction of subatomic particles or natural selection (Singer & Smith, 2013).

Students and the subjects they are learning interact as they learn biology. It is made up of things, procedures, and outcomes. Students study biology more well when they can directly observe the subject. Genetics is one of the physiological processes that takes place in the body of living creatures, however not all biological signs and occurrences can be seen directly. One of the biology topics that students find challenging is heredity (Çimer, 2012). Çimer (2012) cites three aspects of biology that make it difficult to learn: (1) Students are "forced" to memorize biological knowledge in order to learn it; (2) many biological concepts and occurrences are too abstract or invisible to be seen with the naked eye; (3) some students remarked that the time allocated for learning biology was insufficient. As a result, the students' understanding of the material they learned was diminished. Poor learning outcomes for the kids are evidence of this.

Similar to this, Haskel-Ittah et al. (2020) shown that genetics is difficult to teach and understand for different reasons.. First off, many of the fundamental terms and mechanisms in genetics, especially molecular genetics, are new to students in high school and further education. Second, pupils may find it difficult to reason across different organizational levels when dealing with genetic phenomena. The intricate connections between the environment and genetic mechanisms in the development of traits represent a third difficult component of genetic phenomena that has not gotten much attention in genetics education research.

The intricacy of vocabulary and concepts used in the study of biology contributes to conceptual and reasoning challenges. Biology presents pupils with greater difficulty than other high school sciences in developing an integrated understanding across a variety of microscopic and macroscopic sizes. A biology course introduces a significant amount of new vocabulary, which students find difficult to understand. Students' mental models also lead to conceptual and logical problems. The comprehensive understandings of things that humans develop based on their own experiences and prior knowledge are known as mental models. Although students' mental models are packed with details, they are rarely exact to the letter. Students may not yet understand that their personal experience is only a small portion of the greater biological world, which could lead to inaccuracies (National Science teachers, 2009). Achieving meaningful learning requires employing teaching strategies that acknowledge students' misconceptions.

Overall, study results persuade us that student-centered instructional methods, as opposed to conventional teaching methods like lectures, can have a favorable impact on students' learning, achievement, and memory. In addition to assigning groups of students to work on issues, make predictions, and share their thoughts with one another, these strategies also include asking questions throughout lectures. The aim is to use a variety of well planned educational modes, some of which may include lecture, as mentioned in the NRC research. When creating lectures, teachers should think about how to best support students' learning (Singer & Smith, 2013).

Despite overwhelming data supporting the success of student-centered strategies like interactive lectures and team-based activities, science and engineering professors still tend not to adopt these strategies frequently. In fact, science and engineering teachers and instructors are more likely to use lectures than educators in other fields (Singer & Smith, 2013). Given the range of variables that influence perceptions of instructional practices, it is understandable why many academics are hesitant to implement more interactive classroom strategies. Even those who are motivated to use research-based teaching techniques may encounter challenges, such as students who are resistant to change, incentive structures that don't place a high priority on teaching, and departments and organizations that don't provide faculty with the tools they need to change their methods. Nevertheless, many professors have overcame these and other obstacles to improve their teaching techniques with assistance from peers, professional groups, and others (Singer & Smith, 2013).

The learning of students may benefit from a change in the delivery method of education. It's crucial to pinpoint conceptual understanding issues before benchmarking to determine whether various pedagogies have improved understanding. Independent tests of students' comprehension of particular biology topics are crucial since biology professors have abandoned the notion that learning biology should be limited to memorization of information. Teaching should be based on students' past knowledge since the relationship between student experience and biological concepts might help students grasp biological concepts better (Gilbert, 2006). Teachers must take into account their students' prior knowledge and assist them in fusing new information with their held beliefs in order to achieve the goal of teaching for understanding rather than memorization or knowledge (Tanner & Allen, 2005).

2.6.1 Previous studies on conceptual understanding

The Organization for Economic Co-operation and Development (OECD), a global education indicator, conducts the PISA research every three years, and the science literacy component provides significant hints about the comprehension of science in various nations. The understanding of "using science in real life and adopting it as a key in solving real life problems" attracts notice when the scientific education programs of the nations that performed well in the PISA research are evaluated (Aydin-Ceran, 2021). Earlier studies indicated that students participating in context-based courses, achieved science learning negatively, positively or comparable with conventional instructions.

Ultay and Calik (2012) undertook a review of the literature on the impact of context-based learning strategies on chemistry education. They discovered that the context-based strategy has both beneficial and detrimental effects on learning chemistry. Some researchers discovered that the context-based approach was successful in enhancing students' conceptual understanding of some basic chemical concepts, such as thermodynamics, chemical bonding, and chemical reactions. However, prior research reveals that students who take Chemistry courses that are context-based do not do worse than those who take more conventional teaching techniques in terms of concept learning (Bennett et al., 2007; King, 2012). This can be due to an issue with how the science content is handled in light of the context. For instance, Parchmann et al. (2006) reported a positive effect regarding students' interest and motivation during the context-based project, but students also experienced a feeling of 'getting lost in context' and of forgetting the learning objectives of science. However, they did point out that there was some proof that the context-based method was more successful in providing students with what they perceived to be worthwhile experiences in their science courses.

According to Karslı and Patan (2016), when compared to pre-test, the experimental group's pupils had either fully or at least much fewer misconceptions. This circumstance is a direct result of the researchers' interventions employing the context-based method improving their conceptual comprehension. These studies came to the conclusion that activities carried out in harmony with the phase of the context based approach stages and instructional materials had a favorable impact on students' conceptual understanding. It is common knowledge that when real-world examples appropriate for their level are utilized in circumstances that are familiar to them, students are more interested and able to participate in lessons. These outcomes may have also been facilitated by the fact that classes delivered utilizing the context-based method allowed students to see scientific concepts as a part of their everyday life. The outcomes might also have been impacted by the fact that context-based classes encourage students to participate more actively and enjoy themselves while learning (Gilbert et al., 2011).

A study by Karsli and Saka (2017) on the topic of "Let's Know Foods" was covered in the learning environment built in accordance with the REACT strategy from the context-based approach, and it was included in Cabbar and Şenel (2020) review. It was discovered that the application's final data had a beneficial impact on students' conceptual understanding. Additionally, it was shown that in terms of students' conceptual changes, the learning environment created using the REACT technique outperformed the one created using the 5E teaching paradigm. Accordingly, as mentioned in Cabbar and Şenel (2020) review, Acar and Yaman (2011) argued that the courses created and implemented using the context-based learning approach had a beneficial impact on the students' comprehension of the subject of "microorganisms". The context-based learning strategy is crucial for piqueing students' interests and desires, and success is positively impacted by it as a result of activities designed to build biological concepts.

In the review of Cabbar and Şenel (2020), Gul and Konu (2018) also used context based approach to see its effect on conceptual understanding of the topic of digestive and circulatory systems. There was no discernible difference in posttest scores between the experimental and control groups when the results of the digestive system test were compared. However, a statistically significant rise was discovered in favor of the experimental group when the results of the circulatory system test were evaluated. This demonstrates how the technique affects certain subjects in different ways. The method has some drawbacks for some subjects, it was found after the semi-structured interviews.

Even while the majority of research have discussed the benefits of context-based chemistry studies, some of them have also mentioned their drawbacks (Ultay & Calik, 2012). According to Campbell and Lubben, context-based chemistry learning is not automatic because outside-of-school learning predominates, as was mentioned in the review by Ultay and Calik (2012). In their review of 17 research on context-based learning that were published between 1980 and 2003, Bennett et al. (2007) reported that "context-based approaches improve understanding of scientific ideas as comparable to that of conventional approaches." As a result, it can be assumed that there isn't any conclusive proof that context-based learning has improved students' conceptual comprehension thus far (Podschuweit & Bernholt, 2018). However, there has been criticism of context-based learning that claims the extra knowledge contained in such a cultural framework would prevent conceptual acquisition since it would overwhelm the scientific fundamentals (Lye et al. 2001, as cited in Podschuweit and Bernholt (2018)). They favor a more abstract learning style that makes it simpler to identify and comprehend fundamental ideas.

In a recent study by Podschuweit and Bernholt (2018), no differences in scores or learning gains were seen between the two experimental groups of students on the abstract items. Because they had been told that knowledge gained through contextualized learning does not easily transcend the learning domain, students in both groups found it difficult to generalize and de-contextualize the general principles and concepts underlying the context-based learning scenarios they had encountered. However, the brief intervention period and the constrained range of contexts in which students participated may possibly have contributed to the failure of abstract transfer to manifest in experimental groups. They also noted that boosting learning chances and time can have a good outcome. Additionally, they proposed that the nature of the situations in which students learn about scientific concepts affects how well those concepts are understood by students. This indicates that a wider learning window appears to facilitate the application of conceptual information to new contexts.

In summary, the literature study revealed that different variables have been looked at independently and there are differences in the results in relation to knowledge of biological concepts. This study was significant since it joined disparate factors to fill a gap in the literature. Nobody should be shocked that there is currently no conclusive proof that context-based learning has a beneficial overall impact on students' learning. In contrast, it appears that positive motivating effects are strong. As literatures indicated that researches on context based approach were focus on science, chemistry and physics. However, the efficiency of a context-based approach in biology is not well studied. The result of context based approach on a given variable can vary based on the type of specific contexts (De Jong, 2008). Since Ethiopian context and culture is different from other countries, using activities which are context and experience based may enhance science learning.

The research regarding scientific reasoning and epistemologies across disciplines demonstrates a connection between the factors involved in learning. For instance, there is research to suggest that reasoning skills as well as epistemological beliefs and beliefs toward a discipline may both be important influences on content learning (Adams et al., 2006). How important a role each plays, and how these factors relate to one another when learning biology is still not completely clear (Mollohan, 2015). Researching epistemic viewpoints in biology may result in effective teaching strategies for biology teachers (Basu et al., 2017).

Most of researches on context based approach in the literature were focus on motivation, interest and achievement. According to what I have read, there have been no studies that demonstrate how a context-based approach affects students' scientific reasoning, conceptual knowledge, and epistemological beliefs, particularly with regard to biology. This study aimed at addressing how those constructs can be fostered effectively. To reach this goal, a context based intervention material were developed and implemented through REACT strategy in practice to promote fundamental aspects of the understanding of science like (a) suitable notions of the nature of biology's knowledge and knowing, (b) aptitude for using scientific reasoning, and (c) conceptual understanding in biology.

2.7. Conceptual Framework

According to Grant and Osanloo (2014), a conceptual framework is the researcher's understanding of how the research issues should be addressed, the precise paths for investigation must take, and the relationships between the multiple study variables. The major components, structures, or variables are precisely listed in the conceptual framework, which also assumes connections between them. A graphic or visual representation of how concepts in a study relate to one another within the theoretical framework is provided by the conceptual framework, which presents a logical structure of connected concepts. It helps the reader comprehend your worldview, including your ontological and epistemological ideas, as well as how you will approach the subject under study. It does not just present a list of notions. Using the conceptual framework, you may also define and characterize concepts that are part of the issue (Grant & Osanloo, 2014).

The conceptual framework for this study is grounded in many research previously discussed, and in the end combines the factors of epistemology, content learning, and scientific reasoning with the understanding that there is a dynamic relationship among all three.

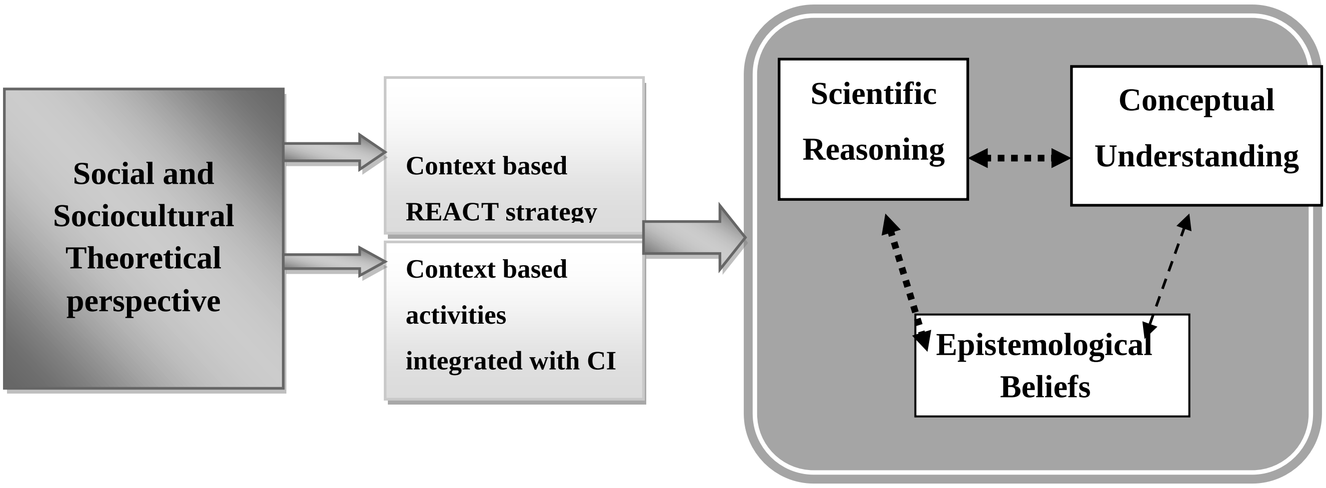

Figure 4 Conceptual framework

CHAPTER THREE: RESEARCH METHODOLOGY

Introduction

Research methodology refers to the use of the most effective methods for data gathering and analysis in order to evaluate research hypotheses and come up with reliable answers to research problems. The main objective of the current study was to investigate the effect of a context based REACT instructional strategy on students' scientific reasoning skills, conceptual understanding, and epistemological beliefs compared to conventional instruction about heredity. The research techniques used in the study to achieve this objective are discussed in this chapter. As a result, the chapter begins with an overview of the philosophical position that serves as justification for the selection of a mixed methods approach. The discussion of the data collecting and analysis methodologies follows this. Discussions will also include the method used, the treatments implemented, and ethical issues.

3.1 Research Paradigm

Before establishing a comprehensive strategy for the research activities, a researcher must first determine the underlying philosophical paradigm that guides the investigation. The research paradigm specifies how the study should be carried out, its objective, and the approaches used to evaluate the findings (Creswell, 2014; Creswell & Plano Clark, 2018). It is vital to have a thorough understanding of and debate of ontological, epistemological, and methodological views in order to conduct research. The researcher's epistemological standpoint influences theoretical viewpoints such as positivist, post-positivist, pragmatics, and interpretative. The approach chosen is influenced by the theoretical standpoint. Finally, the study approach has an impact on the methodologies and tools used to gather data.

This study looked at how students in grade 10 could better develop their scientific reasoning abilities, epistemological views, and conceptual grasp of genetics by using a context-based approach. The researcher created six research questions to address the goals of the current study. The researcher needs both quantitative and qualitative data in order to understand the attainment and development process of those variables in order to respond to those research questions. Therefore the researcher recognizes that neither qualitative nor quantitative method is independently sufficient to answer research questions.

To achieve the specific research objectives that were discussed in chapter one, nested mixed research design was used. In the nested approach, a primary quantitative methodology guides the inquiry while a secondary qualitative method supports the processes, according to Creswell (2014). In other words, the second approach is nested within or integrated into the first. The researcher can simultaneously gather both sorts of data using this mixed research approach, giving the study the advantages of both quantitative and qualitative data (Creswell, 2014; Creswell and Plano Clark, 2018). Because of the presence of both types of data, the researchers' philosophical stand is Post-positivist.

According to Creswell and Plano Clark (2018), the philosophical presuppositions and theoretical application in the mixed methods experimental design are driven by the post-positivist perspective, in which the primary purpose of the study (as a quantitative experiment) dominates the design. This suggests that researchers who use this approach concentrate on the intervention trial, use a theoretical or conceptual framework to guide the experiment, and draw important conclusions from the data. The qualitative element is frequently shaped by this post-positivist attitude as well, especially when it happens during the intervention and the focus is on upholding the validity of the experiment. Mixed-method research is a methodology that focuses on acquiring, interpreting, and synthesizing both quantitative and qualitative data in a single study or collection of studies, according to Creswell and Plano Clark (2018). Its core claim is that using both quantitative and qualitative methods together results in a better understanding of study topics than using each method alone.

3.2. Research Design

Research design, according to Ary et al. (2010), is the researcher's plan of action on how to proceed in order to understand a certain group or phenomenon in its context. It is a rational way to proceed from broad research topics to judgments. Alternatively, Bhattacherjee (2012) defined the study design as "a comprehensive plan for data collection in an empirical research project that focuses on data and data source." It serves as a "blueprint" for empirical research and specifies at least three steps, including data gathering, instrument design, and sampling. Its objective is to test various theories or offer solutions to specific research concerns. According to Creswell (2014), an embedded mixed method design is one in which either quantitative or qualitative data are integrated into a larger design (for instance, an experiment), and the data sources support the overall design. Using a convergent embedded experimental mixed method research design, the qualitative research is integrated with the quantitative research in this study (Creswell & Plano Clark, 2018). QUAN and qual, respectively, are used to represent quantitative and qualitative data.

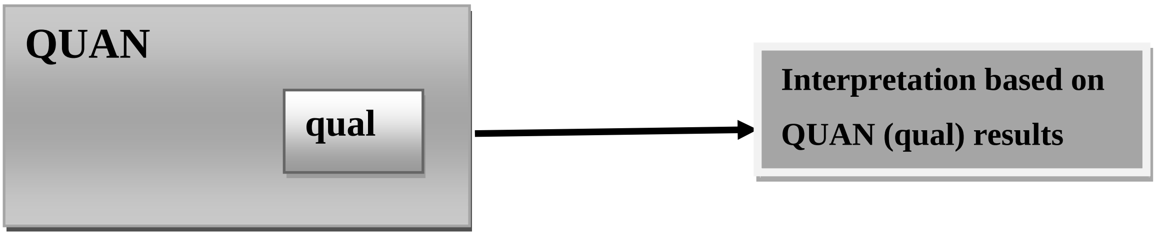

Figure 5, Convergent embedded experimental mixed method research design (adapted and modified from Creswell and Plano Clark, 2018)

The goal of the convergent design, according to Creswell and Plano Clark (2018), is "to obtain different but complementary data on the same topic" in order to better comprehend the study challenge. When a researcher wishes to fully grasp the research problem, they employ this design to compare qualitative findings with quantitative statistical results. The advantages of this design, which combines the advantages and disadvantages of quantitative and qualitative methods, were also discussed. For instance, quantitatively, a large sample size, objective measures, trends, and generalization, combined with qualitatively, a small sample, subjective interpretation, details, and depth. The convergent embedded approach, according to Creswell and Plano Clark (2018), uses a primary technique (quantitative) that guides the investigation and a secondary method (qualitative) that either performs a supporting role in the procedures or the reverse. The secondary technique is, to put it simply, nested within the dominant approach. Based on the aforementioned explanation, the researcher adopted this methodology in this study and simultaneously gathered the two categories of data (before, during, and after) the intervention to benefit from both quantitative and qualitative data.

A mixed methods experimental (or intervention) design, according to Creswell and Plano Clark (2018), occurs when a researcher collects, examines, and incorporates both quantitative and qualitative data into an experiment or intervention trial. The primary research design for this kind of study is either a quantitative experiment or an intervention trial. To improve the quality of the experimental results, researchers supplement this design with qualitative data before, during, or after the experiment. A fundamental design—convergent (during)—is then included into the intervention as a result of the qualitative data being added to the quantitative trial. The researcher of this study collects quantitative data using pre-test before and post-test after the intervention. The qualitative data was collected during the intervention through observation and after the intervention using semi-structured interview and focus group discussion to strengthen the quantitative data.

3.2.1 Quantitative Research Method

An experimental research method is a quantitative research approach where the conditions individuals are exposed to are controlled, an intervention is given, and the effectiveness of the intervention is then evaluated. By administering a specific treatment to one or more groups (the experimental group) and contrasting it with a third group (the control group), researchers can determine the effectiveness of the intervention (Creswell, 2014). Because the experimental group received the treatment, it is expected that they will differ from the control group following the intervention.

In this study, the performance of students exposed to a context-based teaching strategy with those who encountered standard teaching ways was compared using the mixed methods experimental pre-test-post-test methodology. Because it is difficult to assign individuals at random in a school context, a non-equivalent quasi-experimental method has to be used in this study. In order to fairly divide various achiever pupils in a class, the school administration assigned students by utilizing their average test scores. As a result, the study's treatment and control groups were both intact classes.

In order to avoid creating groups at random by assigning subjects to them, non-equivalent quasi-experimental designs use an existing control group that is comparable to the experimental group. Despite the fact that the quasi-experimental research technique design did not allow for randomization of subjects (students) to treatment due to the aforementioned reasons, intact classes and schools were chosen at random as the treatment and comparison groups.

The study has one comparison (CG) group and two treatment groups (TG) with pretest and posttest. Accordingly, Group 1 was with treatment of context based REACT instructional strategy (X1), Group 2 was with treatment of context based activities integrated with conventional instruction (X2) and Group 3 was with conventional instruction. The symbolic depiction of the quantitative research approach utilized in this study is shown in the table below.

Table 4. Symbolic representation of the research design

Treatment group 1	**N**	**O_1**	**X_1**	**O_2**
Treatment group 2	N	O_1	X_2	O_2
Comparison group	N	O_1		O_2

Note: N = represents the non-randomization of subjects to groups.

O_1= represents the pre-test

O_2 = represents the post test

X_1= represents context based instruction with REACT strategy

X_2= represents context based activities integrating with conventional instruction

Students in all groups were given the genetics conceptual understanding test (GCUT), scientific reasoning skill test (SRST), and epistemological belief questionnaire (EBQ) as a pretest (O1) at the beginning of the study to see if the groups were equal in their understanding, reasoning, and beliefs regarding biology learning and knowledge construction. The same tests were given again as a posttest (O2) after the treatment's six-week implementation period. Besides to these tests and questionnaires, focus group discussion with 30 students (ten students from each group) and semi-structured interviews with fifteen students (five students from each group) were conducted. Six weeks were spent doing the study. Each group had three sessions each week.

3.2.2 Qualitative Research Method

To gather qualitative information from students on their perspectives, opinions, and the evolution of dependent variables during the intervention, a semi-structured focus group interview was used. Focus group interviews are meticulously structured conversations intended to gather opinions in a specific area of interest in a welcoming, non-threatening setting. Focus groups are thought to stimulate cooperative reasoning, which could improve the caliber of student responses and recall of forgotten information (Kazeni, 2012). They are also known to offer a wide variety of responses, which could enhance the study's findings. Focus group interviews also eliminate one-on-one information gathering, which some students may find overwhelming, and are likely to yield a wealth of information in a short amount of time. Mostly students reflect their idea while discussing with their friends rather than asking them individually. Therefore, the researcher used this opportunity to gate detail information about their ideas/feelings, reasoning and understanding in relation to the heredity concepts after the intervention.

The researcher also gathered qualitative data from the classroom observation in order to fully understand the instructional process, the manner in which the teacher facilitates learning, the interactions between the teacher and the students as well as among themselves, the level of student participation in the lessons, and the environment of each group's classroom. As a result, a qualitative approach would be helpful in enhancing and triangulating elements of the quantitative data to give more contexts for the outcomes. Through semi-structured interviews, the opinions of the teachers who worked with the treatment group and the five students from each group were gathered.

3.3. Study Variables

According to Morgan et al. (2005), variables are characteristics of the subjects or environment for a particular study that have various weights. According to those writers, there are three different types of variables: independent variables (active or attribute), dependent variables, and unnecessary variables. As a result, this study included four variables. Three dependent variables and one independent variable make up this set.

Independent Variables

The parameters or characteristics that the experimenter controls or manipulates in an effort to determine their relationship to observed phenomena are known as independent variables (Morgan et al., 2005). The teaching approach was the study's independent variable. It has three levels which are context based with REACT strategy, context based activity integrated with conventional instruction and conventional instruction alone.

Dependent Variables

As the experimenter adds, eliminates, or modifies independent factors, dependent variables also are introduced, disappear, or change (Morgan et al., 2005). The conceptual knowledge of genetics, the capacity for scientific deductive reasoning, and the confidence in epistemology were the dependent variables in this research.

The variables used in this study are listed in the table below; three of them are dependent variables, and the other three instructional method types are independent variables, as indicated.

Table 5. Study variables

Type of variable	*Variables*
1. Independent variables	1.1 Context-based REACT strategy 1.2 Context-based activity integrated with conventional instruction 1.3 Conventional instruction
2. Dependent variables (also referred to as "learning outcomes")	2.1. Conceptual understanding 2.2. Epistemological beliefs 2.3. Scientific Reasoning skills

3.4. Population and Sampling Procedures

The population of the study consisted of all grade 10 students at government secondary schools in the Debre Birhan region of Ethiopia. For a number of reasons, secondary education is a crucial component of an educational system. This is because secondary education is the base for higher education; it acts as a stepping stone for more advanced schooling. The quality of secondary education determines the level of highly-qualified professionals that higher education produces in various professions. Secondary education must give pupils the necessary skills and scientific knowledge to equip them for higher education.

The choice of grade ten was made because it is when genetics is introduced as a formal educational topic. Since they had not yet studied the subject, it was presumed that grade 10 students knew very little about genetics. For grade ten and twelve biology, the conceptual knowledge, scientific reasoning, and epistemological views of students are low and not so good, as already indicated in the problem description. Therefore, it is preferable to make an effort to improve students' academic performance and adequately get ready students for higher education at the beginning of secondary education. The knowledge gained in this grade is thought to improve learning in the following two grades. Every area of biology is now better understood as a result of advances in genetics.

Studies of the literature on difficult biological topics at various grade levels, including higher education, revealed that genetics was challenging to both understand and teach, necessitating the use of effective instructional strategies to improve students' learning. The influence of genetic approaches to biology is increasing, and as a result, more people, whether they realize it or not, must assess genetic data and take part in decisions that have an impact on both individuals and society. The study of genetics has greatly benefited society throughout educational history by helping to diagnose and treat diseases, but it has also been exploited to justify terrible things like forced sterilization and mass murder during the human eugenics movement. In school science and biology, genetics has remained a crucial subject that connects other subjects covered in the curriculum. However, it is commonly acknowledged that many secondary students find it challenging to learn the concepts and language of genetics (Tsui & Treagust, 2010). It is vital for students to consider not only the potential genetics has to bring enormous benefit but also to be mindful of potential downsides because many current ethical issues are matched with principles in a genetics course. Genetic material, heredity, mitosis, and meiosis are some of the first ideas that students study. Mistakes in these procedures might result in cancer and miscarriage, among other health problems.

To choose the schools and subjects for the study, simple random sampling technique was adopted. The first step was to create a list of every government high school in the three nearby woredas. Seven schools were chosen from the list to potentially participate in the study if they satisfied the following criteria: proximity to the town for transportation, qualified biology teachers with at least ten years of classroom experience, and presence of one functional biology laboratory. To minimize infrastructure and resource discrepancies, these schools were selected using convenient sampling. Then, three high schools were selected from the seven schools using simple random sampling. Of these 9 teachers who are teaching biology for grade 10 in the selected three schools, only three were purposefully selected using suggestions given by principals based on the teachers' commitment and willingness.

To prevent information contamination during intervention and data collecting, there are three schools. In order to minimize discrepancies between the two treatments and comparison groups, the characteristics of all the participating schools were more or less similar. These measures included exposure of both treatment and comparison groups to the same tests, pre-testing of the experimental and comparison groups at the same time, and the implementation of the intervention of the same period of time. One biology teacher and one or two sections of grade 10 students from each of the three schools participated. First, teachers of biology who have more experience teaching biology than other teachers were purposely selected to each school. Both the experimental and comparison groups of the three teachers who participated in this study were made up of men. Over ten years in a secondary school were spent teaching biology by the researchers' study participants. Furthermore, two of the teachers held master's degrees, and one is a bachelor with over twenty years of experience teaching biology. Second, among the sections that the selected teacher was teaching, one section was selected randomly from one school for treatment group 1, one section was selected randomly from another school for treatment group 2, and one section was selected randomly from the third school for the comparison group.

There were 50 students in the comparison group, 38 students in treatment group 1, 43 students in treatment group 2, and 131 students in the tenth grade (46 boys and 85 girls) in the chosen government secondary schools. The average student age was 17, while the age ranged from 16 to 18. Additionally, 15 students were chosen for semi-structured interviews after the intervention using purposive sampling (based on their conceptual comprehension scores, 2 from high scorer, 2 from low scorer and 1 from the middle scorer) in order to triangulate the results. Similarly, focus group interviews involved 30 students (20 girls and 10 males), 20 from the experimental groups and 10 from the comparison group. Students were assigned to focus groups based on how well they did on examinations and surveys. Under Unit 2 of the text book for the 10th grade, the intervention covered four themes related to heredity. Chromosomes and genes, mitosis and meiosis, Mendelian genetics, and heredity and breeding are among the topics covered in this course. The unit needs 16 periods to be completed, according to the syllabus. As a result, the intervention required three periods each week for around six weeks during the first semester.

3.5. Instructional Materials and Intervention procedures

Development of context-based genetics materials

The creation and use of context-based instructional materials involved selection of a study topic that was genetics and selection of contexts by connecting with selected content. It was deemed necessary to choose a subject that was primarily difficult from the perspectives of the students and teachers, as indicated in literature, in order to fairly analyze the relative efficacy of the context-based approach and of conventional ways in increasing student learning. In order to select the study topic, the researcher reviewed different literature in relation to a difficult topic in biology, and genetics was the first.

According to the survey's results, Kazeni (2012) came to the conclusion that students who were studying genetics valued the context domains of personal advantages (91.9%), social issues (91.3%), scientific and technological breakthroughs (69%) and environmental issues (65%). The context domains taken into account in this study have a strong connection to the appreciation of nature and usefulness in daily life as learning motivators. The chosen scenarios involve social, environmental, and personal concerns. The scenarios employed in this study also matched the criteria below: They were based on the pupils' actual experiences and familiar situations, not on hypothetical ones. They might pique pupils' curiosity and elicit empathy. They were based on topics and concepts from the Ethiopian national curriculum for grade ten on the topic of genetics and were current issues that were pertinent to students' daily lives.

Organization of content and contexts into learning activities

Science educators typically believe that effective classroom education and learning must take into account the prior experiences that students bring to scientific lessons both during the creation of teaching materials and during instruction (Tsui & Treagust, 2010). The grade ten biology national syllabus and text book MoE (2009) were evaluated to find concepts, ideas, and principles that were relevant to genetics in order to produce the context-based materials used in this study. Gene, DNA, and chromosome; Mitosis and Meiosis; Mendelian Characteristic Inheritance; Mendelian Inheritance and Variations in Individual Characteristics; and Heredity and Breeding were the genetics themes into which these were divided. Scenarios were created for each of these topics using narratives that had been carefully chosen based on the surroundings that the researcher had picked (Appendix G). According to the adopted context-based teaching methodology, these narratives served as the contexts for each lesson's introduction. To clarify and explain these situations, pertinent genetics information (concepts, principles, and ideas) was chosen with care. The narrative that follows, which is based on a societal issue, calls on knowledge of genetics terms like chromosome, DNA, and gene as they relate to character inheritance.

The jar contains a variety of seeds, including wheat, barley, peas, beans, and cabbage. All seeds grow into their respective types of plants when they are planted, and barley seeds work the same way. Given that they are located in the same container and were planted in the same garden, why did the barley seed not develop into a wheat plant? Why do parents and children have similar traits? Who among your family members do you resemble? Why?"

The use of appropriate contexts to elucidate genetic content, such as character inheritance, facilitated the linkage of contexts and content. Furthermore, manipulating real-life genetic processes was used help contextualize genetics concepts and ideas.

Everyone has the experience of planting vegetables in their home garden and simply they understand putting together cannot change the characteristics of seeds rather the material inside the seed. Students had to use past knowledge and apply genetics concepts, ideas, and principles to the events in those experience-based activities in order to make sense of them. Since the students were actively participating in the events, this piqued their interest in the study of genetics. There were additional narratives to help people understand the idea of inheritance during the application stage. Students had to apply what they had learned in these exercises to circumstances that were unfamiliar to them but were related to the ones they had studied. For example, for the topic of Mendelian inheritance, the activities performed by the students and contexts were presented using REACT strategy is given bellow.

Lesson Topic: Mendelian inheritance

Lesson Objectives: Students will be able to;

- Explain the works of Mendel on garden peas.
- Distinguish between heterozygous/homozygous, dominant/recessive traits and phenotype /genotype.
- Discuss how Mendel's work relates to inheritance laws.

Phase 1: Relating

Who always speaks and takes others' turns in your 1 to 5 group? What do you call those group members? When other students are given the opportunity to speak during a discussion, Why? Why do some girls look like their mothers? Is it related to the number of chromosomes inherited from the mother and father? Why? Can you see all of the characteristics of an individual from their physical appearance? Why?

Phase 2: Experiencing

The pairing of dominant and recessive alleles, homozygous and heterozygous alleles is demonstrated using black and red pea seeds. Use a chart that shows the different contrasting observable characteristics of pea plants**.**

Steps to perform the activity

1. The teacher prepares 50 red and 50 black pea seeds.
2. The teacher informs the student that black seed color is dominant over red seed color, which is recessive.
3. Put all the seeds in the container and mix them.
4. One student took out two seeds from the container without observing them, and the class students categorized the seeds as black or red. Heterozygous or homozygous? and made a ratio.

Phase 3: Applying

A farmer planting a pea plant wants to grow round seed and wants to know where to get seeds. The farmer wants to get seed that confidently produces round seed. Please aid the farmer's comprehension.

a. What is the genotype of a seed that produces round seeds in the F1 generation? Is it possible to obtain round seed by using a pure breed?

b. If the farmer implants the seed from the F1 generation, what will be the percentage of getting the round seed?

Phase 4: Cooperating

In a group of four, discuss the following questions, communicate with other students, and critique each other's ideas.

a. What makes Mendel's studies with pea plants a good fit?

b. What motivated Mendel to select pea plants for the paternal generation that had varied traits?

c. Explain why you believe he only tested one quality at a time.

d. Why did he permit the F1 generation of plants to self-pollinate?

e. Give illustrations to the laws of Mendel.

Phase 5: Transferring

We Africans are black. A man and a woman who are living in the Gambela region of Ethiopia are both black. They got married last year and have a baby girl who has pale skin. They were concerned and perplexed as to why our child had white skin when we were both black. Can you help them understand?

a. What exactly is this condition, and how does it manifest itself? Explain your answer.

b. Explain the possible genotypes of men and women.

c. Explain homozygous and heterozygous alleles.

Validation of developed context-based materials

To evaluate the materials’ content validity, two college biology lecturers and three high school biology teachers who agreed to conduct the intervention examined them to determine whether:

- The resources introduced genetics topics using the contexts that were designated as their launching pads and bases.
- Only genetics concepts pertinent to comprehending, interpreting, or explaining the contexts were introduced.
- The material was relevant to the Ethiopian biology national curriculum statement and was suitable for use by high school students.

The researcher and assessors talked about the importance and length of particular narratives, suggesting the addition of some genetics themes and the omission of others. The produced materials were revised in response to assessor comments. The experimental group was instructed using the validated materials utilizing the five-phase REACT teaching method, which is detailed below.

3.5.1 Context based approach with REACT strategy

The REACT approach was developed by the Center of Occupational Research and Development (CORD) as a consequence of research done to address issues in mathematics and science. Relating—Experiencing—Applying—Cooperating—Transferring stages make up this process. It helps educators and students connect ideas about the subject with the context brought forth by actual experiences. It increases students' motivation and interest in the subject. Teachers may begin a lesson by posing a hypothetical inquiry about a potential real-world scenario. The setting or elements are introduced in the classroom. The professional part of the context is highlighted when students have had experience connecting context and concept. Students converse with one another, impart what they have learned, and have group discussions about the procedure. Transferring is the application of what a learner has learnt in a new setting or circumstance (Crawford, 2001). The first treatment group in this study experiences REACT strategy. The study's five phases of contextual teaching methodologies were presented in the following order:

1. *Relating:* Learning that is related to one's past experiences or present knowledge. Authentic situations (contexts) linked to the ideas of genetics that were to be studied were given to the students throughout this phase. According to research, students sometimes fail to notice the importance of memories or prior knowledge that they may have brought to a new learning environment. As a result, the learning environment provided by this content allows students to both activate memories or prior knowledge and notice the significance of those memories or knowledge during the related phase. The circumstances were outlined using narratives, stories, genetic conundrums, and well-known societal occurrences (Gilbert, 2006). This phase offers a justification for teaching new scientific concepts (Gilbert, 2006) and a context of real-life experiences in order to relate the learning of science to students' daily lives in order to increase the relevance of learning science. This phase aims to captivate their attention and keep them focused on a particular context upon which the learning of subsequent scientific concepts depends. For instance, the context-based activity utilized for the subject of heredity and breeding was:

"Beza is a grade 10 student, and she has the best sheep to support her parents by gaining income. Many people asked Beza to sell her sheep to them because her sheep are twin givers and give a large amount of meat. Are there animals known as "best" and "poorest" in your house or that of your neighbor? What characteristics of these animals make them the best? How can you increase the number of these animals? Can you increase the quality of poor animals to make them better? How?"

2: Experiencing: Exploring, discovering, and creating are all examples of experiencing. Manipulatives, problem-solving exercises, and laboratories can all be used as part of in-class hands-on learning opportunities. The majority of the provided material included manipulatives and exercises that required problem-solving. When properly included into the curriculum, manipulatives have been found to improve student performance (Crawford, 2001). While studying important ideas, kids can express their creativity through problem-solving tasks. Along with problem-solving techniques, analytical thinking, communication, and group interaction are also taught through these exercises. The instructor was able to recognize and record the pupils' alternate concepts for later remediation. The second phase was designed to encourage students to learn new scientific ideas by piqueing their interest in the scientific concepts connected to the contexts that were first introduced through the use of models and practical exercises (Gilbert, 2006).

Students were instructed, for instance, to "*examine the process of DNA replication using letters of nitrogen bases (A, T, G, and C) and clearly identify which nitrogen bases combined each other based on fitting shapes such as that of a socket."*

3: Applying: - Applying is putting principles into practice while studying. It goes without saying that when students are involved in both mental and practical problem-solving tasks, they apply concepts. By giving students assignments that are pertinent and realistic, teachers can also encourage a need for mastering the topics. These tasks are "word problems" similar to those in textbooks. But there are two key variations: They present incredibly real-world scenarios and show how academic ideas might be applied in some areas of one's daily life. For application issues to be motivating, both are crucial. In conclusion, understanding, sensed significance, and insight can all be attained via relating and experiencing. These liberating realizations help pupils develop the epistemic conviction that "I can learn this." A deeper feeling of meaning and a rationale for learning are developed through the contextual teaching and learning technique of applying. This tactic supports the epistemological tenet "I need or want to learn this." These epistemic convictions are powerfully motivating when taken as a whole (Crawford, 2001). For example, for Mendelian inheritance in humans, the activity used was:

"Almaz has blue eyes, and she said both of her parents have brown eyes." Her family used the Amharic proverb 'Zer keliguam yisbal' when discussing her eye color, and she was always perplexed as to why they used it. Please look at your friends' physical appearance, such as eye color, hair color, and other physical features. You have probably noticed that different people have different traits. Where do people get these different traits from? Explain your reasoning. Is there any possibility of having a blue-eyed child from brown-eyed parents, and can you help me understand Almaz's confusion? Explain how. "What is the distinction between parent and offspring?"

4: Cooperating: Cooperating involves learning while responding, sharing, and interacting with other pupils. The exercises in this stage were created to motivate students to use the material they had learned to clarify and address the problems at hand. In this stage, small groups of pupils may frequently solve these challenging issues without much outside assistance. Teachers who assign exercises or hands-on activities to student-led groups are utilizing the cooperative learning technique, which involves sharing, responding, and interacting with other students. Because it encouraged students to use the material they had learned to explain situations, solve issues, or make judgments, the phase was also intended to help students with higher-order thinking abilities like problem-solving and decision-making. Because an alternative approach to the issue could at times be more effective, they learn to value other people's perspectives. Student members of the group experience greater drive and self-confidence when the group achieves a goal than when they work alone. The phase therefore focused on the components of reasoning and reflection. It was believed that as students participated in the activities in this phase, they would acquire a particular speaking style (scientific language) in response to the topics and circumstances under discussion (Gilbert, 2006).

"For example, the activities used for Mendelian inheritance were "In the shape of an ear, dangly is dominant over an attached ear." If a heterozygous dangly-ear mother marries a man with attached ears, use Punnett square to list possible ear shapes for their children in terms of genotype and phenotype. Mendel explains dominant and recessive alleles in detail. Is there any possibility of the presence of equally dominant alleles? Explain your answer by using examples. What does the Amharic word "Buraburie lam" mean?

5: Transferring: Transferring is the act of applying knowledge to a new scenario or environment that was not previously discussed in class (Crawford, 2001). The teacher's role is increased at this phase to include developing a range of learning activities with an emphasis on comprehension rather than memorization, leading to the contextual classroom. They offer practical, hands-on exercises, and actual issues in addition to skill drills and word problems so that students can develop a basic comprehension of concepts and deepen it. Students' conceptual knowledge and skills, as well as their capacity to apply newly taught concepts to novel scenarios that were not previously used in class, were evaluated using in-class exercises, quizzes, problem-solving tasks, and exams. This stage was meant to provide students practice applying what they had learned to circumstances that hadn't been covered in class and to emphasize the value of knowing scientific principles. Students were given the following assignment during the transferring stage of the heredity and breeding topics.

"Religious ethics and contemporary social norms have adjudged and forbade the marriage of brothers and sisters in human society." What do you think about the fundamentals of genetics?

a. In regard to this premise, does genetics support or contradict societal standards, religious laws, and cultural practices? Why?
b. Do you believe selective breeding and cross-breeding have drawbacks? How?"

Essentially, the teaching process begins with the setting of the context, which is focused on the concept to be taught (contextualization). In order to connect the context with the genetics concept, questions were raised based on the context presented. The teacher then needed to explain the relationships by reconnecting the target concept with the given context (re-contextualization) after concepts were presented by the teacher (de-contextualization). The teacher then created a setting where the pupils had to demonstrate how they applied their knowledge in the real world. The evaluation process must be completed by teachers as well. Students work together at every stage of the learning process. Gilbert et al. (2011) discuss the social setting that was the context offered using implementation model 4. The following figure is used in Germany for context-based approach implementation, and in this study, similar processes of implementation for treatment group 1 were used.

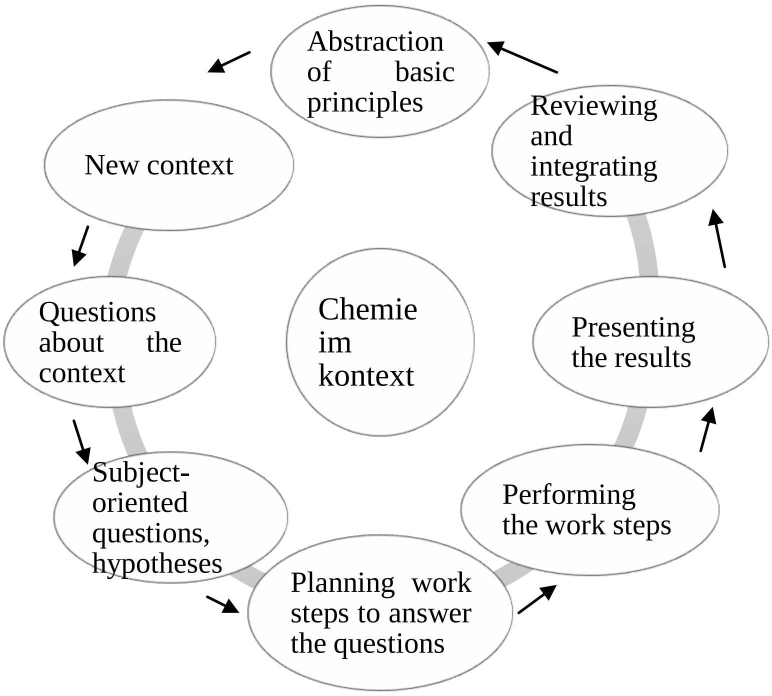

Figure 6 The process circuit of chemie in Kontext (Adopted from Parchmann et al., 2006)

3.5.2 Context based activities integrated with conventional instruction (Context as reciprocity between concepts and applications)

For the second treatment group, the teacher introduced a concept at the beginning of the class before using the setting as an example. In accordance with Gilbert et al. (2011), in this paradigm, a situation is chosen by the instructor or course designer (in this case, the researcher selected the situation) and acts as a vehicle via which important concepts can be taught. The underlying premise is that concepts and context interact in a cyclical manner throughout the teaching process, such that after concepts are taught, examples of how they can be applied in the context are provided, and then a fresh aspect of the context is highlighted as a lead-in to the teaching of new concepts. A dialogue was used to introduce the context. After that, the teacher switched from discussing context to discussing the idea of heredity while continuing to offer context for added understanding. The teacher chose the approach of instruction. Gilbert et al. (2011) used the setting in this instance to underline the reciprocity between concepts and applications, which they named "model 2."

The main issue with this approach in the actual science classroom was whether the status of the situation remained the focus of attention throughout the series of tasks addressed during the teaching sequence or if it eventually became largely forgotten and the science concepts took over as the only thing that was being discussed. As a result, students may or may not find the community of practice framework that is offered to them valuable. The researcher observed the intervention and talked with the teacher about how to modify the activity in order to ensure the adoption of the interchangeable practices between concept and context.

3.5.3 Conventional teaching method

The fundamental structure of conventional classroom instruction was teacher-centered. The teacher began by briefly introducing fundamental ideas, working through some straightforward examples, and then posing more challenging questions for the pupils to answer. For instance, right at the start of the session, the instructor put a title on the board, made a brief statement about heredity, chromosomes, and DNA, then clarified them in depth by reading the notes from the notebook. Students then copied the notes down in their workbooks as the teacher read them to them. The teacher gave a quick explanation before presenting the definitions and principles of inheritance. Actually, the teachers were going about their normal business during class times. The primary teaching techniques were lecturing and questioning; occasionally, students also participated in group discussions centered around the questions that the professors posed. In order for students to understand the relationship between concepts through real-life settings, real-life contexts were not provided to students at the beginning of the course. Even the images and charts in the textbooks of the students weren't taken into account for clarity. Instead, after introducing the key ideas, the instructor typically concentrated on the text-book problems, which emphasized lower-level learning. As a result, kids did not receive instruction in higher-order learning skills like conceptual thinking and scientific reasoning.

Training of teachers

The teacher who instructed the experimental group received training on how to use the context-based teaching resources, particularly with regard to handling context, controlling learning, and placing the proper emphasis on conceptual understanding, scientific reasoning abilities, and the formation of epistemological beliefs. The teachers' exposure to the instructional materials was another component of the training. A two-day session led by the researcher was attended by two teachers who work with the experimental groups separately from one another. A guidebook with context-based teaching resources and hands-on exercises was provided to the teacher who was responsible for teaching TG1. The manual included comments for teachers, an introduction to the teaching technique, a description of the REACT strategy, a list of the study themes, and instructions for teachers and students on how to use the context-based content (Appendix G). In contrast to TG 1 content, which included practical exercises, TG 2 material included activities that provided scenarios for debate once the principles were introduced.

The researcher described the five phases of the technique during the training workshop, demonstrated how to execute the phases, and conducted trial runs with the teacher on how to implement the phases. After the workshop, the instructor was given a week to review the teaching material before speaking with the researcher once more.

The teacher who instructed the comparison group was not provided with a teaching guide or special training for instructing the genetics subject. This is due to the fact that he was compelled to use the teaching resources and techniques that he ordinarily uses when instructing on the subject. A list of the study themes and concepts contained in the context-based manual was taken from the syllabus so that students in the experimental and comparison groups may be exposed to the identical genetics information.

Pre-testing

Pre-testing involved giving the experimental and control groups the three instruments that were created for the study. The consent process employed in the pilot project was adhered to prior to the administration of the instruments. The tests for conceptual knowledge, scientific reasoning, and epistemological beliefs were given to the students in that order. The pre-test results of the conceptual understanding, scientific reasoning, and epistemological belief questionnaires were used to gauge students’ performance and competence with their prior knowledge. To compare the performances of the experimental and comparison groups prior to the intervention, this was required.

Intervention

Following pre-testing, the comparison and experimental groups received the same genetics concepts for a period of six weeks. The majority of the ideas, guidelines, tenets, and theories found in the Ethiopian biology curriculum statement (MoE, 2009) were covered in genetics lessons. In order to teach genetics to the experimental groups, context-based teaching materials and methods were designed. The comparison group received instruction using the resources and strategies that teachers typically use to teach genetics (conventional techniques). The protocol section indicated the intervention process for three groups.

Lessons were delivered to both treatment groups during the intervention period at the regular teaching and learning periods. In a similar vein, learning advances at its usual rate in a group setting. The researcher randomly visited both groups to watch the instruction, videotape a few lessons, and talk about how the students' learning was developing. Where necessary, follow-up meetings were organized with both groups of participating instructors to address operational concerns with the program. There were roughly equal numbers of visits to the experimental and control groups.

Post-testing and interviews

The pre-testing instruments were administered again as a post-test to the experimental and comparison groups at the conclusion of the six-week intervention period in the same order as before. Thirty students from both groups who volunteered to participate in focus groups discussions and fifteen students who had completed the post-tests participated in post-intervention interviews. Audio recordings of each interview session were made. Outside of class hours, pupils were tested and interviewed.

3.6. Data Collection Instruments

To provide information that would help with this study's research topics, data were gathered using a variety of data gathering technologies. The data gathering tools of this research were the two-tier multiple-choice genetics conceptual understanding test (GCUT) and the two-tier multiple-choice scientific reasoning skill test (SRST) (prepared by the researcher) and the epistemological belief questionnaire (EBQ) adapted from the Colorado Learning attitude about science survey for biology

(CLASS-Bio), a focus group interview, semi-structured interview, and a classroom observation checklist. Interviews were conducted after the intervention, and classroom observations were made all throughout the intervention. The three different tests—the conceptual understanding test, the scientific reasoning skill test, and the epistemological belief questionnaire—were used as a pre-test prior to the intervention and a post-test following the intervention. Below is a detailed description of these instruments' properties and development process.

Genetics Conceptual Understanding Test (GCUT)

Although many techniques are used to assess students' levels of understanding and reasoning and to identify misconceptions, multiple choice tests, interviews, concept maps and observations are among the most commonly used. Each, though, has its own restrictions. The use of two-tier diagnostic examinations, which measure students' comprehension and are simple to administer, score, and implement Treagust (1988), is advised when determining students' conceptual understanding. Both traditional multiple-choice items and the first tier of two-tier multiple-choice items can assess content knowledge, which mostly needs memorization. The problem is explaining why they selected the given answer. A two-tiered diagnostic test was used in this study to assess conceptual understanding because it is possible that, in some situations, students will use the second-tier items as additional information rather than a direct explanation to figure out or confirm their answers to the first question.

The Genetics Conceptual Understanding Test (GCUT) was developed by the researcher to determine students' conceptual understanding of genetics. The development of the tests was based on the objectives of heredity in the 10th grade syllabus (MoE, 2009). The first tier tests were developed after reviewing questions from the grade 10 heredity unit that appeared in biology textbooks and the Ethiopia

General Secondary Education Certificate Examination (EGSECE) given to students in the years 2000–2011. Using questions from previous exam papers, the researcher evaluated students' knowledge of the competencies and criteria demanded in the actual biology national examinations. Furthermore, a table of specifications based on Bloom's taxonomy was used to prepare the multiple-choice test items. A total of 15 multiple-choice items with four distracters were created and given as a pre- and posttest for all three groups to gauge students' comprehension of heredity concepts before and after the intervention. Originally, 20 multiple-choice test items were developed and administered for a pilot. Five of those items were removed after item analysis.

Two-tiered multiple choice tests (TTMCT) consist of two interrelated phases, the first of which consists of an item stem and a number of answer options. The first tier of the test contains a content response with four choices, like that of multiple-choice tests. The aim of this tier is to identify how an individual interprets scientific knowledge. The second step of two-tier assessments is what distinguishes them from other tests, and in this part, students are asked to explain the reasoning behind the response they provided in the first phase (Treagust, 1988). Large-scale use of those assessments was made to diagnose students' conceptual comprehension and assist in locating common misconceptions among pupils regarding science. The procedure used to create the researcher's genetics conceptual comprehension test is detailed in the section that follows.

Development Process of GCUT

The GCUT was developed using Treagust (1988) two-tier multiple-choice test development process. The process consists of three stages: topic definition, student misperception data collection, and diagnostic test development. The exam is developed in ten steps total, divided into three phases: four steps in the first phase, three steps in the second, and three steps in the third. Treagust (1988) advocated a two-tier test development method, which is illustrated in the following table with phases and steps.

Table 6. Three phases and ten steps of two tier multiple choice test development process

Phases	**Title**	**Steps**
I	1. Defining the Content	1. Identify propositional knowledge statements 2. Develop a concept map. 3. Relate propositional knowledge to the concept map 4. Content validation
II	2. Obtaining Alternative conceptions	5. Review literature related 6. Conduct interview 7. Conduct multiple choice content items with free response
III	3. Developing the Instrument	8. Develop two-tier items 9. Design a specific grid 10. Refine test

Phase 1: Define the Content

In the first four steps, defining the content was about drawing the boundaries of the subject or concepts of genetics. By looking at each subsection of the heredity unit, which comprises chromosome and gene, mitosis and meiosis, Mendelian genetics, and heredity and breeding, propositional knowledge assertions from the text book and syllabus are first identified. Therefore, these assertions ought to cover every facet of the pertinent subject or idea. The grade ten textbook and syllabus were used to identify the objectives and major ideas of the subject matter. The creation of a concept map is the next stage in phase I after the discovery of propositional knowledge claims. It is crucial to create a conceptual framework for the ideas related to the research issue. The idea map exercise, according to Treagust (1988), gives the researcher the chance to thoroughly analyze the kind of content that has been chosen for instruction. Based on the syllabus and content of the grade 10 textbook, a concept map for heredity was created. The researcher created a concept map to show how the topics covered in the unit on heredity in the tenth grade biology curriculum are connected.

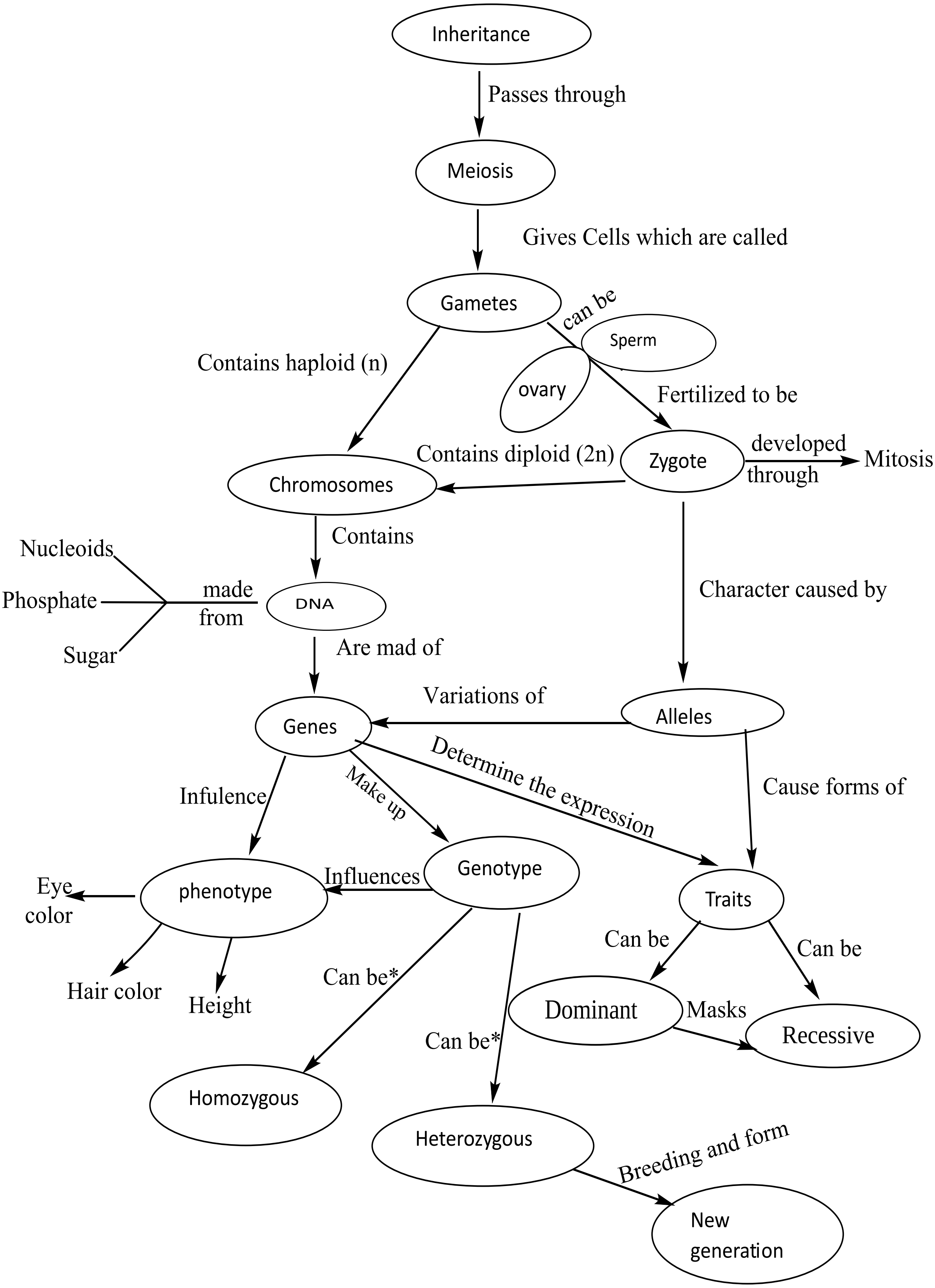

Figure 7 Concept map on heredity concepts

Phase I's third step involves connecting the concept maps created with the propositional knowledge that has been identified. The direct relationship and overlap of these two structures acts as a kind of control mechanism for the internal consistency of the test to be prepared. The idea map and propositional claims are validated in the fourth stage by means of validity checking techniques. To do this, two knowledgeable biology instructors from the course were given the discovered propositional statements and idea maps for validation. The teachers' feedback is taken into consideration to enhance the idea map and propositional knowledge.

Phase 2: Identifying Misconceptions

Phase II involves identifying pupils' misunderstandings or other concepts from various sources. The replies given by pupils during an interview with grade 11 students served as the basis for the alternative conceptions; thus, they learned the topic before a year and answered multiple-choice, open-ended questions, as well as conducted a literature review. Phase II consists of three steps, as follows: In the fifth step, the literature based on the subject determination of misconceptions was reviewed (Tsui & Treagust, 2004; 2010; Çimer, 2012). The data obtained from the review was used to develop the semi-structured or unstructured interview questions, both for the development of the test and for the next step.

In the sixth phase, students are interviewed informally to determine common beliefs regarding heredity. These interviews help uncover any areas of confusion or misunderstanding and generate ideas for more inquiries using multiple-choice questions with a free response. To assess the students' comprehension of genetics concepts, interviews were performed with a total of ten 11th graders, lasting 15 to 25 minutes each. This phase's seventh step uses multiple-choice, open-ended questions that permit students to freely express their opinions as another method of identifying alternate concepts. The researcher then created 20 multiple-choice questions with open-ended answers and administered them to fifty eleventh grade students. Each item was followed by a blank area where the student may explain why they chose the specific piece of content. Misconceptions about genetics were gathered from the replies given in the open-ended response section. The tool was developed using misconceptions discovered based on how each multiple-choice, open-ended question was answered by the pupils, as well as from interviews and literature (Appendix D).

Phase 3: Develop the Instruments

The objects are constructed in the eighth step. The initial iteration of the two tiers multiple choice test items was constructed using the data gathered from phases I and II. The second tier of the test is arranged as multiple choice based on the students' responses obtained from the review, through conducting an unstructured interview, and open-ended answers, which have been determined in steps five through seven. The idea map was created and the propositional knowledge assertions were determined in relation to the two-tier diagnostic tools. As previously mentioned, the two-tier multiple-choice test item's final instrument was divided into two parts: the first part evaluated the students knowledge of concepts like chromosomes and genes, mitosis and meiosis, Mendelian genetics, heredity, and breeding, and the second part included the justifications for the first part's answers. One right response and three alternate distracters made up the first layer. One accepted explanation, three more alternative reasons, and one additional blank spot were included in the second layer, where participants could enter additional justifications if they felt theirs was left out of the list of potential distractions.

The creation of specifications is done in the ninth step. The specification grid was created to ensure that the items adequately addressed the propositional knowledge claims stated in the heredity unit. The specification gird, which was composed of the content area and the propositional statement it refers to, is shown in the following table. Question numbers 3, 6, 8, 9, 10, 13, 16, 19, 22, and 25 are scientific reasoning questions, and question numbers 25, 26, 27, 28, 29, and 30 are rejected items after analysis is conducted.

Table 7 Specification gird

Topic	Sub-topic	No of Items	Propositional statements
Heredity	Chromosome and gene	6	11,13,15,16,21, 29
	Mitosis and meiosis	10	3,5,7,8,10,12,22,24, 25,26
	Mendelian genetics	7	1, 2, 9, 17, 18, 20,27
	Heredity and breeding	7	4, 6, 14, 19,23, 28, 30

Refining the instrument is the tenth step. The pilot study's implementation begins after the items are developed. With the pilot study, performing a substance analysis of the test and calculating its reliability are aimed at. Necessary arrangements are made on the test by taking advantage of these results (Treagust, 1988). The results led to a second revision of each item based on comments from students and feedback from biology experts regarding the amount of difficulty, the clarity of the questions, the correctness of the responses, the accuracy of the distracter, and the extent to which the topics addressed the ideas. Following the pilot test and item analysis, the final version of the two-tier multiple-choice test item consists of 15 items for assessing inherited notions.

Epistemological Belief Questionnaire (EBQ)

A variety of tools are available to gauge students' epistemic beliefs on science. However, all of these instruments are domain-general and do not ask students specific questions about any one scientific discipline. The Colorado Learning Attitude about science Survey (CLASS) instruments, on the other hand, was exclusively designed for use in individual disciplines (Semsar et al., 2011). The CLASS-Bio was designed to probe students’ beliefs about the nature of biology (the nature of knowledge) and epistemological beliefs about learning biology (the nature of knowing and learning) (Semsar et al., 2011). Additionally, students' ideas of a discipline's content and organization, the source of their knowledge, how it relates to the outside world and their methods for approaching problems are all examples of epistemic beliefs. Accordingly, to assess students’ beliefs about biology learning and knowledge construction in biology, the Colorado learning attitude about science survey questionnaire (CLASS-Bio) was used. The researcher translated the questionnaire into Amharic and had it reviewed by one language expert from a university and one biology and one Amharic lecturer in the college, who commented on the idea translated, the clarity of each item, and its suitability for determining students' beliefs concerning the study of biology and the creation of biological knowledge. Items that were not approved by the reviewers were reworded. Following the second evaluation, the reviewers agreed with the researcher regarding the appropriateness and clarity of each item.

Students' views about biology and biology learning were examined using the CLASS-Bio, which was created by Semsar et al. (2011). The creators of CLASS-Bio state that there are differences between experts and novices' perspectives on the following topics: 1) the content and organization of information; 2) the source of knowledge; and 3) approaches to problem-solving in biology. Additionally, this tool can be used to assess the effects of educational reform on students’ development of scientific thinking experties (Semsar et al., 2011). Therefore, to measure a context-based learning approach's impact on epistemological shifts from novice to expert, CLASS-Bio is an appropriate instrument. Seven categories are included in this instrument, including conceptual connection and memorization (experts believe that knowledge is organized around a coherent framework of concepts, whereas novices believe that knowledge consists of isolated facts that are not related), enjoyment (which asks whether a student finds the topic's problems enjoyable or personally interesting), problem solving reasoning, problem solving effort, problem solving strategy, and problem solving synthesis and application. Experts use concept-based approaches to problem-solving that are broadly relevant to a variety of problem-solving contexts, whereas novices frequently use pattern-matching to solve problems they have memorized and concentrate on surface features rather than underlying concepts. Real-World Connection is the seventh category. Experts feel that knowledge about the world is established through experiments that accurately describe nature, whereas novices think that knowledge is passed down by authority and lacks a connection to the real world.

Scientific Reasoning skill Test (SRST)

Measuring scientific reasoning alone is difficult and complex since it needs other types of knowledge. According to Adey and Csapo (2012), "when we are assessing science reasoning, we are by definition not assessing science knowledge, even science conceptual knowledge," they clarify what should be taken into account when measuring scientific reasoning. The challenge then shifts to finding the best way to assess a student's capacity for scientific reasoning while placing the fewest demands on their subject-matter knowledge. We are unsure of whether a student's failure on a question that mixes knowledge and reasoning stems from a lack of knowledge or poor reasoning skills (Adey & Csapo, 2012). In order to accommodate this problem two tier multiple choice were used to collect data about scientific reasoning (Tsui & Treagust, 2010). The observation and semi-structured interview data supports the data from this two tier multiple choice tests to solve the weakness of those tests.

The use of a two-tier diagnostic tool and a bigger sample of students from various school levels, nations, and areas are advised for future research on students' reasoning in the area of genetics (Tsui & Treagust, 2010). The two-tier instrument can be modified, tailored to local circumstances, and expanded in content to incorporate genetics reasoning to help students form concepts suitable for the biotechnology era. The instrument assesses the level of scientific reasoning, including process and propositional reasoning (Tsui & Treagust, 2010). The two tier test was created by the researcher to assess students' abilities to apply scientific reasoning to the principles of heredity. It consisted of ten items. Two of the items (items 1 and 3) that focus on curly hair and albinism were adopted from Tsui and Treagust (2010) two-tier scientific reasoning diagnostic instrument. According to Treagust (1988), the remaining eight items were developed by the researcher by following all of the steps used to develop two-tier multiple choice development. Those two-tiered multiple-choice questions focused on cause and effect, effect and cause, and the processes of phenomena like meiosis and mitosis, as discussed in detail in the literature review section.

Semi-Structured Interviews

Semi-structured interviews were conducted with students to gauge their comprehension of heredity principles and the value of the intervention in addition to the biology conceptual understanding test, scientific reasoning skill test, and epistemological belief questionnaire in order to increase the credibility and validity of the study’s findings. Therefore, 5 pupils from each group (a total of 15 pupils) were chosen for this purpose based on their results on the genetics conceptual knowledge test. There were ten interview questions covering each of the heredity unit's subtopics and ten EBQ statements highlighting each of the seven components. Each student had a 15 to 25 minute interview with researchers, which was audio recorded and typed up.

Focus group interview

For the purpose of gathering qualitative information from students about their perspectives and opinions on the intervention, semi-structured focus group interviews were conducted. Focus group interviews are well-organized talks designed to gather opinions on a particular topic of interest in a friendly environment free from any threat (Kazeni, 2012). Focus groups are thought to induce cooperative reasoning, which could improve the caliber of learners' responses and recall forgotten information (Maree, 2007 as in Kazeni, 2012). They are also known to offer a variety of responses, which could enhance the study's findings. Thirty students, 20 from the experimental group and 10 from the comparison group, made themselves available to take part in the focus group interviews. Seven groups were formed, each with at least four or five kids. Students were assigned to focus groups based on how well they performed on three tests that were given as a post-test.

Focus group interviews also eliminate one-on-one information gathering, which some learners may find daunting, and are likely to yield a wealth of information in a short amount of time. The groupthink phenomenon, in which individual viewpoints are difficult to distinguish, may have been focus group interviews' drawback in the context of this study (Kazeni, 2012). However, as the researcher was interested in the groups' collective viewpoints, this flaw had minimal bearing on the study's findings.

Classroom Observations

Additionally, observations in the classroom were made to assess how well the intervention was being implemented and how well it was being used to teach students about the learning process. For this reason, one classroom observation per week for a total of four weeks was conducted. Manual data collection was used, and the intervention was videotaped for later analysis. A researcher-prepared observation check list was used to assess how well the intervention was being implemented. A three-point Likert scale (yes/partially/no) was used to build three observation checklists, one for each intervention. These checklists were mostly based on the salient features of the instructional strategies. The use of the checklist allowed for both the verification of the treatment and the assessment of the treatment group teachers' adherence to the context-based instruction principles. Additionally, the checklist helped the researcher make a general assessment of the many facets of the educational approaches that were employed.

Investigating students' biology learning, particularly in terms of conceptual comprehension and how they explain the given occurrence, was one of the goals of this study. It is insufficient to evaluate students' conceptual knowledge, scientific cognition, and epistemological views solely using a quantitative approach because they can receive a random score. Therefore, it is useful to employ the qualitative technique in addition to testing students' conceptual comprehension and scientific reasoning using the quantitative method in order to uncover specific information about the students detail understanding. For this study to have strong evidence, the results derived from the qualitative data were utilized to support or contradict the conclusions derived from the quantitative data. To have solid support for a conclusion through triangulation, qualitative data from semi-structured interviews and observation had to be used to supplement the quantitative data from the two-tier multiple-choice exams. Additionally, through classroom observation and interviews, qualitative data regarding the actual classroom practice and students' perspectives of the intervention were gathered.

3.7. Validity and Reliability of the Instruments

Validity of instruments

Validity is the extent to which an instrument measured what it was intended to measure (Ary et al., 2010). Face validity and content validity are the two most prevalent forms of validity. How accurately a measurement tool captures the subject under study is referred to as content validity. The instrument must demonstrate that it fairly and completely covers the region or objects that it purports to cover in order to have this form of validity (Cohen et al., 2017). Exam papers are often verified by subject experts. As a result, the validity of the GCUT and SRST instruments is anticipated to be improved by the first-tier tests derived from previous exam questions. Three high school biology teachers and two biology lecturers from a college were asked to review the questions in order to assess the content validity of the GCUT and SRST instruments. They were asked to identify the learning objectives assessed by each question in order to ensure that the learning objectives and concepts in the syllabus and text book are consistent. Additionally, the lecturers were tasked with checking the questions for clarity, factual inaccuracies, grammatical problems, and errors in the answer key. The questions were reevaluated in light of the reviewers' suggestions and remarks.

After completing all of this, a pilot study was conducted to assess the instruments' reliability and perform item analysis. The process of item analysis, reliability checking, and pilot testing are covered in the section that follows.

Pilot Study

A pilot research included 100 students in Grade 11 (36 boys and 64 girls), since they covered the contents in their Grade 10 learning. They were from a high school in Debre Birhan and were selected randomly. The pilot study’s’ goal, their part in it, the measures' anonymity and confidentiality, as well as the findings, were all explained to the students. The most recent iterations of data harvesting tools such as the genetics conceptual understanding test (GCUT), epistemological belief questionnaire (EBQ), and scientific reasoning skill test (SRST) were pilot tested. Before conducting the main study, the pilot study was conducted to gather data for further evaluation and instrument enhancement, assess the reliability, difficulty index, and discrimination power of the instruments, and look for logistical issues and mistakes.

The first item analysis for the biology conceptual understanding test and the scientific reasoning skill test, including the difficulty index and discrimination index, was carried out using the findings from the pilot test. Secondly, the Cronbach's coefficient alpha for scales (EBQ) was used to measure the internal consistency reliability of the instruments. In the pilot study, 100 students in the 11th grade were given the CLASS-Bio questionnaire, which consists of 31 statements, to further review and assess the instrument's reliability. Items that were not attempted by students or for which a sizable percentage of students selected the "undecided" option were modified as a result of further review of the items since it was thought that these things might have been confusing to the students. A 31-item EBQ questionnaire based on a five-point Likert scale was created as a result of this exercise. Strongly Disagree (SD), Disagree (D), Undecided (U), Agree (A), and Strongly Agree (SA) were the available responses for each issue. Students had to select the option that best reflected their ideas by making it with a (√).

Scoring methods of two-tier multiple choice (TTMC) items

In science education nowadays, two-tier multiple choice (TTMC) items are frequently employed in assessment tools as a reliable way to gauge students' advanced knowledge, including their capacity for scientific reasoning (Bao et al., 2018). Accordingly, a variety of scoring and analysis techniques for TTMC items are frequently employed in the literature. The two-tiered items are frequently given numerical scores by researchers, which are then combined to form population measures for sophisticated psychometric analysis. The two most common techniques for assigning numerical scores to TTMC objects are pair scoring and individual scoring.

Pair scoring treats each item pair as a single item in a dichotomous mode, awarding one point for properly answering each item and zero points for incorrect answers. The second well-liked method makes use of individual scoring, which treats each question in an item pair as a separate item and determines the scores for each tier on its own (Bao et al., 2018). The two scoring methodologies have advantages and disadvantages, as those writers pointed out. Individual scoring gives out intermediate levels but is identical to or encourages guessing, which produces "false positives." Pair scoring lessens the impact of guesswork or the suppression of "false positives," but it also obscures any potential intermediate stage progress. In order to provide a better assessment for both the accuracy and the depth of student thinking, it would be necessary to thoroughly study the potential scoring methodologies. This is because the two tiers of an item pair are related as well as distinct from one another (Bao et al., 2018).

As a result, the newly developed partial scoring method by Han (2013) and Bao et al. (2018) was used in this study for the conceptual understanding test. This newly developed scoring method distinguishes between knowing the result and explaining why the information measured with TTMC items can be fully utilized. According to the evidence, having declarative information by itself is insufficient to result in effective hypothesis-testing performance (Kind & Osborne, 2016). This idea suggests that explaining is harder than knowing, so students may know the content without knowing any explanation or reason. The partial scoring method acknowledges content knowledge, which is the first step for conceptual understanding since students cannot understand without knowing factual knowledge (Mills, 2016).

In the partial model of scoring, a student received a score of 2 marks if he or she responded correctly the first tier (content choice) and correctly to the second tier (reasoning part), signifying full conceptual understanding of concepts. In addition, correct answers to the content part and the wrong reason attracted a score of 1 mark, signifying partial understanding, while the wrong answer and the correct reason or the wrong answer and the wrong reason earned 0 marks, signifying no conceptual understanding or lack of knowledge. This is due to the fact that students whose answers to the first tier are inaccurate but their explanations are correct should not exist on the development path, and this pattern can be attributed to guessing, since it is expected that students' abilities progress from knowing to explaining. Numerous researches have been done to determine whether students move from knowing to explaining or from explaining to knowing. They have found that explaining is more difficult than knowing, therefore in certain cases; students may understand the solution before they understand how to explain it. For instance, Bao et al. (2018)

discovered that, when the findings are known, the second-tier explanation items are much harder than the first-tier questions.

Scoring for scientific reasoning skill test

Two-tiered questions were scored according to whether a student selected the first tier (subject knowledge) and the second tier (reason for the first tier) correctly. The likelihood of getting the right answer by guessing was extremely slim with this rigorous grading system (Tsui & Treagust, 2010; Treagust, 1988). The two-tier test's traditional scoring system only recognizes two levels of performance: either the answer and rationale are accurate, or no credit is awarded. This method of grading is criticized by Han (2013) because, in his opinion, it does not adequately reflect the potential levels of student knowledge. From his perspective, content knowledge must be given credit; hence it is the first level of understanding. But in this study, the researcher wants to measure the reasoning levels of students using pair scoring. When using a pair-scoring system, students' answers are given a score of 1 if they are correct for both the question and the appropriate related justification. Students who miss one of the answers for both the first and second-tier questions score 0. The likelihood of getting the right answer by guessing was extremely slim while using this strict grading system.

Scoring for Epistemological belief questionnaire

In this study, responses to the assertions were divided into seven categories and used to evaluate data from pre- and post-CLASS-Bio surveys. If students selected "strongly disagree" or "disagree" on the Likert scale, the statements scoring was collapsed and classified as disagree; "neutral" if they selected "neutral"; and "agree" if they selected "agree" or "strongly agree." Responses that concurred with expert responses were labeled "favorable," whereas responses that disagreed with expert responses were labeled "unfavorable" (Semsar et al., 2011). The percentage of all student replies that corresponded with expert responses on the identical survey statements is reflected in the CLASS-Bio scores. A student scored a 1 if they agreed or strongly agreed with the expert. A score of -1 was given if the student disagreed or strongly disagreed with the expert. When a student checked "neutral," they received a score of 0. The CLASS-Bio ratings represent the proportion of all student responses that coincided with expert responses on the same survey statements. Non-expert-like and unclear responses were both regarded as erroneous when calculating individual student scores in SPSS (i.e., the percentage of attitude survey questions responded to in an expert-like manner) (Jeffery et al., 2016).

Item Analysis

Examining test items to determine their appropriateness in terms of difficulty (P) and discrimination (D) is known as item analysis. This involves assessing the items' level of difficulty and how well the test distinguishes between students who scored well and poorly on previous exams. The test results were analyzed using the item difficulty and discrimination index of the items. Item analysis is a crucial but relatively easy process used after the test to provide details on the validity and reliability of a test item. We can determine how easy or tough the questions were using the Difficulty Index (DIFI), which measures the proportion of right responses to the total response (Mehta & Mokhasi, 2014). The value (p-value) of the item difficulty index, which reflects how challenging the item is, runs from 0.0 to 1.0; the higher the scores, the simpler the items; the lower the scores, the more challenging the items (Mehta & Mokhasi, 2014). In other words, the more students who chose the right answer, the higher the score, and the lower the score, the fewer students who chose the right answer. It is computed by adding the items that were correctly answered and dividing the result by the percentage of students who scored in the top 27% and bottom 27% of the class.

Determination of Item Difficulty and Discrimination Index

The formula outputs the item's *difficulty index (p)* P = R/T x 100 or P= R/T

Where *P* = difficulty level or difficulty index

R = the number of testees who got the item right in both the upper and lower groups

T = the total number of testees in the upper and lower groups

The percentage of all students in the two groups that properly answered the question makes up the difficulty index. Items with a p value between 30 and 70% are often regarded as acceptable. Ideal items have a p value of between 50 and 60%. According to Mehta and Mokhasi (2014), items with a p value of less than 30% (too challenging) and more than 70% (too easy) should be changed since they are unacceptable. Based on their difficulty index, the items' acceptability is displayed in the following table.

Table 8 Difficulty index and interpretation

P value	**Interpretation**
>0.7	Too easy - Need modification
0.3-0.7	Average
<0.3	Too difficult– Need modification

Students who are performing well are distinguished from those who are performing poorly using the discrimination index (DI). It displays the difference between the proportion of high achievers who correctly answered the question and the proportion of low achievers who correctly answered the question. The total number of students who received the right answers in the top 27% and the bottom 27% of the class were then tallied. The test item's ability to distinguish between students with higher test scores and those with lower test scores improves with increasing DI. The point-biserial correlation, or DI, has a value between -1 and +1. It is +1 when more students in the top group (high achievers) properly respond to the question, and -1 when more students in the lower group do so. The "d" value is generally regarded as favorable between 0.20 and 0.35. Items with a DI above 0.35 are regarded as outstanding, and those with a DI below 0.20 are regarded as poor. The following formula is used to determine an item's discriminating power:

Item Discrimination index (DI)=Ru-RL/1/2T

Where Ru=Upper 27%of the score

RL= Lower 27% of the score

T= Total number of testee in upper and lower groups

Table 9 Discriminating Index and interpretation

d	**Quality**	**Recommendation**
>0.39	Excellent	Retain
0.30-0.39	Good	Possibilities for improvement
0.20-0.29	Mediocre	Need to check/review
0.00-0.20	Poor	Discard or review in depth
<0.01	Worst	Definitely discard

Following the description given above, the following analysis was done on the item difficulty and discrimination of the items in the current study: The conceptual understanding exam (GCUT) and scientific reasoning skill test (SRST) both have a mean difficulty level of 0.25, indicating that the items are too challenging for pupils to understand. The GCUT and SRST have items with a difficulty ranging from 0.08 to 0.39. The majority of the 30 items fell within an acceptable range of difficulty; some of them were updated, but five of them (items 26, 27, 28, 29, and 30) were deleted since they appeared to students to be extremely tough and had low discrimination index. The difficulty level of Question number 26 is rated as 0.08, Question 27 is 0.10, Question 28 is 0.16, Question 29 is 0.12, and Question 30 is 0.20.

The mean discrimination index for the genetics conceptual knowledge test was .30, showing that it was an effective test for pupils. The GCUT and SRST's discrimination indices range from 0.03 to 0.48. Out of 30 items, 22 of them distinguished between high achievers and low achievers pretty well, while 8 of them seemed to perform poorly since they had a low discrimination index, or 0.2. Three of the items (9, 12, and 22) were reviewed, and five of them (26, 27, 28, 29, and 30) were dropped. The scientific reasoning skill items are questions numbers 3, 6, 8, 9, 10, 13, 16, 19, 22, and 25. The other questions ask about conceptual understanding.

Table 10 Discrimination index of items

Test item type	*Discrimination index (d)*	*No of items*
GCUT and SRST	> 0.39	GCUT =1, 7, 12, 14, 20, 21, 23
	0.30-0.39	SRST= 3, 25
	0.20-0.29	GCUT and SRST = 4, 6, 8, 9, 11, 15, 18, 24
	0.00-0.20	GCUT and SRST = 2, 5, 10, 13, 16, 17, 19, 22, 26, 27, 28, 29, 30

As a result, all treatment and comparison groups received the final GCUT and SRST, which had 25 items (ten for SRST and fifteen for GCUT), as a pre-test and post-test. Similar to this, the epistemological belief questionnaire were used as a pretest and a posttest following intervention after passing all of these steps and receiving the appropriate changes.

Reliability of Instruments

The degree to which various items, measurements, or evaluations are consistent with one another and the degree to which each measure is free of measurement error are both indicators of reliability, according to Morgan et al. (2005). According to Ary et al. (2010), reliability describes how consistently a test measures whatever it does. According to Kimberlin and Winterstein (2008), reliability estimates are used to assess (1) the consistency of measures administered to the same people at different times or using the same standard (test-retest reliability), (2) the equivalence of sets of items or instruments from the same test (internal consistency), or (3) the reliability of different observers scoring a behavior or event using the same instrument (inter-rater reliability). Coefficient alpha is one of the methods frequently used to determine internal consistency reliability (Ary et al., 2010). In order to assess the reliability of the instruments after pilot testing, the researcher for this study employed the Cronbach's alpha coefficient for both scales (EBQ) and conceptual understanding tests.

The maximum score for the conceptual understanding test was 30, and the lowest score was 0. This is because the correct answers for both tiers (first and second tier) were coded as 2, the correct answers for the first tier were coded as 1, and the incorrect answers in both tiers were coded as 0. Students received a score of 1 for correctly answering questions on both tiers of the SRST and a score of 0 for all other responses. The scientific reasoning competence exam has a maximum score of 10 and a minimum score of 0. Calculating internal consistency measures for the GCUT and SRST tests using coefficient alpha and KR-20, respectively, allowed researchers to examine the reliability of the tests. The reliability coefficient for the GCUT was found to be .691. Cronbach's alpha coefficient for a scale should ideally be higher than.7.

However, the Cronbach alpha values are very sensitive to the scale's item count. For small scales, such as those with fewer than ten items, Cronbach's alpha values of less than.5 are typical (Pallant, 2005). As a result, there were only three scales used in this investigation, which may account for the low reliability (.691). The KR-20's SRST value of .701 showed that it was trustworthy.

To obtain Cronbach's coefficient alpha, the reliability coefficient of the Epistemological Belief Questionnaire (EBQ) was computed using the SPSS program. It turned out to be .878. All instrument values fall within allowable ranges. The test items were therefore regarded as a valid and reliable instrument to be used in the current study. The values for GCUT, SRST, and EBQ's Cronbach's coefficient alpha are shown in the table below.

Table 11 Cronbach’s coefficient alpha value of each instrument

Instrument type	No of items	Cronbach alpha	Kr 20
GCUT	15	.691	
EBQ	31	.878	
SRST	10		.701

The level of categorical reliability for each category was low because there were just a few items in each category (range from 4 to 8).

EBQ constructs	**CC**	**Enjoy**	**PSR**	**PSE**	**PSS**	**PSSA**	**RWC**
Cronbach’s Alpha	.525	.749	.547	.607	.630	.538	.595

Table 12 Cronbach’s coefficient alpha value of each category of EBQ

3.8 Method of data analysis

The raw data gathered from data sources was analyzed using descriptive and inferential statistics as described in the following sections to ascertain the effects of context-based instruction with conventional methods of instruction on students’ conceptual understanding, epistemological belief, and scientific reasoning ability.

Analysis of quantitative data

Data gathered from these many sources were statistically and qualitatively examined using the proper statistical data analysis techniques. Software from the Statistical Package for Social Sciences (SPSS) version 20 was used to analyze the data. The pre- and post-test quantitative findings were recorded, and codes were issued to each participant in the study. At first, mean scores and standard deviations were produced for the results of all performance tests as descriptive statistics. For use with parametric statistical studies, the assumptions of normality, homogeneity of variance (Levene's test at 5% level of significance), and independence of observations were examined and found to be true (Morgan et al., 2005). Parametric tests including ANOVA, paired sample t-test, MANOVA, and Pearson correlation were utilized because the results fully supported the assumptions. Additionally, the findings from the tests of conceptual comprehension and scientific reasoning ability were grouped, examined, and contrasted among the three groups.

To compare the proficiency of the experimental and comparison groups on all of the learning outcomes—the genetics conceptual comprehension test, the scientific reasoning skill test, and the epistemological belief questionnaire—an ANOVA of the pre-test mean scores was computed. To determine the significance of any differences, if any, between the groups' prior abilities, the ANOVA testing was required. At a p-value of 0.05 or less, the non-significant ANOVA findings obtained show that the groups were similar in terms of their learning outcomes competency prior to the intervention. For examining significant correlations between two or more study variables, Pearson's r was utilized.

Using SPSS 20, a paired t test was conducted to compare overall Pre and Post percent positive scores and shifts in beliefs in order to examine overall changes in epistemological views. Effect sizes were also calculated in order to determine the extent of the difference (Cohen's d). When computing individual student scores in SPSS (i.e., the percentage of attitudinal survey questions responded in an expert-like way), both non-expert-like and uncertain responses were considered incorrect (Jeffery et al., 2016). The researcher utilized distinct paired t tests to examine variations between Pre and Post scores for the seven categories because the seven categories are interdependent and there is some overlap between the statements. Hansen and Birol (2014) discovered a similar outcome: there was a significant overall difference between Pre and Post scores, but no difference in categories.

Positive shifts in percent favorable replies over time suggest an increase in expert-like thinking, while negative shifts in percent favorable responses indicate a decline in expert-like thinking. All of the statements in a category were tallied up, divided by the total number of statements, and then multiplied by 100 to determine the percentage agreement with experts. A score of 100 for an individual or a class average would signify complete agreement with professional opinion. The results of the three student groups were compared using one way ANOVA to see if there was any difference between them in the seven categories between the pre- and post-test results.

Analysis of qualitative data

The basis for analyzing the qualitative data is the information gathered from classroom observation and interviews. Written texts were created from the audio recordings of the students' interviews after they had been coded. The themes were also allocated to the coded and transcribed writings. The overall ideas and opinions of the participants were ascertained by carefully examining each interview theme, which included numerous recorded texts. In order to confirm information and clarify quantitative data, the interviewee's general perspectives were collected, compared, and evaluated in connection to the quantitative data. Additionally, to make an overall assessment of the many aspects of instruction, the relationship between instructor and student engagement, and the classroom environment, the data gathered from the classroom observation was assessed based on a set of criteria. The discussion of the study's findings will be based on these overarching perspectives and comparisons.

3.9 Ethical Issue

Any study involving people ought to have an ethical basis. In order to accomplish this, the researcher, who was in possession of an official letter from the department of science and Mathematics Education, asked the director or principals of each participating school for permission to conduct the study there by outlining its purpose. The researcher acquired formal approval from the participating teachers and pupils after receiving authorization from those authorities. Their data will be kept private, secret, and anonymous, according to the form.

The study's aims, goals, student and teacher roles, and potential negative effects on participants were all fully communicated to participating students and teachers prior to the study's start. The anonymity and degree of secrecy of the study results were guaranteed to the participating schools, teachers, and students. Instead of asking students to write their names, they were given codes to use as identifying numbers. Teachers who participated in the classroom observation were made aware that the purpose of the study was not to examine their level of knowledge, but rather to offer proof that the intervention had been implemented as intended. The necessity of using a video recorder was discussed, and participants were made aware that, if necessary, only their consent and that of the appropriate authorities would be obtained before using their photographs in the dissertation or its results. Additionally, participants were made aware of their right to object to being recorded on camera.

As far as the researcher is aware, there are no false statements in the thesis, and all of the conclusions are accurate representations of the data used to arrive at them. The University, which is the custodian of all research done within its purview, will receive a copy of the thesis as needed. To ensure confidentiality and anonymity during the thesis writing and study dissemination, codes were used in any references to the participants or participating schools. Only the advisers had access to the material, and personally identifying data was kept secure. The thesis did not contain any images of the participants or the affiliated institutions.

CHAPTER FOUR: RESULT AND DISCUSSION

Introduction

The study's findings and discussions are presented in this chapter. This study sought to determine how students' conceptions of biological knowledge and biology education, as well as their conceptual grasp and scientific reasoning on themes related to heredity, were affected by the context-based approach. Therefore, in light of pertinent literature, the chapter first gives the results of the quantitative and qualitative data analysis. It then goes on to analyze the results pertaining to students' conceptual understanding of genetics, their epistemological beliefs, and their scientific reasoning across groups.

4. 1 Results

This section contains a report on the data analysis results. While the numerical data were statistically examined using SPSS version 20 software, narrative analysis was used for qualitative data. Frequency, mean, and standard deviation were determined as descriptive statistics. Assumptions for particular statistical analysis approaches were examined before implementing statistical techniques. The results of pretest and posttest scores analysis of the Genetics Conceptual Understanding Test (GCUT), Scientific Reasoning Skill Test (SRST), and Epistemological Belief Questionnaire (EBQ) using descriptive statistics, paired sample t-tests, one-way analysis of variance (ANOVA), and multivariate analysis of variance (MANOVA) were presented, described, and interpreted as shown below in the following section.

4.1.1 Results of Pretest Scores Analysis

There were three groups in this study: treatment group 1 (TG1), treatment group 2 (TG2), and comparison group (CG). Before the implementation of the intervention, an epistemological belief questionnaire, GCUT, and SRST were given to each group as a pretest to determine their status of belief about biological knowledge and biology learning. Pretests were given to students in two treatment groups and a comparison group to see if they differed from one another in terms of their knowledge and comprehension of genetics topics prior to the intervention. The three aforementioned factors were therefore compared using an ANOVA to see if there was a significant mean difference. Prior to analyzing the pretest results, the normality, independency of scores and homogeneity of variance assumptions made by the ANOVA were verified. As indicated in table 15, the assumptions were not violated.

Evaluation of assumptions for pre test scores

One assumption for this analysis method is the normal distribution of scores. Different researchers specified the skewness and kurtosis values for normally distributed scores. A simpler rule of thumb is that skewness less than plus or minus two (+/-2) indicates that the variable is at least roughly normally distributed (Best & Kahn, 2006; Leech et al., 2005). The skewness and kurtosis of the pretest data are shown in the accompanying table (Table 13), and they were both within acceptable bounds in both instances. This indicates that the information was about regularly distributed.

The Levene test was used to examine the other ANOVA premise, the homogeneity of variance; however it was not significant for all dependent variables (the pre-genetics conceptual understanding test (pre-GCUT), the pre-scientific reasoning skill test (pre-SRST), and the pre-epistemological beliefs questionnaire (pre-EBQ). This indicates that for the population of the groups, the variances of the scores on each variable are almost comparable. As a result, neither the tests nor the questionnaire violated the ANOVA assumptions. The outcome is displayed in the table below (Table 13).

Table 13 Skewness, kurtosis and Levene test of homogeneity of variances of pre- EBQ, pre-GCUT and pre-SRST

Dependant variables	N	Skewness	Kurtosis	Levene Test of homogeneity of Variance	
				F	*P*
Pre-EBQ	131	-.412	-.600	.826	.492
Pre-GCUT	131	-.036	-.454	.98	.42
Pre-SRST	131	-.351	-.176	.322	.725

After checking the assumptions, a one-way ANOVA was computed. The descriptive statistics result in the table below (Table 14) showed that the overall mean scores of pre-EBQ questionnaire for TG 1 (M = 58.29) and comparison group scores (M = 59.62) were almost similar, but TG 2 (M = 55.51) was smaller than the two groups. The mean of TG 1 (M = 5.21) was higher in pre-GCUT than the means of TG 2 (M = 4.81) and CG (M = 4.48). Similarly, students' scores in pre-SRST TG 2 (M = 4.95) were slightly lower than those in the other two groups, TG1 (M = 5.11) and CG (5.54). Table 14 provides an overview of the descriptive data for the groups' Pre-EBQ, GCUT, and SRST test results.

Table 14.The descriptive statistics of pre-EBQ, pre-GCU and pre-SRST scores of the group

	GROUPS								
Variables	**Treatment group 1**			**Treatment group 2**			**Comparison group**		
	N	**M**	**SD**	**N**	**M**	**SD**	**N**	**M**	**SD**
Overall	38	58.29	.17	43	55.51	.16	50	59.62	.14
C Connection		42.76	.19		47.97	.21		43.5	.20
Enjoyment		66.32	.29		72.25	.30		70.47	.20
PS Reasoning		73.16	.27		65.12	.31		68.2	.25
PS Effort		61.29	.27		65.05	.26		66.2	.20
PS Strategy		65.92	.30		65.35	.32		65.4	.25
PSS Application		43.99	.28		47.28	.20		44.86	.21
RW Connection		66.17	.23		55.31	.22		64.94	.23
PRE-GCUT		5.21	2.12		4.81	2.5		4.48	2.55
PRE-SRST		5.11	2.24		4.95	2.18		5.54	2.51

Between the groups, there was no statistically significant mean difference in the pre GCUT F (2, 128) =.988, p =.375, and pre-EBQ tests F (2, 128) =.826, p =.440, according to the results of the ANOVA analysis (Table 15). This indicates that prior to the intervention's execution, it was thought that the groups had a similar conceptual understanding and set of epistemic beliefs. Similarly, prior to the intervention, there was no discernible difference between the groups in terms of their between the groups in terms of their capacity for scientific reasoning F (2, 128) =.80, p =.452. As a result, the difference seen after the intervention could not be attributable to variations between treatment groups prior to its implementation. The table below displays the ANOVA result.

Table 15 ANOVA result comparing groups in terms of pre-GCU, pre-EBQ and pre SRST scores

		Sum of squares	df	Mean Square	F	Sig.
Overall Pre-EBQ	Between Groups	.04	2	.02	.83	.44
	Within Groups	3.09	128	.02		
	Total	3.13	130			
Pre-GCUT	Between Groups	11.53	2	5.77	.99	.38
	Within Groups	747.31	128	5.84		
	Total	758.84	130			
Pre-SRST	Between Groups	8.67	2	4.34	.80	.45
	Within Groups	693.91	128	5.42		
	Total	702.58	130			

Result of one way ANOVA Pre-EBQ F (2, 128) =.826, p =.440, showed no statistically significant mean difference between the groups (Table 16). In conclusion, there were no groups that differed statistically significantly in epistemological belief before the intervention in overall and all seven categories. So, the groups were assumed to be the same with their beliefs about biological knowledge and biology learning. The pre-EBQ results from the overall and seven category ANOVA results are shown below.

Table 16 ANOVA result comparing groups in terms of pre-EBQ scores

		Sum of squares	**df**	**Mean square**	**F**	**Sig.**
Pre-over all	Between Groups	.040	2	.020	.826	.440
	Within Groups	3.086	128	.024		
	Total	3.126	130			
CC pre	Between Groups	.067	2	.034	.826	.440
	Within Groups	5.213	128	.041		
	Total	5.280	130			
Enj-pre	Between Groups	.810	2	.405	5.851	.412
	Within Groups	8.861	128	.069		
	Total	9.671	130			
PSR pre	Between Groups	.149	2	.074	.965	.384
	Within Groups	9.868	128	.077		
	Total	10.017	130			
PSE pre	Between Groups	.210	2	.105	1.821	.166
	Within Groups	7.378	128	.058		
	Total	7.587	130			
PSS pre	Between Groups	.497	2	.249	2.944	.156
	Within Groups	10.814	128	.084		
	Total	11.311	130			
PSSA pre	Between Groups	.041	2	.021	.391	.677
	Within Groups	6.711	128	.052		
	Total	6.752	130			
RWC pre	Between Groups	.015	2	.008	.152	.860
	Within Groups	6.485	128	.051		
	Total	6.500	130			

In relation to pre-SRST the following table shows the proportion of pupils who correctly answered each question at each level of scientific reasoning. The percentage of students in each groups was more or less similar at each level of reasoning, and the difficulty level of scientific reasoning was also observed by decreasing number of students as the level increased. For instance, at level I, the proportion of students in the treatment group 1, 2, and comparison group, respectively, was 28.95%, 23.26%, and 24%. At level V of scientific reasoning, this percent decreases to 9.87%, 9.88%, and 10.08%, respectively, for each group.

Table 17 Pre-scientific reasoning ability in relation to five levels vs. groups

Group	**N**	**Level 1**	**Level II**	**Level III**	**Level IV**	**Level V**
		Pre (%)	Pre(%)	Pre(%)	Pre(%)	Pre(%)
TG 1	38	28.95	21.05	26.32	10.53	9.87
TG 2	43	23.26	25.58	23.26	10.47	9.88
CG	50	24	18	22	19	10.5
Total	131	25.4	21.54	23.86	13.33	10.08

4.1.2 Post test score analysis

After checking equivalency of the groups, implementation of the intervention was stated. Following the completion of the intervention's implementation, data were gathered using the post-SRST, post-GCUT, and post-EBQ. The validity of the assumptions underlying statistical analysis methodologies was examined prior to statistical analysis of these data. The assumptions for statistical analysis methods are covered in the section that follows.

Evaluation of Assumptions for post test scores

There are various statistical assumptions that must be met for various statistical analysis approaches. The data measured through the post-GCUT, post-SRST, and post-EBQ in respect to groups was taken into consideration for the examination of the assumptions. In this study, the main statistics used were descriptive statistics, and after checking and fulfilling the assumptions, parametric inferential statistics like the dependent (paired) t-test, one-way ANOVA, and multivariate analysis of variance (MANOVA) were used because of the presence of two dependant variables provided that the assumptions are fulfilled. The sample size and independence of the observations, as well as normality, outliers, linearity, homogeneity of the variance-covariance matrices, multicollinearity, and singularity assumption, are among the MANOVA's presumptions. For post-test results, the assumptions underlying these statistics were examined. The results of each test for each premise for both ANOVA and MANOVA are shown in the section that follows.

Sample size and independence of observation

If researchers intend to perform any kind of statistical analysis on their data, many writers recommend using sample sizes of at least thirty. There are three main assumptions to use ANOVA as a statistical analysis. These are normal distribution, independency of observation and homogeneity of variance. Since the sample sizes in this study were identical (N = 38, N=43, and N = 50), all of the ANOVA's assumptions may not be necessary (Field, 2009). ANOVA is resilient to violations of homogeneity of variance and normality when sample sizes are comparable. According to Field violations of the assumption of independence are very serious indeed in ANOVA. In this study both classroom teacher and researcher found during post-test administration and each individual done their own to make the observation independent. So, the assumptions were not violated.

A sophisticated statistic called a multivariate analysis of variance (MANOVA) is comparable to an ANOVA, except it analyzes numerous dependent variables simultaneously. Low to moderate correlations and conceptual connections between the dependent variables are desirable. If they are excessively coupled, one runs the risk of multicollinearity. There is typically no benefit to analyzing them together if they are uncorrelated (Leech et al., 2005).

If groups are almost equal in size (N of the largest group is no more than approximately 1.5 times the N of the smallest group), MANOVA is resilient to violations of multivariate normality and to violations of homogeneity of variance/covariance matrices.

Normality

One can ascertain whether the data are regularly distributed by looking at the skewness and kurtosis numbers. If the skewness and kurtosis values are near zero, the data are expected to have a regularly distributed distribution. Researchers often consider one standard deviation from the mean to be a particularly important point on the normal curve. This is due to both mathematical and practical considerations. This leads to roughly 68% (slightly more than two-thirds) of the population falling between one standard deviation above and one standard deviation below the mean, which is the practical explanation. This is the point on the curve where the direction changes numerically. Ninety five percent of the population will be contained within a 1.96 standard deviation range from the mean. The curve, which is frequently adjusted to 2 standard deviations from the mean, hits another crucial point at this location (Best & Khan, 2006). They also stated that data derived from observations of samples do not exhibit the normal distribution. Since an observer cannot possibly have all of the observations that make up the normal distribution, there is usually some observed deviation from the symmetrical pattern. This demonstrated that a data set's skewness and kurtosis values should be between -2 and +2 in order for it to be normally or nearly normally distributed (Seltman, 2018). As may be seen in the table below (Table 19), the investigation's skewness and kurtosis values fell within acceptable ranges. The normality assumption was not sufficiently broken because the data were relatively regularly distributed to justify conducting a parametric test.

Homogeneity of Variance-Covariance Matrices

Another assumption is presence of equal variance among groups. The following table16 showed levene test results for both post GCUT and EBQ. Since there is no difference in group variances, the p value is bigger than .05. As a result, the presumption was upheld.

Table 18 post EBQ, post GCUT & post SRST Skewness, kurtosis & homogeneity of variance

Variables	**N**	**Skewness**	**Kurtosis**	**Levene statistic**	**df 1**	**df 2**	**sig**
Post-EBQ	131	-.306	-.651	.280	2	128	**.757**
Post-GCUT	131	1.205	1.646	2.177	2	128	.118
Post-SRST	131	.498	-.258	2.598	2	128	.078

To determine whether the covariances between the two dependent variables are the same for the three groups, the Box's test of equality of covariance matrices is used. The Box test is susceptible to deviations from normalcy and so may not be reliable. The Box test should not be used if the Ns for the various groups are roughly similar (Leech et al., 2005). There is no need to look at the Box test because the N=50 sample size is not more than 1.5 times that of the N=38 sample size. The homogeneity of the variance-covariance matrices was not violated, as shown by Box's M significant values of the post test p > 0.001 (Pallant, 2005) (Table 19). None of the multivariate tests would be valid if Box's test had been significant and group sizes had varied much, which was not the situation in this investigation. If group sizes were significantly different and the results of Box's test were significant, which they were not in this study, then none of the multivariate tests would be robust.

Table 19 Box’s Test of Equality of Covariance Matrices of post test

Box’s Test of Equality of Covariance Matrices

	Box’s M	F	df1	Df2	Sig.
Post test	16.352	2.663	6	304775.637	.014

To further analyze the homogeneity of variances between groups, Levene’s test was further looked into. For all variables with p > 0.05, as shown in Table 20, the homogeneity of variance assumption was not broken. The Levene test for the variables is displayed in the table below.

Table 20 Levene’s Test of Equality of Error Variances of post test

Levene’s Test of Equality of Error Variances

Variables	F	df1	df2	*p*
Post-GCUT	2.177	2	128	.118
Post-SRST	2.598	2	128	.078
Post-EBQ	.287	2	128	.751

Outliers

Another presumption was that the data should not contain any outliers in order to perform MANOVA. By studying Mahalanobis distances as described by (Pallant, 2005), outliers were verified. He provided the crucial value for various combinations of dependent variables, such as 13.82 for two dependent variables. Compare the highest value obtained from the output with the crucial value to see whether there are any outliers. There are multivariate outliers' in the data file if the output value exceeds the critical value. The two post tests (GCUT and SRST) were used in this study as the two dependent variables. In light of this, the Mahalanobis distance for the study's post test data was 1.783 (Table 21). This result is way too low compared to the critical value of 13.82 for two dependent variables. There was therefore no anomaly in the post-test data. Therefore, no outlier value needed to be eliminated from the data.

Therefore, the presumption of an outlier was not broken. The post-test results' Mahalanobis distance values are displayed in the table below.

Table 21 Mahalanobis distances for post test scores

Variables		**N**	**Min**	**Max**	**Mean**	**SD**
Post tests	Mahal. Distance	131	.013	1.783	.992	.723

Linearity

According to Pallant (2005), this presumption states that each pair of dependent variables has a straight-line relationship with one another. By creating scatter plots for each pair of the dependent variables for each group, the linearity assumption was tested. Two treatment groups and a comparator group were used in this investigation. Understanding and reasoning are two dependent variables that are assessed by a post test. In order to determine whether the assumption of linearity was met, scatter plots were created for each pair of the dependent variables. These plots did not contain any indication of non-linearity.

Multicollinearity and Singularity

Pallant (2005) asserts that moderately correlated dependent variables are ideal for MANOVA. You should think about performing separate univariate analyses of variance for multiple dependent variables when there are low correlations. Multicollinearity is the term for when the dependent variables are significantly correlated. Three dependent variables, Post-GCUT, Post-SRST, and Post-EBQ, had correlation calculations performed to test these hypotheses (Table 22). SRST and GCUT did not have a significant correlation ($r < .8$) rather moderately correlated (Pallant, 2005). Therefore, there were no violations of assumptions in conducting MANOVA for these two dependent variables. However, post-EBQ has a low correlation with both SRST($r=.052$) and GCUT ($r=.111$). As a result, there is no need for post-EBQ analysis using MANOVA; instead, univariate analysis is appropriate.

Table 22 Pearson's coefficient of correlation dependent variables post-GCUT, post-SRST, and post-EBQ

Correlations

	PostGCUT	PostSRST	PostEBQ
PostGCUT	1		
PostSRST	.433**	1	
PostEBQ	.111	.052	1

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

After checking assumptions for statistical analysis, MANOVA was conducted for post-GCUT and post-SRST since all assumptions were fulfilled. On the other hand, post-EBQ was analyzed using a one-way ANOVA. The findings of the post-test analysis were presented in the next section.

Results of post-SRST and post-GCUT analysis

The post-SRST, post-GCUT, and post-EBQ statistical findings in regard to groups are reported in the section that follows. The mean scores of TG 1, TG 2, and CG on the post-GCUT and post-SRST tests varied, as shown in the table below (Table 23). In the post-GCUT, TG 2 had a higher mean score (15.53) than the other groups. In line with this, TG 2's mean score (21.02) in the post-SRST is greater than that of the other groups. In two of the three factors, the mean score for the CG is comparatively lower than that of the others.

Table 23 Descriptive statistics for post GCUT, and post SRST scores among groups

Variable	**Groups**								
	Treatment group 1			**Treatment group 2**			**Comparison group**		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
Post-GCUT	38	14.53	3.029	43	15.53	4.322	50	13.12	2.939
Post-SRST	38	15.32	5.855	43	21.02	5.902	50	14.38	4.462

Descriptive statistics showed, as previously mentioned, that there was a mean score difference between groups with regard to the post-test scores of the GCUT and

SRST tests. Students from treatment group 1 scored between those from treatment group 2 and the comparison group. The mean scores of TG 1 (14.53), TG 2 (15.53), and CG (13.12) post-GCUT are different. The following table showed paired t-test analysis of GCUT and SRST and indicated a considerable improvement in both variables of post-test scores.

Table 24 Comparison of pre-post results of GCUT for each group through paired sample t-test

Group	Test	N	Mean	Std. Deviation	Mean difference	Std. deviation	t	df	Sig.(2-taild)
TG 1	Pre-test	38	5.21	2.12	9.32	3.71	15.47	37	.000
	Post-test		14.53	3.03					
TG 2	Pre-test	43	4.81	2.50	10.72	3.71	18.94	42	.000
	Post-test		15.53	4.32					
CG	Pre-test	50	4.48	2.55	8.64	3.08	19.82	49	.000
	Post-test		13.12	2.94					

The paired sample t-test was used to evaluate how each lesson affected the students' conceptual understanding of heredity (Table 24). The data indicates a substantial difference in favor of the post-test mean scores for both the treatment and comparison groups between the pre- and post-tests. Students in the treatment group 2 recorded a higher mean score of 10.72 mean differences between pre-test and post-test, compared to 8.64 mean differences for the comparison group, which was a very low mean score differences.

According to the table below, the mean SRST score for students in TG 1 was 15.32, that for TG 2 was 21.02, and that for students in CG was 14.38. The outcome revealed that the students in treatment group 2 did better on the tests than the students in the other two groups. Test results also showed that students in treatment group 1 outperform those in the comparison group. The paired sample t-test was used to evaluate how each lesson affected the students' ability to think scientifically between the pre- and post-tests (Table 25). The data indicates a significant difference in favor of the post-test mean scores for both the treatment and comparison groups. The comparison group students recorded a comparatively low mean difference score, 8.84, while the treatment group 2 students recorded a larger mean difference score (16.07) between pre- and post tests.

Table 25 Comparison of pre-post results of SRST for each group through paired sample t-test

Tests in group	**N**	**Mean**	**Std. Deviation**	**Mean difference**	**Std. Deviation**	**t**	**df**	**Sig.(2-tailed)**
Post-SRSTTG1 – Pre-SRSTTG1	38	15.32 5.11	5.86 2.24	10.21	5.88	10.71	37	.000
Post-SRSTTG2 – Pre-SRSTTG2	43	21.02 4.95	5.90 2.18	16.07	5.91	17.84	42	.000
Post-SRSTCG - Pre-SRSTCG	50	14.38 5.54	4.46 2.51	8.84	4.5	13.89	49	.000

To determine if there were statistically significant post-test mean score differences between the three groups for the SRST and GCUT, a MANOVA was used. The findings of the MANOVA showed that the post-test mean scores of the three groups differed statistically significantly; F (4, 254) = 9.994, p =.000; Wilks' lambda =.747; η2 =.136 (Table 26). The value of eta squared (η2) is significantly greater than the average value as determined by Cohen (1988). The intervention was linked to 13.6% of the multivariate variance of the post-test mean scores, according to the eta squared (η2) value. This indicates that the intervention was responsible for the group differences. The MANOVA result is displayed in the following table.

Table 26 MANOVA result - Multivariate test

	Wilks' Lambda	**F**	**Df**	**Error df**	***p***	**η2**
Treatment groups	.747	9.994^b	4.00	254.00	.00	.136

The between-subjects effects tests (Table 27) revealed a significant mean difference between the groups in the following measures: post GCUT (p =.004), Eta-Squared.08, post SRST (p =.00), and Eta-Squared.24. For the post-GCUT period, the eta squared (η2) values are.08 and.24, respectively, meaning that 8% and 24% of the dependent variables' multivariate variation was related to the intervention. Based on the Cohen (1988) distribution (.01 = small, .06 = moderate, .14 = big effect), the eta squared (η2) values are larger than the moderate average value for post GCUT and large or larger than normal for post SRST. This suggests that the intervention was responsible for the variation in the dependent variable between the groups.

Table 27 Tests of Between-Subjects Effects

Independent variables	**Dependent Variable**	**Type III Sum of Squares**	**df**	**F**	**p**	**η2**
Groups	Post-GCUT	137.083	2	5.670	.004	.081
	Post-SRST	1143.338	2	19.739	.000	.236

The findings of the tests of between-subject effects showed a statistically significant mean score difference between treatment groups in all dependent variables, however it was unclear which group differed from the other. Therefore, to ascertain which group differs from the others, post hoc multiple comparisons were performed. The size of this class can be calculated, and the Bonferroni correction can be used to assure a smaller type 1 error on multiple comparisons (Seltman, 2018, p. 327). In this situation, "compare all pairs and compare the mean of any two groups to any other single group," according to (Seltman, 2018). Consequently, the adjustment is calculated by dividing the predetermined alpha by the entire number of dependent variables in the study. This study's alpha value was 0.05.As a result, we get 0.025 as the adjusted alpha for the multiple comparisons when we divide 0.05 by 2 (dependent variables). Conceptual comprehension and scientific reasoning are the two dependent variables in this investigation.

There was a statistically significant mean difference in GCUT mean scores between TG 2 and CG, according to the post hoc multiple comparison results (p =.003). Students in TG 2 (M = 15.53) performed better than students in TG 1 and CG (M = 14.53 and 13.12, respectively), despite the fact that there was no statistically significant difference between TG 1 and TG 2. Similar to this, students in TG 2 (M = 21.02) outperformed TG 1 and CG much more than they did, with mean SRST scores of 15.32 and 14.38, respectively. There was a statistically significant mean difference in SRST mean scores between TG 2 and the other two groups (TG1 and CG), according to the post hoc multiple comparison results (p =.000). Students in TG 1 outperformed CG in both the SRST and the GCUT; however, the difference was not statistically significant. In comparison to the other techniques for improving conceptual comprehension and scientific reasoning, utilizing the combined strategy helped students score considerably better mean scores in both the post GCUT and post SRST tests, demonstrating its efficiency.

Table 28 Post-hoc multiple comparison test result

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p
Post-GCUT	TG 1	TG 2	-1.01	.774	.585
		CG	1.41	.748	.187
	TG 2	CG	2.41*	.723	.003
Post-SRST	TG 1	TG 2	-5.71*	1.198	.000
		CG	.94	1.158	1.000
	TG 2	CG	6.64*	1.119	.000

Results of the analysis of post-test scores in relation to SRST level

The following table shows the percentage of students that right responses to each question level of reasoning after intervention in the classrooms that used different instructions. By counting the number of students who answered the least and most difficult questions we can consider the percentage of students in each level of domains. Because of the differences in the level of reasoning the point of an individual can be added by multiplying each item scores' by its' level of difficulty. Therefore, the scores from different questions and levels can be scaled together after multiplication was made. Regardless of teaching, the first thing to assess is whether or not expected group differences are present. Comparing the proportion of students at each level of reasoning allowed for this.

Table 29 Post - Scientific reasoning ability Vs groups

Groups	**N**	**Ability of students in each Level of scientific reasoning**				
		Level I Count (%)	**Level II** Count (%)	**Level III** Count (%)	**Level IV** Count (%)	**Level V** Count (%)
TG 1	38	26(68.42)	28(73.68)	20(52.63)	10(26.31)	8(21.05)
TG 2	43	32(74.41)	34(79.07)	25(58.14)	15(34.88)	11(25.58)
CG	50	30(60)	29(58)	18(36)	7(14)	3(6)
Total	131	88(67.17)	91(69.46)	63(48.09)	32(24.42)	22(16.79)

Based on the percentage of students who correctly answered each level of scientific reasoning before and after intervention, the following table displays students' pre- and post-intervention abilities. When the level of scientific reasoning difficulty increases, fewer students answer the question, and students in all groups demonstrate improvement between pre- and post-examinations. This indicates that the majority of pupils have scientific reasoning skills at levels one and two. However, TG 2 students do better than TG 1 pupils. Students in TG 1 perform better than students in comparison group while increasing the level of scientific reasoning. For example, all group members of students perform well at the first and second level of reasoning TG 1= 68.42%, TG 2= 74.41% and CG=60%. But the number of students and percentages differ among group when the level increases to level V 21.05% of TG 1, 25.58% of TG 2 and 6% of CG students answered the process questions.

Table 30 Pre and Post - Scientific reasoning ability results Vs groups

Group	**Level I**		**Level II**		**Level III**		**Level IV**		**Level V**	
	Pre (%)	Post (%)	Pre (%)	Post (%)	Pre (%)	Post (%)	Pre (%)	Post (%)	Pre (%)	Post (%)
TG 1	15.79	68.42	23.68	73.68	10.53	52.63	5.26	26.31	2.63	21.05
TG 2	18.60	74.41	23.25	79.07	11.63	58.14	6.97	34.88	2.33	25.58
CG	16	60	22	58	12	36	6	14	4	6
Total	16.79	67.17	22.9	69.46	11.45	48.09	6.1	24.42	3.05	16.79

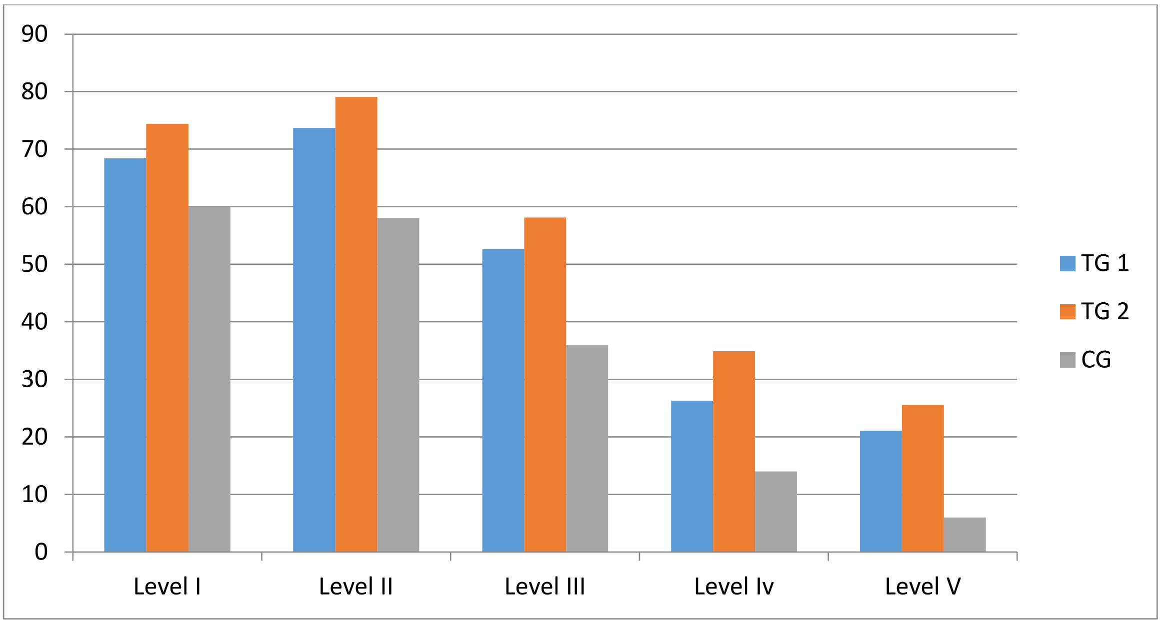

Figure 8 Percentage of students at different levels of reasoning across groups based on their post test results

As indicated in the figure above TG 2 who learned by combined method of teaching reason out well than their counterparts. Level II questions which asked to reason from cause to effects between generations answered by large number of students than the other questions. The least number of students answered questions which needs process reasoning between generations.

Qualitative results of SRS

During the interview session, one student told me about the assessment questions and gave suggestions for future assessments. He also criticizes exam items prepared by their teacher by relating them to national exam items. He said:

"Why you asked this type of question umm... I mean why you are asked our reason for our answer? This makes us confuse since it is new. We all experiences lower level questions which needs recalling of biological facts even much easier than national exam items. This is because if our teacher asked higher order questions, only few pupils pass the exam and I think the teacher assumed to be failed in his teaching.

There for, the teacher asked very easy questions to help all students. If your concern is improving reasoning abilities of students, I advise to start from grade seven in steady of grade ten to help students in developing reasoning skills".

At the beginning of the intervention, the researchers observed that many students in each class were passive in their participation, they were not confident when they reflected their ideas. Only group leaders react to the question raised by the teacher. In the case of TG 1, when the intervention process was going on, they showed a change gradually in their reaction in the classroom to do different activities. Many students were interested, actively participated, and interacted well with their peers to perform the practical activities and discuss the given problem when they were taught about heredity through context based REACT strategy. However, students also commented that:

"The method is good, but we faced a problem of relating the activity given and the expected learning concepts since the concepts are new to us."

In support of this idea, the researchers observed that call the names of students and objects instead of using the terms in heredity. For example, in cell division activities they did not use the terms centromere, chromatids, and the likes. Students have seen the activities as a game rather than relating the activity with expected concepts. This may increase their interest but may not improve conceptual understanding.

Students who were taught by context-based activities integrated with conventional instruction became confident when they performed different activities. And also, when they reflected on their ideas about the given activities, they used the appropriate terms in genetics instead of using the name of students and objects hence they were introduced at the beginning of the lesson. For example, students in TG 2 call all four nitrogen bases fully by saying Adenine, Cytosine, Guanine, and Thiamine while doing DNA replication activities instead of saying A, G, T, and C like that of students in TG 1.

Students who were taught by conventional instruction had less participation and interest; rather they were passive listeners and their interactions during the discussion were not good. As usual, group leaders speak, and other group members listen to what the leader said.

People's personal and social objectives influence their ontological conceptions of the universe (Lynch et al., 2019). In this study, the above idea was reflected and observed during the implementation of the lesson. The activity given was on sex determination concepts and the case, and the activities were:

The six children Henok and his wife Marta have are all male. Both of them aspire to have a daughter, but they find it puzzling because they constantly have sons. Marta speculates that perhaps it is her fault that she is able to have only sons. The couple decides to get a divorce and get married again. Do you believe Marta, Henok, or neither of them is in charge of deciding the sex of the kids? Explain.

Students in TG 1 discussed the above question, and one student said that sex is determined by God using the Amharic term '*yihe eko yegiziabiher sira new'*. The other student tried to negotiate between science and religion by saying, *Sex is determined by sex cells, which contain sex chromosomes, but the chance of getting male or female is determined by God'.* Another student also asked, Do you think you can have a child without sexual intercourse? And students responded by saying it could not. At last, they reach consensus on the idea that Henok is responsible for their children's sex determination, and this is not the fault of Marta. This indicates that culture, religion, and other values direct the way of reasoning and understanding the same natural phenomena.

Qualitative results of CU

Semi-structured interviews were used to collect thorough information on students' conceptual understanding, justifications, and epistemological beliefs on heredity concepts after the intervention had been put into place. Five students from each group made up the fifteen participants in the interview. The five subtopics of the unit that were addressed in the interview findings were hereditary material (chromosomes, DNA, and genes), cell division (mitosis and meiosis), Mendelian genetics, heredity and breeding, and views about biology learning and the creation of biological knowledge. Interviewees from the three groups were questioned about these subtopics in heredity in order to gauge their conceptual comprehension and their epistemological beliefs using reasoning and belief questions.

The interview questions were centered on the minimum learning competencies listed on the syllabus, such as: defining mitosis and meiosis and describing their stages; explaining Mendel's works and how they relate to the concept of inheritance; illustrating and demonstrating the concept of inheritance using examples and colored beads; defining chromosomes and describing their structure; defining DNA and describing its components; and defining breeding and describing its methods, importance, and examples. The sentences that follow are quotes from students' answers to the question, "Where is genetic material found?" and describe the genetic material's structure.

Genetic material umm…genetic material is stored in the nucleus of each cell in chromosomes, which are like genetic material. DNA molecules are long strands of nucleic acids, which are like codes for the genetic information and bounded by histon *protein and genes are the smallest unit of genetic material and formed from nitrogenous bases (Student 4, TG 1).*

Genetic material of an organism is found in the nucleus of each cell with in an individual organism. Let me give an example which was discussed with my friend to explain the relationship of chromosome, DNA and gene. The outer cover of the pen is considered as a chromosome, the inner plastic which contains the ink is considered as a DNA and the ink which determines the writing style is considered as a gene. This implies that gene determines all the characteristics of an organism (Student 4, TG 2).

Genetic material is found in a nucleus of the cell of an organism. The DNA is a thread like structure found in the chromosome and controls all activities of the cell as well as the organism (Student 4, CG).

In relation to the genetic material all the three interviewees explain the place where genetic material is found and they consider all individual cells in living things contains genetic materials. On the other hand students in both treatments group 1 and 2 explains the characteristic of an individual is determined by gene instead of saying general term like chromosome and DNA approximating that of students in CG. A student in TG 1 explains the structure of DNA and gene is a hereditary unit. In advance student in TG 2 explains the relationship between chromosome, DNA and gene using analogy. This shows that TG 2 students explain and internalize the concept of genetic material better than students in the other group.

When compared to the responses from the students, most interviewees from all groups described mitosis and meiosis and their stages in the following ways:

Meiosis is a type of cell division that produces four daughter cells, each with half the number of chromosomes as the parent cell, Whereas mitosis is the result of *cell division that produces two daughter cells with the same number and kind of chromosomes as the parent cell (student 1, TG 1).*

Both meiosis and mitosis are procedures used in cell division. While sexually reproducing creatures require a process called meiosis to divide their germ cells into gametes, such as sperm or egg cells, Mitosis is a type of body cell division and is also a type of asexual reproduction for single cell organisms like bacteria or germs. However, for large organisms, mitosis is used for growth and replacement of worn-out cells within the organisms (Student 3, TG 2).

Meiosis is the division of sex cells into four daughter cells with half as many chromosomes as the parent cell, whereas mitosis is the division of body cells into two identical daughter cells (student 2, CG).

As shown in the above three of the interviewees define both mitosis and meiosis correctly but they consider different aspects to define them. Student from TG 1 defines them, for instance, in terms of the quantity of daughter cells produced and the number of chromosomes in each daughter cells. This is also repeated by students in CG but student in CG added the type of cell divided by each type of cell division like that of student in TG 2. Student in TG 2 relate the type of cell division with the type of asexual and sexual reproduction including their importance for different type of organisms. This showed that students tried to relate different concepts instead of memorizing each word separately.

When students asked to explain the phenomena occur in each phase of cell division almost all the interviewees listed the four common phases of both cell divisions. But the difference comes during explaining the phenomenon in each phase. The following paragraphs indicated answers of interviewees.

Both meiosis and mitosis have four stages. Chromosomes swelling and nuclear membrane disintegration signal the start of mitosis during prophase. Chromosomes align along the cell's midline during metaphase. During anaphase, each pair of chromatids splits into two identical chromosomes, which is why the spindle fibers pull the chromosomes to the opposite ends of the cell. The nuclear membranes reform and the chromosomes reach the poles during telophase. Two daughter cells with the same number of chromosomes as the mother cell are created when the mother cell's cytoplasm splits (Student 3, TG 1).

In cell cycle, interphase is the preparation phase for cell division. Both mitosis and meiosis cell division starts with prophase then metaphase next anaphase and at last telophase. At prophase, chromosomes are condensed and paired. The next phase is metaphase. In this phase the spindle fibers forms and chromosomes arranged at the equator of the cell umm…. in meiosis crossing over occurs. At anaphase the centromer divide and moves to each end of the cell. But this is for mitosis in meiosis chromosome pairs do not separate. In the last stage telophase, the nuclear membrane builds again and the cells begin to divide and division of cytoplasm occurs. In meiosis second phase (meiosis II) continuous (Student 5, TG 2).

Prophase is the beginning of mitosis, during which the chromosomes coil and thicken and the nuclear membrane separates. The chromosomes line up along the cell's midline during metaphase. During anaphase, the split chromosome pairs are drawn to the opposing ends of the cell by the spindle fibers. During telophase, the spindle fiber breaks down and the nuclear membranes resurface. Two daughter cells are produced when the cytoplasm of the mother cell splits; these cells have the same number and kind of chromosomes (Student 1, CG).

The above response of interviewees showed different understanding regarding cell division. The three students were more focus on the mitosis cell division and they use chromosome and chromatids interchangeably. Students in TG 2 clearly differentiate between interphase and cell division by saying before cell division there is a preparation phase that is interphase. In the comparison group, most students explain how cells divide, including DNA replication in the prophase, but no one mentioned the G1, S, or G2 phases of the interphase. The G1 phase of the cell cycle is the first interphase phase and is devoted to cell expansion. The DNA of the chromosomes is duplicated during the S phase. The cell makes its final preparations for meiosis during the G2 phase. Students indirectly discuss DNA replication when explaining the metaphase, but they do not go into detail on how, when, or at what stage DNA replication occurs. Each chromosome develops two identical copies (known as sister chromatids) during DNA duplication during the S phase, which are retained together at the centromere until they are separated during anaphase. Students in TG 1 tried to explain about cytokinesis by saying the cytoplasm of the mother cell divides to form two daughter cells.

In relation to Mendelian Genetics, students asked "Why did Mendel choose the pea plant for his experiment?" Interviewees from three groups list out the reasons they assumed. For example:

Pea plant is a dicot plant and easily breeds umm.. it has also chromosome for inheritance that means to transmit different characters, the plant has easily observable contrasting traits like stem height, the plant also can grow and become productive with in short period of time(Student 5, TG 1).

Mendel used the pea plant because the plant has genetic material umm..DNA, it also has many characters for example tall and short stem, a yellow and green seed *color and others. Additionally, it is a dicot plant that is simple to grow and maintain. The plant is naturally self-pollinating, but Mendel also cross-pollinated it with his own hands to eliminate self-pollination (Student 5, TG 2).*

Mendel chose pea plants for his studies since they have unique visible characteristics. It is a dicot plant that may be easily cultivated in great quantities and over a short period of time (Student 5, CG).

Mendel conducted tests to test if certain traits would always remain recessive, whether inherited traits have an impact on one another, and whether DNA might change certain features. He derives the subsequent findings from his research. The genotype, which describes the genetic makeup of a plant, is one of them. Phenotype, on the other hand, refers to a plant's external characteristics. The genes are passed down from parents to offspring in pairings known as alleles. During gametogenesis, when the chromosomes are split in half, one of the two alleles has a 50% chance of fusing with the allele of the gamete of the other parent. Alleles that are homozygous have the same allele, but alleles that are heterozygous have different alleles.

To explain the response of interviewees the purposes and conclusions given by Mendel are important. All the interviewees listed the general characteristics of pea plants which was not the criteria for selection of the plant by Mendel. For example its dicot feature and the presence of genetic material were not considered by him. Because the number of cotylyden does not play the role in the experiment the genetic material is found in all living organisms and confirmed by Mendels' experiment instead of using it as criteria by him. TG 2 students also list considered characteristics like the presence of observable contrasting traits, ability of self pollination naturally and cross pollination artificially by Mendel and short time plant. Students in CG and TG 1 list two criterions with two common characters of the plant. The TG 1 and TG 2 students consider the type of pollination which was important to determine inherited characters like dominant and recessive traits using cross pollination. The laws of dominance and laws of segregation also developed based on this pure breeding.

According to the results above, interviewees from TG 2 appeared to have a better understanding of inheritance principles after describing the role of cross-pollination. Students in TG 2 outperformed the other two groups on item 1 of this category, according to the quantitative data analysis result.

Regarding the monohybrid cross students asked about the gamete formation and allele segregation students faced difficulty about the reason behind separation of two letters during gamete formation. For example, students explain their difficulties like the following.

I'm not sure how one precisely constructs a punnett square. I'm not sure how many alternatives you can show in a horizontal and vertical orientation such that they can cross, but I do know that the two letters cannot be put and cross together (student 1, CG).

The interviewee mentioned above was unsure of how many alternatives the punnett square illustrated. Above and beyond, the interviewee did not express what is depicted horizontally and vertically. It seems that she did not realize that the possible gametes from the parents concerning the trait under consideration are demonstrated in the punnett square. When students do not see the relationship with the preceding process of meiosis, resulting in the formation of gametes, the punnett square becomes a fixed diagram and tool. Consequently, it is logical that they do not know how many possibilities they can represent because they do not know what (i.e. Gametes) is symbolized and by means of what process (i.e. meiosis) it is formed.

The results from the quantitative data are corroborated by the findings from a semi-structured interview and classroom observation. Even though the students in the various groups gained a better knowledge of the material, their explanations of the responses varied. The findings of the interviews revealed that members of treatment group 2 were very good at explaining questions by connecting their responses to real-world situations, demonstrating their grasp of genetic principles. While the TG1 students were clearly engaged in the classroom, however, their responses to the questions posed were not accurate, as the observation in the classroom attested to.

Results of post EBQ analysis

The post epistemological belief questionnaire was analyzed using descriptive statistics, paired sample t-test and ANOVA. The descriptive analysis results for post-EBQ are presented in the following table (Table 29).

Table 31 Descriptive statistics results of the seven categories of post-EBQ among groups

Variables	**Groups**								
	Treatment group 1			**Treatment group 2**			**Comparison group**		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Overall	38	70.66	16.55	43	64.58	16.07	50	56.09	17.26
CC	38	60.16	19.64	43	60.88	24.91	50	46.7	21.34
Enj	38	81.5	26.37	43	69.25	28.57	50	63.74	25.66
PSR	38	66.84	34.88	43	57.21	30.42	50	61.6	21.14
PSE	38	64.29	25.02	43	60.47	23.3	50	60.34	23.79
PSS	38	69.74	32.44	43	61.05	31.48	50	58.8	30.77
PSSA	38	60.05	23.74	43	55.91	24.23	50	40.56	20.8
RWC	38	77.68	23.81	43	70.8	21.59	50	57.12	21.97

CC- Conceptual connection	PSS- Problem solving strategy
Enj- Enjoyment	PSSA- Problem solving synthesis & application
PSR- Problem solving reasoning	RWC- Real world connection
PSE- Problem solving effort	

The overall and seven categories pre- and post-means, shift of belief and its statistical significance (paired t test) are shown below. There is an overall similarity in their percent expert views towards biology with mean of TG 1 =58.29, TG 2 =55.51 and CG =59.62 showed no significant difference (p=.44) at pre-intervention p > .05 as indicated in the ANOVA table for pre-test analysis. A somewhat common starting point may make it easier to apply interventions to alter epistemic beliefs in a way that benefits all treatment groups. Following intervention, the percentage of respondents who agreed with experts increased across all categories.

Table 32 Percent agreement with experts, pre-post means, shift in beliefs among three groups

CLASS-Bio category	**Treatment group 1 % agree with experts**			**Treatment group 2 % agree with experts**			**Comparison group % agree with experts**		
	Pre (M)	**Post (M)**	**Belief shift**	**Pre (M)**	**Post (M)**	**Belief shift**	**Pre (M)**	**Post (M)**	**Belief shift**
Overall	58.29	70.66	12.37	55.51	64.58	9.07	59.62	56.09	-3.53
CC	42.76	60.16	17.4	47.97	60.88	12.91	43.5	46.7	3.2
Enj	66.32	81.5	15.18	72.25	69.25	-3	70.47	63.74	-6.73
PSR	73.16	66.84	-6.32	65.12	57.21	-7.91	68.2	61.6	-6.6
PSE	61.29	64.29	3	65.05	60.47	-4.58	66.2	60.34	-5.86
PSS	65.92	69.74	3.82	65.35	61.05	-4.3	65.4	58.8	-6.6
PSSA	43.99	60.05	16.06	47.28	55.91	8.63	44.86	40.56	-4.3
RWC	66.17	77.68	11.51	55.31	70.8	15.49	64.94	57.12	-7.82

Table 33 Paired t-test analysis result of pre and post EBQ

Group		**Mean**	**Std. Deviation**	**Std. Error Mean**	**T**	**df**	**Sig. (2-tailed**
TG1	EBQPostoverallTG1 - PreoverallTG1	12.37	18.73	3.04	4.07	37	.000
	CCTG1post - CCTG1pre	17.4	24.93	4.05	4.3	37	.000
	EnjTG1post - EnjTG1pre	15.18	33.71	5.47	2.78	37	.009
	PSRTG1post - PSRTG1pre	6.32	44.63	7.24	-.87	37	.389
	PSETG1post - PSETG1pre	3.0	32.24	5.23	.57	37	.570
	PSSTG1post - PSSTG1pre	3.82	33.9	5.5	.69	37	.492
	PSSATG1post - PSSATG1pre	16.07	28.79	4.67	3.44	37	.001
	RWCTG1post - RWCTG1pre	11.52	30.0	4.87	2.37	37	.023
TG2	EBQPooverallTG2 - PreoverallTG2	9.07	25.32	3.86	2.35	42	.024
	CCTG2post - CCTG2pre	12.92	32.1	5.03	2.57	42	.014
	EnjTG2post - EnjTG2pre	-30.0	36.45	5.56	-.54	42	.592
	PSRTG2post - PSRTG2pre	-79.07	40.56	6.19	-1.28	42	.208
	PSETG2post - PSETG2pre	-4.58	36.26	5.53	-.83	42	.412
	PSSTG2post - PSSTG2pre	-4.30	44.22	6.74	-.64	42	.527
	PSSATG2post - PSSATG2pre	8.63	24.5	3.74	2.31	42	.026
	RWCTG2post - RWCTG2pre	15.48	33.05	5.04	3.07	42	.004
CG	EBQPostoverallCG - PreoverallCG	-3.52	18.62	2.63	-1.34	49	.187
	CCCGpost - CCCGpre	3.2	26.69	3.77	.85	49	.401
	EnjCGpost – EnjCGpre4	-6.73	28.63	4.05	-1.66	49	.103
	PSRCGpost - PSRCGpre	-6.6	30.75	4.35	-1.52	49	.135
	PSECGpost - PSECGpre	-5.86	27.88	3.94	-1.49	49	.144
	PSSCGpost - PSSCGpre	-6.6	39.74	5.62	-1.17	49	.246
	PSSACGpost - PSSACGpre	-4.3	24.54	3.47	-1.24	49	.221
	RWCCGpost - RWCCGpre	-7.82	28.18	3.99	-1.96	49	.055

The results table above (Table 31) showed the CLASS-Bio results for TG 1, TG 2, and CG students both before and after the six-week intervention. The four CLASS-Bio domains of "Conceptual Connection, Enjoyment, Problem Solving Synthesis and Application, and Real World Connection" as well as the total scores of the TG 1 students (N = 38) all shown significant shifts toward expert-like beliefs. But when it came to the three subcategories of problem-solving—"Problem Solving Reasoning," "Problem Solving Effort," and "Problem Solving Strategy"—TG1 students had simplistic notions. The only subcategory of problem-solving where those students showed discernible improvement toward expert-like perspectives was problem-solving synthesis and application. In TG 2, students (N = 43) showed statistically significant shifts toward expert status in three categories: Conceptual Connections, Problem Solving Synthesis and Application, and Real World Connection. However, enjoyment did not change from the prior results. Students in REACT (TG 1) and combined techniques (TG 2) showed a substantial movement toward more expert-like beliefs in several CLASS-Bio categories, but no shifts were seen in the three CLASS-Bio categories (TG 1) and four CLASS-Bio categories (TG 2). There was no statistically significant difference observed between the mean pre-test and mean post-test scores for the students in the comparison groups. The following graph showed the test results and shifts for each group.

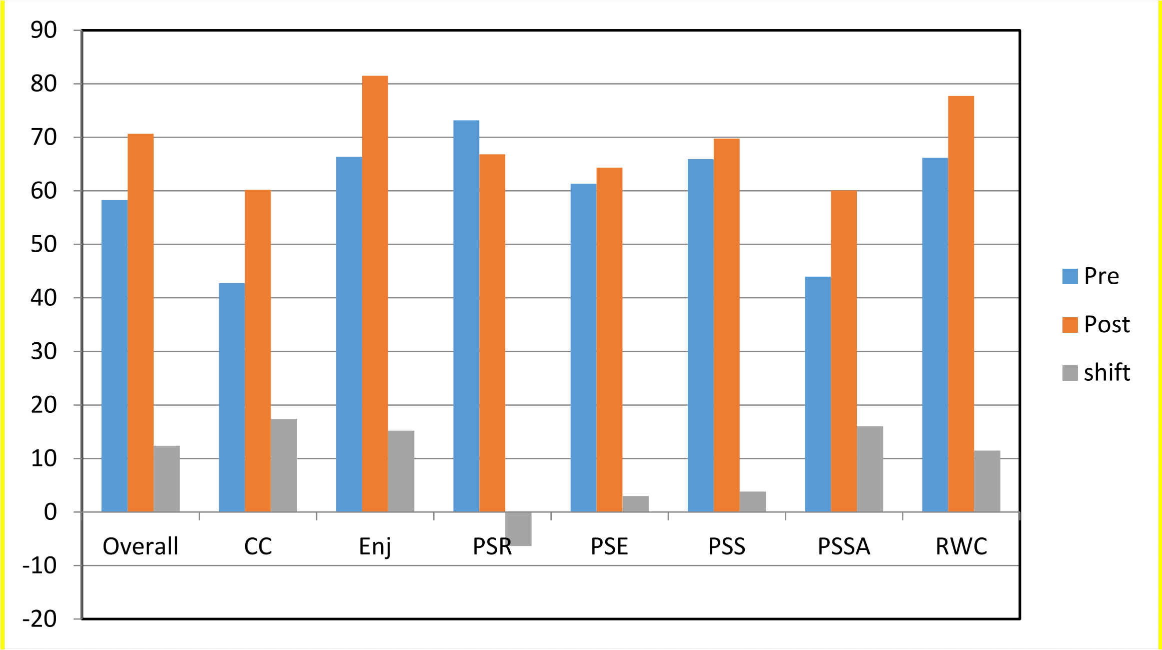

Figure 9 Treatment group 1 students' CLASS-Bio outcomes before, after six weeks and the shifts made.

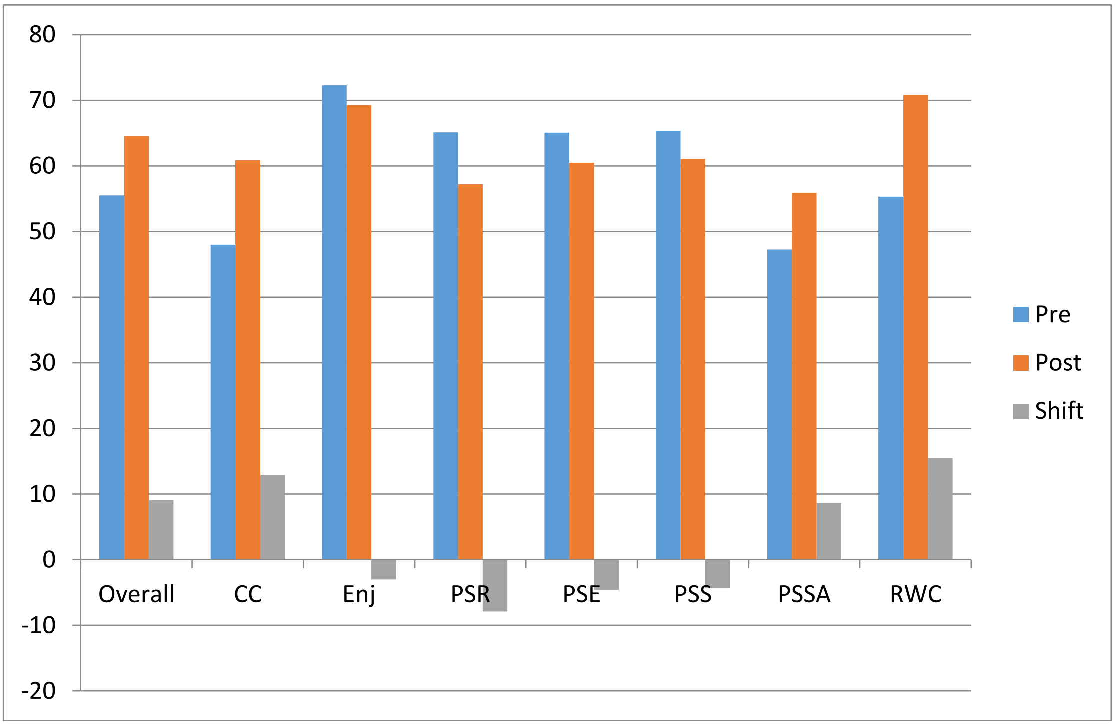

Figure 10 Treatment group 2 students' CLASS-Bio outcomes before, after six weeks and the shifts made.

Both overall and in three of the seven CLASS-Bio categories, students in treatment group 2 experienced significant adjustments in their beliefs toward those of experts. In three categories—Problem Solving Synthesis and Application; Real World Connection and Conceptual Connections; and Memorization—students in the second treatment group (N = 43) made statistically significant shifts in the expert direction (significance $p < 0.05$; 2-tailed matched-pair t tests). While the difference was minor, students in this group scored worse on their post-test and showed negative trends in the categories of enjoyment, problem-solving reasoning, problem-solving effort, and problem-solving strategy. As a result, students in both treatment groups dramatically moved their perceptions in a number of CLASS Bio categories toward those of experts.

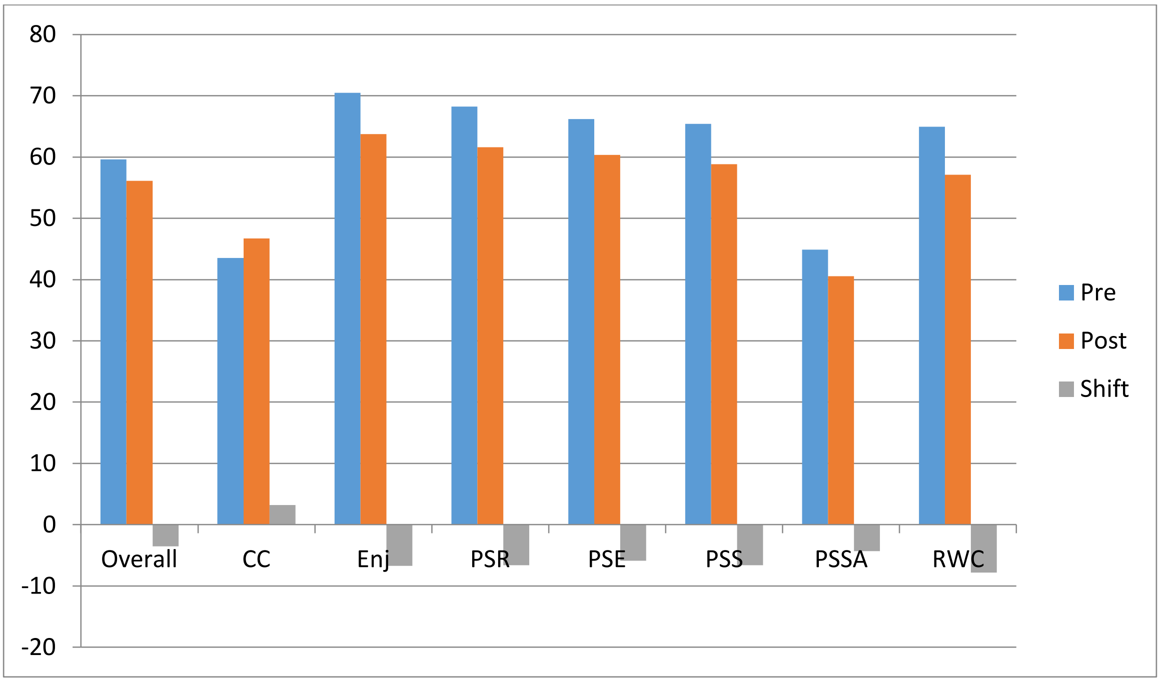

Figure 11 Comparison group students' CLASS-Bio outcomes before, after six weeks and the shifts made.

Overall mean post-test scores for the comparison group's students did not differ substantially from mean pre-test scores ($p>0.05$). Students in comparison group scored higher on the pre-test than their post tests in all categories except conceptual connections but the changes in both directions are insignificant.

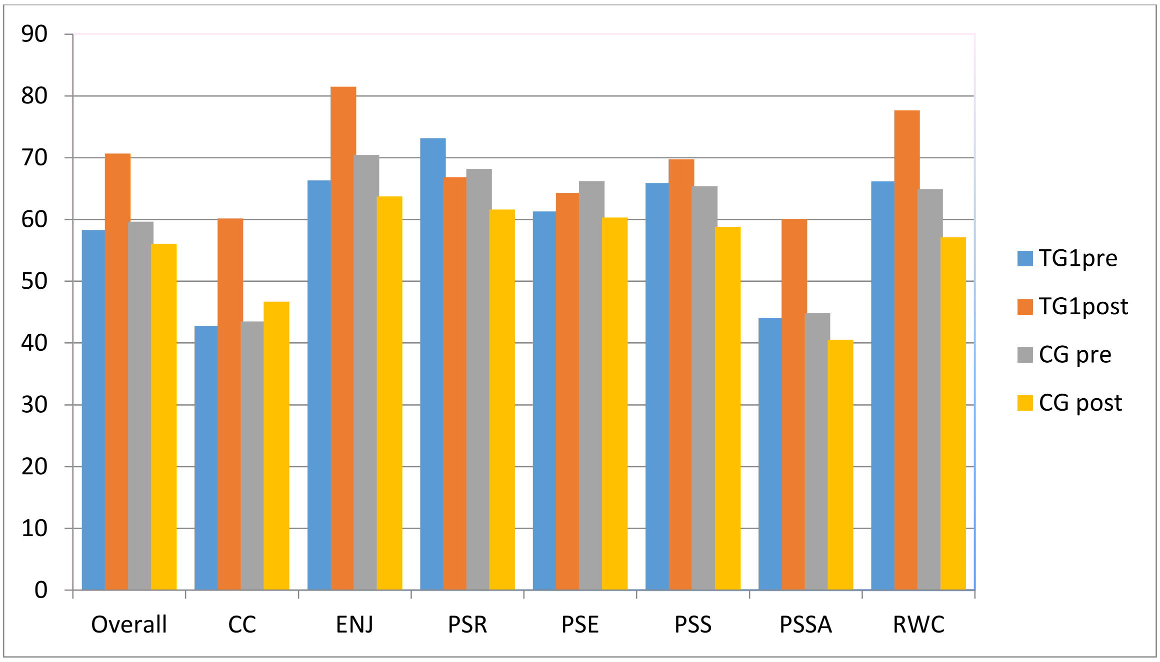

Figure 12 Treatment group 1 & comparison group students' CLASS-Bio outcomes after six weeks intervention

As can be seen in the above image, students in TG 1 and CG scored similarly in the three problem-solving categories: problem-solving reasoning, problem-solving effort, and problem-solving strategy.

The following ANOVA table shows that there was a significant mean difference in the four CLASS Bio categories as well as between the groups as a whole. These were: Real World Connections, Enjoyment, Synthesis and Application of Problem Solving, and Conceptual Connection. Students in the treatment groups and comparison groups did not substantially differ in the categories of problem-solving reasoning, effort, or strategy, which has $p > 0.05$ value.

Table 34 ANOVA result comparing groups in terms of post-EBQ scores

		Sum of Squares	**df**	**Mean Squares**	**F**	**Sig.**
PostoverallTG1	Between Groups	.472	2	.236	8.489	.000
	Within Groups	3.558	128	.028		
	Total	4.030	130			
CCTG1post	Between Groups	.594	2	.297	6.064	.003
	Within Groups	6.264	128	.049		
	Total	6.858	130			
EnjTG1post	Between Groups	.695	2	.347	4.817	.010
	Within Groups	9.228	128	.072		
	Total	9.923	130			
PSRTG1post	Between Groups	.187	2	.094	1.021	.363
	Within Groups	11.736	128	.092		
	Total	11.923	130			
PSETG1post	Between Groups	.041	2	.020	.354	.702
	Within Groups	7.367	128	.058		
	Total	7.408	130			
PSSTG1post	Between Groups	.276	2	.138	1.391	.253
	Within Groups	12.695	128	.099		
	Total	12.971	130			
PSSATG1post	Between Groups	.959	2	.480	9.203	.000
	Within Groups	6.670	128	.052		
	Total	7.629	130			
RWCTG1post	Between Groups	.979	2	.490	9.757	.000
	Within Groups	6.422	128	.050		
	Total	7.401	130			

Post hoc analysis was performed to determine between which groups the difference was discovered. The results revealed a substantial difference in the overall beliefs, conceptual connection, enjoyment, problem-solving synthesis and application, and real-world connection categories between the treatment and comparison groups. However, there was no discernible change in the problem-solving, reasoning, effort, or strategy categories between the treatment groups and comparison groups. There was no discernible difference between treatment group 1 and 2 in any category.

Table 35 Post-hoc multiple comparison test result using Bonfferonni test

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p.
PostoverallTG1	TG1	TG2	6.08	3.71	.234
		CG	14.56*	3.59	.000
	TG2	CG	8.49*	3.47	.041
CCTG1post	TG1	TG2	-.72	4.93	.988
		CG	13.46*	4.76	.015
	TG2	CG	14.18*	4.6	.007
EnjTG1post	TG1	TG2	12.25	5.98	.105
		CG	17.76*	5.78	.007
	TG2	CG	5.51	5.58	.587
PSSATG1post	TG1	TG2	4.15	5.08	.694
		CG	19.49*	4.91	.000
	TG2	CG	15.35*	4.75	.004
RWCTG1post	TG1	TG2	6.89	4.99	.353
		CG	20.56*	4.82	.000
	TG2	CG	13.67*	4.66	.011

Qualitative results for EB

In relation to Epistemological beliefs, quantitative data were collected using 31 statements for seven categories in the epistemological beliefs questionnaires. The subsequent quotation was taken from pupils' dialogue in relation to those beliefs in order to triangulate the students' belief.

For me, genetics is challenging. I always begin a genetics challenge by writing down the data provided in the work, and then it is frequently like and what to do next. Then, in order to save time, I frequently sought the advice of my classmates or the teacher. By working together, we were able to solve the issue because each person had a modest part to play. My only issue was that I frequently lacked the *knowledge necessary to proceed; otherwise, I comprehended everything (student 1, TG 2).*

While attempting to solve genetics problems, it appeared that they learned by practicing numerous genetics problems and frequently by using trial and error, but they did not seem to fully understand the concepts of genetics. They repeated until they got it. They have no real understanding of Mendelian genetics task. Mostly, they wrote down the information given in a task but did not know what to do with it. Consequently, it seems like a trial-and-error approach without connecting biological phenomena with information (and symbols) in the genetics task. In terms of problem-solving effort, the statement *"I do not spend more than a few minutes stuck on a biology question before giving up or seeking help from someone else"* is relevant. On this assertion, experts disagreed. The aforementioned interviewee, however, agreed with this assertion because, upon writing down the information supplied, she promptly sought support from her teacher or peers instead of trying to figure out the solution on her own. She also took issue with the assertion that was made in the conceptual connection category, which read, "*If I run into trouble answering a biology question on my first try, I usually try to figure out a different approach that works."* In this example, she does not link several concepts, including meiosis and gamete formation, without using any different strategies or approaches. Furthermore, by accepting and recording knowledge from peers, they persisted in putting themselves in the role of passive recipients of knowledge from outside authorities.

Students were asked about ways of learning and studying biology. The following is sample idea taken from student answers from different group students.

During class, I was usually attentive and taking notes. I also put effort into my regular studies and my learning. I asked someone who knew the subject if I didn't *grasp something, and I worked through issues related to the material I was trying to learn. When I was studying, I made an effort to comprehend the reasoning rather than memorize it (student 3, TG 1).*

One might infer from this interviewee's responses that the student has strong opinions about the aspect of intrinsic ability that learning is reliant on effort rather than innate talent. If he still had any difficulty, he studied more because of him. In addition, he holds views on conceptual connections that are similar to those of an expert since, as he indicated, biological knowledge is difficult to memorize.

Through active participation, taking notes, asking questions, and problem-solving, I gained knowledge. When I came home from class, I reviewed what I had learnt and worked on related tasks. I addressed my teacher questions to clear up my misconceptions because I was aware of them (student 3, TG 2).

Because she thought biological information was rather simple, she had medium-level epistemological views in the dimension of knowledge simplicity, although she had high-level beliefs in other dimensions. By using extra sources, she made an effort to understand and tried to assimilate the idea.

Aside from at exam periods, I fully participated in the courses and took notes. I did not choose to study at home. I studied for the tests using my lecture notes to better understand the material (Student 2, CG).

This respondent maintained naive belief in the component of natural talent and held high levels of believe in the quick learning dimension, which states that learning is not a progressive process. This demonstrated her belief that there is no need to expend a lot of time and effort in order to answer difficult issues. Because of this, it is possible that is why she did not put much effort into her learning or performance assignments.

In summary, the interview findings corroborated the quantitative data analysis findings regarding the overall mean score and the percentage of each item. Specifically, students in TG 2 were found to have a higher mean score in comprehending hereditary ideas than their second-placed counterparts in TG 1. Regarding epistemological beliefs, TG 1 performed well than comparison group significantly but insignificantly better than TG2.

The interview result supports quantitative results in terms of overall mean score and percentage of each item in which pupils in the intervention groups displayed more experts like beliefs than CG. Students from TGs showed sophisticated epistemic beliefs, which indicate that they attained expert epistemic beliefs. For example, student 3 from TG 1 responded on the question '*how do you learn biology*', as follows:

I always paid attention and took notes during the class times. I also studied daily, and I used my effort to learn. If I did not understand something, I asked someone who knew it and I solved problems about the content that I tried to learn. I tried to understand the rationale instead of memorization while studying (student 3, TG 1). From the above statements, the student had expert beliefs on conceptual connections because he explained that he did not prefer memorization to learn concepts in biology instead the student tried to understand the rationale behind the concept. The student had also relatively good expert beliefs in relation to problem solving effort because he said that he had used his effort to learn concepts in biology.

Students from TG 2 also developed expert epistemic beliefs in some categories of CLASS-Bio as portrayed in the quantitative results. Their interview indicated that they developed expert epistemic beliefs. One of the students (student 4) responses to the interview question, ‘*how do you learn biology*’ is given below, as an example:

I learned by listening, participating, taking notes, asking questions, and solving problems. I repeated what I had learned at the class when I got home and solved problems about the subject. I was aware of my misunderstandings and asked questions to my teacher to get rid of those confusions (student 4, TG 2).

Here, the student had expert like epistemological beliefs in conceptual connections because the student used the effort to learn and tried to internalize the concept by interconnecting different concepts using additional sources. However, the student held naïve belief in the dimension of problem-solving effort. It was showed in their response that they believed as they should ask others when they faced difficulty. They did not explicitly say that they should try by themselves first and used their efforts to solve problems in biology learning. They believed they asked whenever they faced difficult problems. Similarly, another student (student 1) believed that they should ask help before they tried by themselves as soon as they faced challenging problems. The following interview responses to the same interview question indicate the aforementioned idea:

Genetics is difficult to me when I get a genetics problem, I always start with writing down the information given in a task, after that it is, often like, what to do now. Then I often consulted other students in my class (or the teacher) to save time, and together we could solve the problem, because everyone could contribute a small part in solving the problem. My only problem was that I often did not know how to continue, otherwise, I understood everything (student 1, TG 2).

In relation to problem solving effort one statement was ‘*I do not spend more than a few minutes stuck on a biology question before giving up or seeking help from* *someone else*'. Experts disagreed with this statement. Whereas the above interviewee agreed with this statement because, after writing the information given, immediately seek help from classmates or from teacher instead of trying to solve by herself. The same interviewee disagreed on the statement in the conceptual connection category said that '*If I get stuck on answering a biology question on my first try, I usually try to figure out a different way that works*'. In this case, she did not apply different ways and strategies by connecting different concepts like meiosis and gamete formation. Additionally, they continued to place themselves in the position of passive receivers of knowledge from outside authorities by receiving and documenting knowledge from peers.

Those students' interviews indicate that students in TGs showed expert like epistemic beliefs in some categories, and they did not attain expert epistemic beliefs in some categories, which agrees with the quantitative results. Likewise, CG students' interview responses agree with the result of quantitative data. The following quote was taken from CG students' interview responses (student 2) to the same question, '*how do you learn biology*?':

> *I actively participated in the lessons, and I took notes, I did not prefer to study at home apart from exam times. I used my class notes to learn the content better while studying for the exams (student 2, CG).*

In the statements, it is showed that learning is passing the exam by memorizing facts and principles. Besides, when the researcher probed student (student 2) further, she said:

I like biology and have high score than the other science disciplines because questions of our exam ask a direct question that can be answered by recalling the idea of the teacher while giving at the revision session.

Researcher asked: “If so, why do you think most students fail to pass the national examination?” The student answered, as follows:

Most of the questions included in the national exam asks concepts which are different from what we exercise in the class test and final exam.

From the probes, one can understand that the type of exams, activities and teaching methods determines the belief of students towards learning. Therefore, in this study the activity designed and used during the intervention period helped students in the TGs to interconnect different concepts and may be a means to change novices to expertise belief.

The researcher’s observation of students while they were working on different activities also portrayed the belief that was depicted in their responses to the interview questions.

4.1.3 Results in relation to association of three dependent variables

The following table showed there is medium correlation between post GCUT and post SRST (r =.433) since this r value is found in the range of .3 to .49. Whereas, post EBQ no or weakly correlated with post GCUT (r =.111) and post SRST (r = .052). Cohen (1988) determined that r= +.10 to.29 is a weak correlation, r= +.30 to.49 is a medium correlation, and r= +.50 to 1.0 is a big correlation. There for, the result of these analysis r=111 shows the presence of small correlation between EBQ and GCUT. Similarly the correlation value (r=.052) showed that nearly no correlation is found between EBQ and SRST.

Table 36 Pearson correlation among post GCUT, post SRST and post EBQ

Pearson correlation

	Post GCUT	**Post SRST**	**Post EBQ**
Post GCUT	1		
Post SRST	.433**	1	
Post EBQ	.111	.052	1

Qualitative results for progression of variables

When the intervention first started, the researchers saw that a large number of the students in each session were not confident when they reflected on their ideas and were only passive participants. Only the group leaders respond to the teacher's query. During the intervention procedure, treatment group 1 demonstrated a progressive shift in how they responded to various activities in the classroom. When teaching students about heredity using the context-based REACT technique, a large number of them showed interest, actively participated, and interacted well with their classmates to complete the practical exercises and debate the provided subject. Students did, however, also note that "the method is good, but since the concepts are new to us, we faced a problem relating the activity given to the expected learning concepts." The researchers' observation that they referred to students and items by their names rather than by the term "hereditary" supported students saying. For instance, they did not employ terminology like chromatid and centromere in cell division activities. Instead of connecting the activities to anticipated themes, students have perceived them as games. Their curiosity might grow as a result, but their conceptual comprehension might not advance.

When they completed various tasks, students who were given context-based activities combined with conventional education gained confidence. Additionally, rather than referring to the students and items by name—which is why they were introduced at the start of the lesson—when they thought back on their ideas regarding the assigned assignments, they used the proper terminology in genetics. For instance, when participating in DNA replication tasks, students in treatment group 2 refer to all four nitrogen bases fully, saying adenine, guanine, thiamine, and cytosine, as opposed to treatment group 1 students who say A, G, T, and C. Conventional instruction taught students to be more passive listeners with poor interaction during the talk, showing less enthusiasm and participation. Group leaders speak as one, and the other members of the group pay attention to what they have to say.

Additionally, to ensure that the intervention was carried out as intended, classroom observations were made while it was being implemented. A checklist containing a list of the tasks that instructors are required to implement was used during classroom observation, and it was discovered that teachers were carrying out the intervention as planned. Similar to this, the instructional models deployed, notably combined and REACT techniques, have received excellent feedback from instructors and students in treatment groups. The teachers said that by using a combination of strategies, they were able to plan the lesson efficiently, and the REACT technique helped them focus students' attention on learning by allowing them to ask questions constantly. Students said that the instructional models had made it easier for them to be actively involved in their learning, particularly those who had used the combined method to show that they were both actively involved and monitoring it. They also indicated that the REACT strategy helped them while they are doing their different activities but they underline about the time of concept introduction by saying we don’t know the concept while doing the activity and it is time consuming.

4.2 Discussion

The results of the data analysis and the interpretation of the quantitative and qualitative data were covered by the researcher in the previous sections. This section presents, triangulates, and discusses the data analysis findings with regard to conceptual understanding, scientific justification, and epistemological beliefs with respect to findings from various related literature. As stated, the primary goal of this research was to ascertain the impact of a context-based approach with the REACT strategy on students' conceptual understanding, scientific reasoning, and epistemological views related to heredity subjects in the 10th grade.

4.2.1 Discussion on SRST results

"What is the difference between the two treatments and comparison groups in their scientific reasoning skills after intervention?" was the initial research topic. All classrooms demonstrated improvements in reasoning skills from the pretest to the posttest in terms of the intervention's results. The results showed that after completing the assessment both before and after teaching, students in all three groups showed an improvement in their overall thinking abilities. Conventional instruction was implemented in comparison groups. The Ethiopian grade ten textbook was used to guide the teacher-led and self-paced drill-and-practice classroom activities in comparison groups. The content used in TG 1 and TG 2 mostly consisted of instructional exercises created around student experiences, with some variations in application processes and the order in which concepts and situations were introduced. The gains were somewhat larger for both treatment groups than the comparison group, especially in questions that require reasoning, especially about the process of cell division and Mendelian monohybrid crosses between parents and offspring.

The pre-SRST descriptive statistics findings indicated that there was a similarity among the three groups. The ANOVA analysis of the pre-test results showed no significant difference among groups (p >.05, =.452). However, the post-SRST score ANOVA analysis revealed a significant difference between groups, with TG2 students outperforming both TG1 and CG students (p =.000). This could be due to a variety of factors. One possible explanation is that using students' personal daily life experiences as an activity helps them develop their reasoning skills because TG2 was taught with conventional instruction integrated with context-based activities and the teacher introduces the concept before the context. This helps students discuss their experience-based activities by relating them to introduced concepts. Likewise, Ultay and Ultay (2014) argued that the activities designed for day-to-day life encourage students to discuss physics for understanding and enhance their reasoning abilities using group talks. Another reason for the improvement in scientific reasoning skills of students in treatment group 2 could be group activities that encourage students to ask questions and defend others' ideas based on introduced concepts.

Treatment Group 2 students who experienced context-based activities integrated with conventional instruction showed significant improvement in their scientific reasoning skills compared to TG 1 students who experienced the REACT strategy. This may be because of the age of the students, which means that since the students are not matured enough to take responsibility for their learning, when they perform the activity in the REACT strategy, they focus on the game and fail to connect the activity to the targeted concept. In order to manage this problem, the teacher should interrupt and guide students' learning by continuously connecting context and concept in the case of integrated methods of instruction intervention in TG2. Another reason for the lower level of scientific reasoning in the REACT strategy may be a shortage of time; since, they need extra time to find the lost concept. Due to the possibility that the development of scientific reasoning may be a gradual and organic process in which pupils build the reasoning independently (Adey & Csapo, 2012), Or it could be due to the fact that this is a new concept for them because it was introduced for the first time at this grade level, as well as the nature of the heredity concept, which has been identified as a difficult and complex topic in literature.

In accordance with the findings of the current study, Saad et al. (2017) found that students' achievements are still low to medium level and that they lack the ability to connect scientific concepts to context-based socio-scientific problems. Biology students lack the skills necessary to respond to inquiries about scientific issues that affect their daily lives, such as the environment, medicine, health, and genetic engineering. They contend that discussion of context-based socio-scientific issues needs to be prioritized in order to produce excellent students in reasoning, particularly in making reflections, strategies, and approaches. This will allow students to practice their problem-solving and decision-making skills in real-world situations. In addition, Smith and Bitner discovered that the teaching approaches used in their study (ChemCom, which emphasizes chemistry in the community, and GenChem, which emphasizes traditional chemistry courses) had no appreciable influence on the students' development of reasoning Skills.

In the case of treatment group 2 students, after concepts are introduced by the teacher, additional context-based activities are given to facilitate the improvement of their capacity for scientific reasoning. This result coincides with Adey and Csapo (2012). The authors proposed that by offering context-based activities, it is feasible to hasten students' cognitive development and raise their level of reasoning to satisfy the demands of the learning tasks. Learning science provides a lot of effective options to hasten pupils' cognitive development. Research has demonstrated that specific activities and exercises can boost development. Based on this idea, the activities were designed based on the syllables of Ethiopia in order to facilitate students’ reasoning by focusing on "how and why" questions instead of asking low-level questions. Finally, Saad et al. (2017) discuss the potential of the context-based socio-scientific issue technique used in research and development to help students master science concepts, meet learning goals in biology, and improve higher-order thinking, including reasoning, if properly guided by the teacher.

In a 2009 study by Zeidler et al., four classes of 16–18-year-old students taking anatomy and physiology courses were divided in to treatment and comparison groups. The researchers discovered that the treatment classes had much more instances of reflective thinking. These researchers came to the conclusion that familiarity and a sense of personal connection with the instructional environments resulted in higher-level argumentation and reasoning as well as a more complex comprehension of epistemology. Although students in treatment groups displayed an overall decrease in the number of conclusions stated, the mean number of justifications per conclusion and the number of ideas expressed in conversational turns significantly increased, according to Zohar and Nemets' (2002) study of context-based socio-scientific issues treatments in teaching genetics.

The students who were taught using conventional instruction scored lower than those in the other two treatment groups. The majority of students in the comparison group correctly answered the first tier but failed to respond to the second tier, which asked them to justify their first decision. This may be the case because, despite learning new information, children may not have a solid grasp of conceptual comprehension. Studies have confirmed this conclusion, since it has been found that teaching and acquiring biology material knowledge in the conventional manner frequently does not transfer to aiding students in the development of sound reasoning skills (Bao et al., 2018). This implies that the instruction should go beyond conventional instruction if developing students' scientific reasoning is the target. Researchers identified conventional instruction and the overloaded curriculum as the main reasons for students failure to reason scientifically (Adey & Csapo, 2012). Additionally, Piraksa et al. (2014) found that after graduating high school through transmission teaching, students enroll in universities, and in Thailand, most university students think and reason non-scientifically.

"What is the level of scientific reasoning skills of the two treatments and comparison group students?" was the study's second research question. The percentage of pupils at each level of scientific reasoning was utilized by the researcher to examine the degree of scientific reasoning in the treatment and comparison groups following the intervention. According to Table 34, there are 68.42% of students in TG 1 at level I and 21.05% at level V. This indicates a considerable number of students are able to respond correctly to the lower-level reasoning questions; however, only a few students are able to answer the higher-level reasoning questions. Treatment group 2 students achieved greater scores at level I (74.41%) and at level V (25.58%). This indicates that students in TG2 had better reasoning skills and were able to answer more high-level reasoning questions than other group students. And comparison group students perform 60% at level I and 6% at level V. The proportion of students in treatment group 2 at all levels of reasoning is higher than that of treatment group 1 than that of the comparison group, in descending order. The decrease in the percentage of students showed that those questions at level

V asked higher-level reasoning than level I and II reasoning questions. The high percentage of students in TG 2 also showed that conventional instruction integrated with context-based activities facilitates higher-order reasoning than the REACT strategy and is more advanced than the conventional method of teaching. Additionally, as noted by Lawson (2000), they might not correctly apply logical reasoning when drawing conclusions from the available facts while responding to these questions.

As indicated by Tsui and Treagust (2010), the assessment questions showed the difference in relative difficulties when starting from questions one and two (cause-to-effect), which need low-level reasoning, to questions seven through ten (process reasoning), which need high-level reasoning. The results of the student tests confirmed this assumption because the number of students who answered questions at levels I and II was relatively high. Generally, in this study, only monohybrid inheritance was included because of restrictions in the Ethiopian syllabus. However, problems requiring an understanding of meiotic processes were more challenging to address than cause-and-effect between-generation issues or classic Mendelian inheritance issues, which called for probabilistic (e.g., 1/1, 1/2, or 1/4) reasoning. As a result, students typically answered questions correctly only to the extent of their knowledge, missing relatively few simple questions while correctly answering many more difficult ones.

The majority of secondary life science instruction, as demonstrated by Tsui and Treagust (2010), does not go beyond cause-to-effect reasoning, typically in the context of straightforward inheritance problems involving Punnett squares, though straightforward effect-to-cause problems involving pedigree analysis are occasionally used. And they paid particular attention to the trickier effect-to-cause puzzles that call for higher order thinking and domain knowledge. Assessment in this study was done with two-tier multiple-choice questions, which was quite different from Ethiopian assessment mechanisms, as the majority of questions asked for lower-level knowledge that needs regurgitation of facts and no multiple tiers (MoE, 2018). The assessment questions developed in this research were new for the sampled school students. Even if they showed efficiency, students in both treatment groups and comparison groups scored much lower than Australian grade ten students, as assessed by Tsui and Treagust (2010). In general, one requires some type of integrated domain model to be able to reason from consequences to causes. But our students lack this type of experience because these kinds of questions are not common in Ethiopian classrooms. During the interview session, one student told me about the assessment questions and gave suggestions for future assessments. He also criticizes exam items prepared by their teacher by relating them to national exam items. He said:

> *"Why you asked this type of question umm... I mean why you are asked our reason for our answer? This makes us confuse since it is new. We all experiences lower level questions which needs recalling of biological facts even much easier than national exam items. This is because if our teacher asked higher order questions, only few pupils pass the exam and I think the teacher assumed to be failed in his teaching. There for, the teacher asked very easy questions to help all students. If your concern is improving reasoning abilities of students, I advise to start from grade seven in steady of grade ten to help students in developing reasoning skills".*

Practically speaking, this means that learning is typically limited to memory for students while learning and assessing biological learning. This may be the reason why they score lower than other country students, although they are making progress. According to Hannaway and Hamilton (2008), scientific education has to change from emphasizing knowledge and the lower-order cognitive demands of memory and understanding to the higher-order cognitive demands of evaluation and synthesis. This can only be achieved by changing the nature of assessment. Assessments that merely require the lower-order cognitive skills of comprehension and memory convey a perspective on what is important and support an educational paradigm that neither challenges students' learning nor satisfies the modern workforce's need for qualified STEM (science, technology, engineering, and mathematics) professionals. A paradigm like this is ingrained in the minds of scientific instructors and curriculum designers. This may be the reason why students perform poorly in scientific reasoning (Osborne, 2013).

As indicated in the result section (Table 23), students in the comparison group who were taught by the conventional methods scored lower than the two treatment groups in scientific reasoning skills. This conclusion is supported by studies as well, as teaching and learning material knowledge in the conventional manner frequently does not transfer to aiding students in the development of sound reasoning skills (Bao et al., 2018). Reasoning ability and content knowledge might belong to separate groups and do not need to be related. In order to assist students in developing both material understanding and reasoning skills, new teaching strategies are therefore required. To accomplish this, this study developed and used context-based activities that focused on how and why questions were either integrated with conventional methods or context-based using the REACT strategy. These context-based activities encourage students to ask others, defend their ideas, and facilitate the construction of knowledge. In this study, TG 2, who used context-based activities integrated with conventional instruction, provided better reasons than students who experienced the REACT strategy. As noted before, students’ lack of focus on the activities and counting them as games was the shortcoming of the REACT strategy. Since the teacher does not guide the students to the concepts, they failed to connect the activities with the concepts by themselves. As mentioned above, this problem was managed for TG2 students by the teacher by directing the activity towards the concept.

During the intervention of this study, the researcher continuously discussed with teachers who taught treatment groups the need to ask continuous questions to dig out the reasoning abilities of students. Students immediately reach the conclusion using their own ideas. For example, when they are asked the question, Why are children similar to their parents?’, they respond immediately by saying because of their parents’ blood type. They conclude that inheritance occurs through blood simply without considering organisms that have no blood, including plants. Using multiple-hypothesis theory and ongoing questioning, it is possible to grasp the concept of inheritance using sophisticated scientific reasoning (Lawson, 2000). Advanced reasoners also develop greater reflectiveness, activity, and inference-making skills while coming to conclusions. According to Lawson (2000), experienced reasoners employ two or more precursor circumstances in these reasoning processes, in contrast to novice reasoners, who frequently use mental representations of just one antecedent condition.

Other students explained that characters are inherited from parent to offspring through genes, and a gene is a substance that parents give to their children. Those students considered genes to be particles, and due to this, they did not address the question of why a trait develops in a person when neither parent had it. This was observed in the activity that asks why a girl has a blue eye color from both brown-eyed parents. Explaining the inheritance of a feature that skips a generation is another challenge for students. This is due to the fact that while genes, or DNA molecules, are physical qualities, they are informational in nature (Tsui & Treagust, 2010).

We take into account the contextual aspects of the phenomenon that may lead to the elicitation of those ideas when analyzing the concepts that students bring to bear as they build a mechanistic explanation. Current ideas about knowledge, whether intuitive or learnt in school, imply that it consists of disjointed parts that can be triggered by particular contextual cues and combined into an explanation in particular circumstances (Lynch et al., 2019). When knowledge is presented in diverse contexts, its context-specificity may cause various concepts and explanations to emerge for what is basically the same reality. People don't always approach the world with logic. It shouldn't be surprising that these biases manifest themselves in the understanding of genetic causality as both experts and the general public’s are susceptible to them when debating cause and effect links. Motivated cognition is the most prominent of these, in which individuals' ontological ideas about the universe are impacted by their individual and group goals (Lynch et al., 2019).

In this study, the above idea was reflected and observed during the implementation of the lesson. The activity given was on sex determination concepts and the case, and the activities were:

The six children Henok and his wife Marta have are all male. Both of them aspire to have a daughter, but they find it puzzling because they constantly have sons. Marta speculates that perhaps it is her fault that she is able to have only sons. The couple decides to get a divorce and get married again. Do you believe Marta, Henok, or neither of them is in charge of deciding the sex of the kids? Explain.

Students in TG 1 discussed the above question, and one student said that sex is determined by God using the Amharic term ‘*yihe eko yegiziabiher sira new’*. The other student tried to negotiate between science and religion by saying, *Sex is determined by sex cells, which contain sex chromosomes, but the chance of getting male or female is determined by God'.* Another student also asked, Do you think you can have a child without sexual intercourse? And students responded by saying it could not. At last, they reach consensus on the idea that Henok is responsible for their children's sex determination, and this is not the fault of Marta. This indicates that culture, religion, and other values direct the way of reasoning and understanding the same natural phenomena.

With the aforementioned issue, students are unable to understand genetics problems or reason about them. For instance, when they memorize terms' definitions or human inheritance patterns without understanding, they might be able to solve a problem accurately, but they might not be able to explain it properly. In this study, during the students' interview, students can solve the monohybrid inheritance using punnet square but are not able to connect the gamete formation process through meiosis; rather, they simply separate the two alleles. When they were asked why they used one allele or letter to cross, they said that they could not cross together. Therefore, most of the students failed at the process of reasoning. As part of the genetic reasoning used in this study, students must construct their learning from known pieces of information (domain-specific dimension) using logical reasoning (domain-general dimension). Some students in TG 2 find the relationship between meiosis and allele segregation.

Students' reasoning processes when completing levels I–IV of the genetic reasoning tests can be explained by Lawson's multiple-hypothesis theory. For instance, students at levels III and IV must utilize effect-to-cause reasoning to connect specific phenotypes to the genotypes of their parents, either within or between generations. Levels III and IV mapping is more difficult than level I and II mapping (cause-to-effect) because it is not one-to-one; multiple genotypes may correspond to a particular phenotype. Successful reasoners must use many antecedents for inference in order to obtain the answer, regardless of the kind of inheritance—dominant or recessive, or, in more complicated difficulties, sex-linked or autosomal. In order to reason and solve issues, they also need to consider alternatives. For example, question no. 5, which asked the genotypes of offspring from dangly and attached ear lobe parents, requires considering both heterozygous and homozygous dangly ear parents to reach the conclusion of the genotypes of the produced offspring, and many students failed to do level IV reasoning.

The bar graph (Figure 12) compares TG 1, TG 2, and CG based on students' achievement on the two tier scientific reasoning skill exams in relation to the five genetic reasoning levels. Students seemed to find propositional reasoning-based items on Levels I through IV easier than process reasoning-based ones on Level V. While Level III and IV (effect-to-cause reasoning) items were predicted to be harder than Level I and II (cause-to-effect reasoning) items, Level IV items actually proved to be harder than Level I-III items because Level IV items call for reasoning across generations and also require some understanding of probablity to determine the potential genotypes from the given phenotypes.

In the case of question number 5, which asked level IV reasoning, students who correctly chose the answer had a solid grasp of the dominant-recessive pattern because first they expected to know the first husband's blood type, either homozygous or heterozygous, to give a blood type O child. The nest husband also has two possibilities to be blood type B (homozygous or heterozygous) to give a blood type AB child. They might also determine that the person in the second generation is blood type O because he has two recessive alleles in his genotype and has heterozygous parents for the trait. On the other hand, those who selected incorrect answers did not draw conclusions from more than one antecedent when testing their ideas. Because according to Lawson (2004), both dominant and recessive characteristics might produce the identical phenotypes in the first and second generations. One homozygous recessive son can only be produced by two heterozygous parents or carriers in the second generation. Since they were unable to reason clearly, students who gave incorrect answers to this question may not have fully understood the meaning of the terminologies used in genetics and their underlying concepts (Tsui & Treagust, 2010)

The concept of meiosis (Level V reasoning), the reduction of chromosomes for the production of haploid sperm or eggs, is required to answer the question regarding the number of chromosomes in a nerve cell. Students who comprehend the meiosis process and how it relates to bodily cells should be able to appropriately respond this question. However, without understanding the ideas and their relationships, individuals who had memorized the number of chromosomes in a human cell naturally selected choice D, which has 23 pairs of chromosomes.

In accordance to this study, Reginaning-Charysma et al. (2018) discovered that if the teacher directs students' discussions, the setting has a favorable impact on the learner's interest in knowledge of their achievements in immune system content. This is due to Reginaning-Charysma et al. (2018) finding that the inconsistency between material (content), context, and pedagogy made it challenging for both teachers and students to enlarge higher order thinking, particularly problem-solving and scientific reasoning skills.

In contrast to the present study results, Zeidler and Sadler (2011) argue that context-based activities that focus on socio-scientific issues enhance the reasoning skills of students more than conventional instruction. It puts into focus all the skills and higher-order thinking processes that can be developed while negotiating the issues in the specified activities because scientific reasoning is a desirable outcome of context-based socio-scientific issues. These negotiations and discussions can develop the abilities that lead to better science learning into sophisticated scientific thinking abilities.

4.2.2 Discussion on GCUT result

What was the difference between the two treatments and comparison groups' conceptual understanding of hereditary ideas? was the third research question. After the intervention was implemented, students in treatment group 2 had the highest mean score for conceptual comprehension among the other groups, followed by students in treatment group 1. These results were based on descriptive statistics. There was a slight difference between treatment group 1 and the comparison group according to the mean score of this measure. There were statistically significant differences between the groups, mostly favoring treatment group 2 over the other groups, based on the dependent variable's MANOVA results. According to the findings, students in treatment group 2 who participated in context-based activities combined with traditional teaching methods performed better than students in treatment group 1 who were exposed to context-based REACT methods and the comparison group that only got traditional instruction.

In relation to conceptual understanding, as indicated above, all the three groups showed an improvement even if it was at different degree. Students in TG 1 who experienced context based REACT strategy does not differ significantly from the other two groups (TG2 & CG) in their conceptual understanding. This finding supports some previous study results (e.g., Parchmann et al., 2006; Podschuweit & Bernholt, 2018), but contrasts with other study results (e.g., Acar & Yaman, 2011; Karslı & Patan, 2016; Karslı & Saka, 2017). This contrasts might be due to the difference in contexts of different countries (De Jong, 2008). Besides, less effectiveness of REACT strategy might be related to students' lack of attention to the concepts while they are focused on the contexts. When employing the REACT technique, studies have shown that students may become lost in context and miss the science learning objectives (Parchmann et al., 2006). According to some (Parchmann et al., 2006), context-based teaching does not always lead to student learning progressions. However, when familiar contexts are used in lessons and real-world examples that are appropriate for their level are presented, pupils are more engaged and capable of contributing. According to Gilbert et al. (2011), context-based classes do not help students' in developing conceptual knowledge; rather, they make learning more enjoyable and engaging for the students. This may be related with the age of students to take responsibility for their learning. Likewise, Brist (2012), who used a context-based instructional strategy for his action research, the findings showed that the instruction had a modest negative impact on students' beliefs and comprehension. In the same way, past research showed that students taking context-based Chemistry courses do not achieve the minimum requirment in terms of concept learning than those taking more traditional teaching methods (Bennett et al., 2007; King, 2012). This can be as a result of a problem with how the science material is handled in relation to the context.

In contrast to the findings in treatment group 1of this study, some researchers argued that (e.g. Aydin Ceran and Ates, 2019), context based approach enhances conceptual understandings of students. Those researchers argued that the students can use the activities to establish the relations between concept and context; they do not necessarily need a guide from teacher that introduces the concept to them before the activities. Transferring the idea into other everyday contexts and helping to correctly configure the link of the concept with other ideas are further examples of how the concept and real-life context are connected. According to the findings of the research from both life-based concept tests and concept maps, it is actually observed that the students in the experimental group are more successful in transferring the concepts into other everyday life contexts and making accurate connections among the concepts. The assessment questions that were created in accordance with real-life contexts to determine whether or not students understand the concepts have great importance in laying the groundwork for future courses when the real-life context-based learning approaches are viewed from the perspective of teaching assessment (Lubben & Benneth, 2008). Ultay and Calik (2012) also conclude from their review that context-based approach is useful in improving students' conceptual understanding of some basic chemical concepts, like chemical bonding, thermodynamics, and chemical processes.

Thus, real-world context-based questions were utilized in the concept exam, which assesses conceptual knowledge levels, as well as in the process of evaluating the teaching model used in the research. It is therefore possible to conclude that creating assessment tasks for the teaching model that are based on real-world situations aids in the students' successful application of the concepts they acquire in the courses in various settings (Aydin Ceran & Ates, 2019). Accordingly, even though it differs marginally from comparison groups, the REACT technique supported by life-based settings can be considered as an additional feature that aids in the development of conceptual understanding. The sort of evaluation items used in this study, however, may not have had an impact on students' performance, particularly for those in both treatment groups. Because the majority of the learning activities were the same for both treatment groups 1 and 2, and the test items were solely based on the Ethiopian curriculum.

Whereas students in TG 2, who experienced context-based activities integrated with conventional instruction, are significantly different from comparison group F (2, 128) = 5.67, p =.003. This finding is in line with other findings (Van Moolenbroek & Boersma, 2013). In the case of TG 2, teacher guides students to return to the concept after discussing the context. This may be advantageous since the genetics concept was new to them; since it is the first time to be incorporated in to the curriculum at this grade level. The introduction of the concept before the presentation of the context may help students to relate the concept and context. The concept-context approach is an approach for selecting learning goals and organizing knowledge (Van Moolenbroek & Boersma, 2013). This might be important for the implementation of the Ethiopian curriculum to achieve the stated objectives for each unit and topic. Before tackling issues connected to real-life situations, Bennett et al. (2007) suggested that students need to be familiar with scientific facts, concepts, principles, laws, and theories in order to convey their knowledge more effectively. As a result, combining concept-led-context-based activities with conventional instruction might be the one that enhanced treatment group 2 students to understand those concepts.

The observational findings indicated that treatment group 1 students increasingly changed how they responded to various classroom activities as the intervention process progressed. When teaching about heredity utilizing the REACT technique, many students were intrigued, actively participated, and they interacted well with their peers to complete the practical activities and to debate the provided problems. In general, the context-based approach encouraged students to take an active role in their understanding of the concepts, particularly when they were engaged in the assigned activities. However, the students added in their response about the instruction by saying “the method is nice, but we had trouble connecting the provided task to the anticipated learning concepts because the concepts were unfamiliar to us”. In support of this idea, the researcher observed that call the names of their friends and objects instead of using the terms in heredity. For example in cell division activities, they didn’t use the term centromer, chromatids and the likes. Students were seen the activities as a game rather than relating the activity with expected concepts. This may increase their interest but may not facilitate conceptual understanding. Therefore, according to De Jong (2008), the context-based approach's failure to help students understand scientific concepts stems from the inability to make a connection between the concepts that teachers and students use and the concepts that are relevant to the circumstances.

The interview results also demonstrated that the respondents from treatment group 2 explained questions very well by relating their answer with its application indicating their understanding of genetics concepts. However, interviewees from TG1 and CG were seen straining to give the right answer to some queries with justifications. This offers proof in harmony of the findings of the study of quantitative data analysis. The way the teachers taught their students can be used to explain why there are differences between the groups. There for combining concept led-context-based activities may enhance treatment group 2 students to understand those concepts. The study of both quantitative and qualitative data demonstrated that students who were taught genetics utilizing context-based material combined with conventional method of teaching learned genetics more effectively than the other groups. As a result, this group of pupils outperformed the others in terms of concept comprehension. Additionally, REACT alone helps students to understand biology more effectively than conventional instruction alone, despite the difference being negligible.

From the interview result, for example for question number 1 many students in treatment group 1 select the choice B that is pea plants but when they asked to the reason why Mendel choose pea plant for his experiment, they miss the appropriate reason. That is why some students choose all characteristics of pea plant like has inherited traits which is common for all living things and the plant is a dicot plant which was not considered by him. This showed that giving the reason for their choice was challenging.

The researcher found that many students in each class were passive in their involvement and lacked confidence when they shared their views, according to observation data collected at the start of the intervention. Only group leaders react for the question raised by the teacher.

The additional findings from observation data from treatment group 2 students revealed that students who were taught using an integrated approach gradually gained confidence in their ability to complete various tasks. They also used the proper terms in genetics to reflect their thoughts on the tasks rather than the names of the students and objects since they were introduced at the start of the lesson. For instance, pupils in treatment group 2 call all four nitrogen bases fully by saying Adenine, Guanine, Thiamine and Cytosine while doing DNA replication activities instead of saying A, G, T and C like that of students in treatment group 1. Therefore, introducing the concepts first and followed by the experience based activities to apply the concept help students to internalize the concept. Therefore, pupils in treatment group 2 may have performed better than pupils in the other groups for this reason.

The majority of the students in this class, according to the data gathered from classroom observations of comparison group students who received conventional instruction, had less participation and interest. Instead, they were passive listeners, and their interactions during the discussion were poor. As usual, group leaders speak, while the rest of the group members listen what the leader said. Students were taught concepts in text form and were expected to accept the material given to them without questioning, debating, or pointing out any of its shortcomings. As a result, it was discovered that this approach did not help pupils better understand topics or accelerate their learning.

According to research, a student's academic success is not defined by their ability to memorize information in order to pass an exam, but rather by how well they comprehend the subject that is being taught to them (Mills, 2016). Another finding from this study was that while students may achieve better on exams created using multiple choice assessment methods that are widely utilized, this does not necessarily suggest that they have learned anything valuable or have a conceptual grasp of it. For instance, according to the study's findings, the majority of students in the comparison group correctly answered the first tier but failed to answer the second, which required a justification for their first selection. This is so that students can learn things, but not necessarily understand them. According to Mills (2016), learning about science might not be the same as understanding it. They made the connection between the phrases "knowing" with facts, memorization, and surface knowledge. On the other hand "understanding," which refer to various parts of information integration into a learner's own conceptual framework leads to metacognition.

The study's problem statement states that although Ethiopia's national learning evaluation assessed students' knowledge at lower levels using a traditional multiple-choice exam, the findings indicated that students could not satisfy the minimal criteria. It was discovered that combining a context-based approach with a traditional teaching strategy helped students' to enhance both students' conceptual and scientific thinking. Despite the fact that there was no statistically significant difference in the case of conceptual understanding, this study's finding adds to the empirical evidence for studies Gul & Konu, 2018; Karsli & Saka, 2017 as in Cabbar & Şenel, 2020) revealed the usefulness of using the REACT approach alone on students' comprehension and scientific reasoning compared to traditional instruction. The results demonstrate that using context-based instruction to supplement conventional ways of instruction is superior to using REACT or conventional methods of instruction alone.

The integration of context-based learning with conventional education allowed students to draw connections between the subject and the situations they encountered every day. Students can learn by creating a connection their own life experience through contextual events and real-world scenarios. The context-based learning-based exercises made it easier for students to retain the knowledge they had learned. This circumstance improves the information's long-term viability for grasping biological concepts (Cabbar & Şenel, 2020). Learning happens at the conceptual level when the learner is able to make meaning of the information. This conceptual level learning is applied to other contexts and used to address issues, demonstrating higher-level cognitive processing abilities in the learner. The student can use any situation to understand concepts while using the context based approach. It is important to create a variety of social, cultural, and physical situations that are conducive to conceptual learning. Increased knowledge and desire for the topic will result from questions and circumstances that relate these surroundings to real-life (Cabbar & Şenel, 2020).

Generally, context based approach emphasizes on a meaningful learning and associates with the environment and students' experience making it simpler for pupils to comprehend what is being learned. Context based approach also gives students the opportunity to gain knowledge, find experience and then discuss it in groups so students become motivated in learning and their learning outcomes become increase. Learning by using context based approach emphasize the context relating to the students' learning environment, so that the learning lead to a meaningful and influential learning on students' cognitive learning outcomes (Hasanah et al., 2019). Moreover, learning in the form of group work proved to be able to show excellent learning outcomes. This is due to the process of constructing knowledge on context based approach carried out together while in the conventional learning process with the lecturing system, discussion and question and answer process the construction of knowledge is carried out individually according to what is captured by individual students (Hasanah et al., 2019). Constructing knowledge together with group members allows students to express ideas and opinions, listen to the opinions of others and jointly build knowledge. Group members can also encourage each student to help each other to master the material topics taught by the teacher.

The pupils in the two treatment groups scored higher than the students who received conventional education. The majority of students in the comparison group correctly answered the first tier but failed to respond to the second tier, which asked them to explain their first choice. This may be the case because although kids may learn topics, they may not fully grasp them. The lecture method of teaching and studying biology topics typically does not help students to develop a solid grasp (Bao et al., 2018). This implies that the instruction should go beyond conventional instruction if developing students’ conceptual understanding is the goal. In the following section, studies are discussed that support and contrast the present study.

According to Karslı and Patan (2016), when compared to pre-test, the experimental group's pupils had either fully or at least much fewer misconceptions. This circumstance is a direct result of the researchers' interventions employing the context-based method improving their conceptual comprehension. These studies came to the conclusion that activities carried out in accordance with the phases of the context-based approach stages and instructional materials had a favorable impact on students' conceptual understanding. It is common knowledge that when real-world examples appropriate for their level are utilized in circumstances that are familiar to them, students are more interested and able to participate in lessons. These outcomes may have also been facilitated by the fact that classes delivered utilizing the context-based method allowed students to see scientific concepts as a part of their everyday life. The results might also have been impacted by the fact that context-based teachings encourage students to participate more actively and have more fun in class (Gilbert et al., 2011).

A study by Karsli and Saka (2017) on the topic of "Let's Know Foods" was covered in the learning environment built in accordance with the REACT strategy from the context-based approach, and it was included in Cabbar and Şenel (2020) review. It was discovered that the application's context based approach had a beneficial impact on students' conceptual understanding. Additionally, it was shown that in terms of students' conceptual changes, the learning environment created using the REACT technique outperformed the one created using the 5E teaching paradigm. Accordingly, as mentioned in Cabbar and Şenel (2020) review, Acar and Yaman

(2011) argued that the courses created and implemented using the context-based learning approach had a beneficial impact on the students' comprehension of the subject of "microorganisms". The context-based learning strategy is crucial for piqueing students' interests and desires, and success is positively impacted by it as a result of activities designed to build biological concepts.

In the review of Cabbar and Şenel (2020), Gul and Konu (2018) also used context based approach to see its effect on conceptual understanding of the topic of digestive and circulatory systems. There were no discernible differences in posttest scores between the experimental and control groups when the results of the digestive system test were compared. However, a statistically significant rise was discovered in favor of the experimental group when the results of the circulatory system test were evaluated. This demonstrates how the technique affects certain subjects in different ways. The method has some drawbacks for some subjects, it was found after the semi-structured interviews.

Even while the majority of researches have discussed the benefits of context-based chemistry studies, some of them have also mentioned their drawbacks (Ultay & Calik, 2012). According to Campbell and Lubben, context-based chemistry learning is not automatic because outside-of-school learning predominates, as was mentioned in the review by Ultay and Calik (2012). In their review of 17 researches on context-based learning that were published between 1980 and 2003, Bennett et al. (2007) reported that "context-based approaches improve understanding of scientific ideas as comparable to that of conventional approaches." As a result, it can be assumed that there isn't any conclusive proof that context-based learning has improved students' conceptual comprehension thus far (Podschuweit & Bernholt, 2018). However, there has been criticism of context-based learning that claims the extra knowledge contained in such a cultural framework would prevent conceptual acquisition since it would overwhelm the scientific fundamentals (Lye et al. 2001, as cited in Podschuweit and Bernholt (2018). They facilitate a more abstract learning style that makes it simpler to identify and comprehend fundamental ideas.

According to a recent study by Podschuweit and Bernholt (2018), when comparing students in the two experimental groups on the abstract items, no changes in scores and learning gains were discovered. Students in both groups found it challenging to generalize and de-contextualize the general principles and concepts underlying the context-based learning scenarios they had encountered because they were told that knowledge gained through contextualized learning does not easily transcend the learning domain. However, the short intervention period and the constrained range of contexts in which students participated may possibly have contributed to the failure of abstract transfer to manifest in experimental groups. They also noted that boosting learning chances and time can have a good outcome. Additionally, they proposed that the nature of the situations in which students learn about scientific concepts affects how well those concepts are understood by students. This indicates that a wider learning window appears to facilitate the application of conceptual information to new contexts.

Out of 32 investigations, five concluded that settings boost students' achievement, and three discovered some evidence of better motivation and interest in physics. Three studies, however, found no distinction between students' achievement as measured by the contexts and the content. The findings and conclusions of the studies indicate that there are no adverse effects on students' attitudes or academic performance, however some studies' findings did not indicate any beneficial benefits on students. Accordingly, a context-based approach to education cannot guarantee a solution to systemic problems, but it can make them easier to resolve (Ultay & Ultay, 2014). One study that was included in the evaluation also demonstrated that PLON students did not learn as well as students in traditional courses. However, three studies also discovered no distinction between context-based classes' success and problem-solving abilities and those of control classes.

By stimulating students' assumptions, which serve as the foundation for meaningful learning, context-based education is anticipated to increase students' knowledge (Abd-Raub et al., 2015; Janssen & Fred, 2014). As a result, through social contact with their teachers and peers, the students will combine the new information they have learned with what they already know to create new knowledge in their minds (Abd-Raub et al., 2015). Students with varying abilities, passions, backgrounds, and cultural backgrounds can benefit from a context-based education approach, where teachers modify their teaching methods to better suit the needs of their students and account for their assessment. Students will not only digest the lesson's content through contextual learning exploration, but they will also look for supporting evidence to support the lessons they have learned in real-world scenarios (Abd-Raub et al., 2015).

According to Stanisavljević et al. (2016), there was a statistically significant difference in how well the treatment group performed on the post test evaluation of knowledge, scoring highly on both individual ranks and the exam as a whole. Studies have also shown that biology lessons are more effective when they are related to the prior experience that students have gained in real-world settings. Giamellaro (2014) provides an account of the fundamental contextualization procedures that take place during science immersion excursions and the subsequent student learning in high school ecology classrooms (n=67) and teachers. He made the following claims: (1)

These immersion experiences were connected with significant learning; and (2) There was a positive relationship between the degree of contextualization and the degree of learning (Giamellaro, 2014). However, the data source for this study was primarily self-reports of student learning experiences. The data indicated a definite association between contextualization and the growth of scientific knowledge, but the range of conditions necessary for this relationship and how closely the content and context must be aligned to produce the outcomes are unknown.

According to Kazeni and Onwu (2013), using a context-based teaching strategy improved students' performance in genetics, higher-order thinking abilities including problem solving and decision-making, and attitudes toward life sciences more effectively than using a traditional teaching strategy. There was no mention of the approach or instructional method employed to deliver the lesson. Additionally, Özay Kose and Çam Tosun (2015) research demonstrated that the context based approach benefits conceptual comprehension and ideas about biology. Additionally, their qualitative study reveals that context-based teaching methods facilitate student understanding, learning, and memory.

4.2.3 Discussion on Epistemological belief (EB)

"What is the difference between the two treatments and comparison groups on their epistemological beliefs?" was the study's fourth research question. Students' epistemological beliefs were tested by giving out an epistemological belief questionnaire before and after the intervention to see if there was a significant mean score difference in the students' epistemological beliefs between groups. Pretest analysis indicates that no significant differences between groups were found. Following the intervention, there was a difference between the groups with TG 1 (M = 70.66) and TG 2 (M = 64.58) having higher mean EB questionnaire scores than the comparison group (M = 56.09). The ANOVA result showed that some groups' mean scores are statistically different from those of the other groups. Treatment groups 1 and 2 both had mean EB questionnaire scores that were significantly different from the comparison group. But TG1 and TG2 did not differ in a statistically meaningful way.

This study looked at the students' epistemological beliefs in relation to whether they learnt biology using the CLASS-Bio in a short amount of time and developed more expert-like perspectives on the subject. The statistical importance of perceptional variations along the novice-to-expert-like continuum was examined through analysis. The results of this study revealed that substantial variations were seen in a number of CLASS-Bio categories as well as in students' overall epistemological attitudes about acquiring "expert-like" knowledge. The findings were inconsistent, ranging from more mature, expert-like ideas of biology (TG1) to students' thinking becoming much less expert-like over the course of a term of education (CG) to changing little in three categories (TG2). In light of this, Semsar et al. (2011) discovered that significant changes were observed both generally and in problem-solving-related categories, such as reduced reliance on memory, higher pleasure of science, and improved comprehension of conceptual connections. The results of this study indicate that, beyond basic gains in content or conceptual understanding, the REACT technique with diverse activities is likely to have significant effects on students' perceptions of the nature of scientific knowledge and scientific thinking abilities.

Students in treatment group 1 significantly changed their beliefs in four CLASS-Bio categories, including "real world connection, enjoyment, conceptual connections, and problem solving synthesis and application," to reflect those of experts. On the other hand, students have inexpert ideas about three areas of problem solving, including "problem solving effort, problem solving reasoning, and problem solving strategies." Students in treatment group 2 demonstrated expert-like shifts in all three CLASS-Bio categories, in accordance with TG 1 students, with the exception of enjoyment, which remained unchanged. Thus, students in both REACT and combined methods significantly shifted in the direction of more novice-like beliefs in three CLASS-Bio categories (problem solving effort, problem solving reasoning, and problem solving strategies), but significantly shifted in the direction of expert-like beliefs in several CLASS-Bio categories (real world connection, conceptual connections, and problem solving synthesis and application). Ultay and Calik (2012) examined 34 studies and found general knowledge claims regarding the context-based studies to be both favorable and negative. They have observed that context-based chemistry lessons are more successful at fostering favorable views of chemistry. The context-based approach combines chemical concepts into actual life or situations; thus, this result is expected.

Supplementing the biology curricula with context based activity presented with materials concerned on fundamental concepts could be an imperative way in assisting students in acquiring more mature perspectives on science. This may reduce the possibility of students being overcome with specific details and perhaps even serve as a benefit to help them navigate through core concepts in describing and explaining natural phenomena (Ding & Mollohan, 2015). Another reason for belief shift may be because activities which are closely related to their experiences and in contexts with their own life were frequently introduced. As such, the students may tend to view the subject matter from a more holistic and positive perspective. In similar manner, Ding and Mollohan (2015) conclude that the usefulness of the information that means not burdened by detailed information to which the non-science students are exposed may have facilitated their shift toward more expert perspective. The changes show a growing awareness of the nature of biological knowledge and a rise in scientific reasoning proficiency. The observed alterations suggest that scientific thinking abilities have improved along with an evolving understanding of the nature of biological knowledge.

Students in the comparison group did not differ significantly in their epistemological views and in all categories of epistemological beliefs; they shifted negatively at post-instruction with the exception of conceptual connection, which improved insignificantly. Similarly, other researchers have discovered that science majors have epistemological beliefs that are more expert-like prior to instruction, which then deteriorate or do not significantly improve after receiving conventional instruction (Hansen & Birol, 2014; Ding & Mollohan, 2015). This is because students in the comparison group use an overloaded curriculum and may feel overwhelmed by the large amount of content details, hence the alternative to memorization as a way to simply pass the exam. Moreover, it is due to the fact that the textbook contains theoretically abstract details with less emphasis on how applicable the topic is in the actual world. The textbook contains review questions for each topic, and the question asked to list terms that asked the students to memorize what they had learned. For example, list out the phases of mitotic cell division. Consequently, this may lead comparison groups to perceive the content as intrinsically detached from and less pertinent to their everyday lives. Similarly, they feel that genetics are difficult and even hard to memorize.

Professionals are able to recognize "features and meaningful patterns of information that are not noticed by novices," according to an article on the development team of the CLASS-Bio instrument. According to Adams et al. (2006), Barbera et al. (2008), Semsar et al. (2011), and others, experts "acquired a great deal of content knowledge that is organized in ways that reflect a deep understanding of their subject matter." In REACT classrooms, adding in student discussions of scientific topics might help students feel more confident and improve their ability to organize and apply their subject-matter knowledge. They therefore do higher in the field of problem solving, synthesis and application. In turn, this skill might help students become better at spotting informational patterns (Madsen et al., 2015). Therefore, Igwebuike and Oribhabor, (2016) proposed that if students are provided the topics using a context-based teaching method, in terms of their opinions on the field and the best ways to learn it, they ought to be on par with or even closer to specialists.

This study's findings are consistent with those of other studies. For example, Ding and Mollohan (2015) and Mollohan (2015) used CLASS-Bio to compare an introductory biology course for non-majors with a different course for science majors on the same campus, they found that non-majors made some expert-like gains while science majors made none. Despite having differing objectives, the two studied courses both "covered" introductory biology. After teaching in every category of CLASS-Bio, science majors demonstrated noticeably more novice-like beliefs, which is why the course for majors focused on biological detail and theory. Two CLASS-Bio categories (overall and problem solving method) showed significant expert-like shifts, whereas just one category (problem solving reasoning) showed a novice-like shift. The non-majors' course adopted a broader viewpoint and placed emphasis on the societal importance of science and technology. This result may be highlighted and taken into account as evidence that alternative curricular design can have a significant impact on how students perceive science and perform on the CLASS-Bio. To avoid overloading the content with abstract notions, which would have forced students to develop memorization of facts and theories in order to get 50% or above on the exam, the activities used in the current study were crucial to giving the concept tangible meaning.

Madsen et al. (2015) reviewed 24 research projects on epistemological beliefs and made a number of statements about how different teaching techniques or curricula affect shifts differently. They came to the conclusion that the teaching style accounts for the most difference in the CLASS and MPEX changes. It's interesting to note that physics students in a sizable "reform-oriented course" did not change their opinions of CLASS-Physics to reflect those of experts (Adams et al., 2006). However, considerable expert like movements on CLASS physics were observed in a course that was redesigned to concentrate on Physics and Everyday Thinking, modeling, and moving away from the more conventional curriculum.

According to the literature, everyday thinking and experience are included in activities or classes that encourage reflection on learning, interaction with intuitive notions and formal scientific reasoning, and an understanding of how scientific information is produced. The courses taught using conventional or reformatted teaching techniques have a tendency to cause negative shifts in views. Even when pre-test scores are taken into consideration and pre-test scores are marginally predictive of these shifts, Madsen et al. (2015) discovered that the teaching technique is the strongest predictor of shifts on the CLASS and MPEX. Since the type of teaching strategy and activities utilized in the current study were what caused the shift, all students initially held beliefs that were quite similar, and there was little variation between the groups' pre-test results.

Similarly, in two sections of a large-lecture introductory course on cell and molecular biology, Cleveland et al. (2017) used a quasi-experimental design to examine the effects of various active-learning strategies on students' conceptual understanding, epistemological beliefs, and motivation. Students in both groups showed comparable and significant learning improvements as a result of the use of active learning methodologies like clicker-based case studies and graphic organizer/worksheet tasks. Particularly, students who had engaged in worksheet and graphic organizer exercises showed more expert like epistemological attitudes in relation to their love of biology and capacity for making connections with the real world than comparison groups. The epistemological beliefs of genetics students who used CLASS-Bio in a newly created summer genetics course built in active learning communities are described by Westerlund and Chapman (2017). The investigation was done over the course of two summer sessions in 2015 and 2017. Multiple CLASS categories showed substantive and statistically significant variations between pre- and post-averages, showing the importance of community-based activities in the development of beliefs.

In general, research has shown that learners' epistemic views frequently alter over time due to developmental and cultural changes. For instance, Duell and Schommer-Aikins (2001) demonstrated that some kids, but not all, start to understand that knowledge is a subjective concept and that several viewpoints on a subject may be equally legitimate when they enter middle school and high school. At the high school level, further changes can happen as well. For example, students in grade twelve are more likely than those in grade nine to believe that knowledge is made up of intricate relationships rather than discrete facts, which necessitates conceptual understanding and memorization; that learning occurs gradually rather than quickly, necessitating the use of problem-solving techniques; and that learning capacity can be enhanced through practice rather than being fixed at birth, which calls for problem-solving effort in the CLASS-Bio categories (Duell and Schommer-Aikins, 2001).

When we look at CLASS-Bio categories, different changes were observed in the present study in different categories at different levels. In the following section, the CLASS-Bio categories in which significant differences were observed are shown below with their possible reason for change or not.

Enjoyment- This area focuses on how much a student likes or is personally engaged in the subject. A representative statement is #2. *I think about the biology I experience in everyday life.* The result showed a statistically significant difference between the mean towards more expert-like views in TG 1. Similarly in TG 2 there was an increase in percent agreement with expertise in this category, but the shift was not significant. In Madsen et al. (2015) reviews' also a positive shift was reported in introductory physics classes in this category while using modeling instruction in their community environment in which students work together on problems. In line with this, Westerlund and Chapman (2017) discovered that one of the five CLASS-Bio categories that saw a positive shift was enjoyment. They draw the conclusion that the community approach used in the summer course, which included chromosome groups and small group discussions, boosted the students' interest in and comprehension of genetics. A noteworthy upward trend was observed in the enjoyment (personal interest) category (74–82%) by Hansen and Birol (2014). The purpose of the current study's activity was to encourage students in treatment group 1 to ask pertinent questions both in small discussion groups and as a class, helping them to relate the material to real-world situations and potentially making the exercise more enjoyable for them. They therefore had a positive move in this area.

Real World Connection- Whether or if students were able to relate the genetics material to their own lives is the focus of this category. The fourteenth statement is illustrative. Understanding biology has altered my perception of how the natural world functions. The study's findings demonstrated a statistically significant difference in percent agreement with knowledge between the mean and more expert-like opinions in both treatment groups 1 and 2. In a similar vein, Westerlund and Chapman (2017) found statistical significance in one year, but not in another, when comparing the pre- and post-survey means. It's possible that the lecturer will have made more efforts to offer practical examples of genetics by the time another year comes around. Hansen and Birol (2014) discovered a noteworthy increase in the real-world link category (78–85%). As stated earlier, in this study, almost all of the activities designed for discussion in treatment groups 1 and 2 related the life of an individual to each genetic concept. This might encourage pupils to take a more expert-like stance when it comes to drawing linkages to the outside world. In our society, there is a common Amharic saying that *"science le mark new."* This means they learn science to pass the exam instead of using the concept in their everyday lives. In order to solve this problem, incorporating the experiences or practices of learners while teaching the concept is very important.

Conceptual Connections and memory: This area deals with comprehending ideas through fact memory. For instance, assertion #6 requires knowledge of biological concepts. The laws of biological principles are not going to aid in my comprehension of the concepts. In this category, the pre- and post-means differed significantly. Similarly, conceptual connections/memorization (66–74%) showed a considerable favorable shift, according to Hansen and Birol (2014). It could be because more students thought towards the end of the course that the fundamentals of genetics were crucial to their comprehension in general. Mendel's Law of Independent Assortment, which links crossing over during prophase I of meiosis and results in organismal variation, is an illustration of a genetics principle. By the end of the unit, more pupils expressed disagreement with the aforementioned statement.

The evaluation methods and teaching strategies forced students to believe that learning meant memorizing facts and principles in order to pass exams, according to the results of the data analysis of student interviews. For example, student 1 said, "I like biology and have higher scores than the other science disciplines because our exam questions ask direct questions that can be answered by remembering the concept the teacher presented during the revision section." If so, what makes you believe that most students fail the national exam? "The majority of the questions on the national exam cover topics that aren't covered in class exams and final exams," the student answers. One might infer from this exchange that the types of tests, activities, and instructional strategies affect students' attitudes toward learning. As a result, in treatment groups 1 and 2, the activity that was devised and implemented throughout the intervention period encouraged students to link many ideas, and it may have been a way to convert novices to experts in their perceptions.

The development of students' epistemological ideas was influenced by instruction, planned activities, and assessments, according to the literature (Schommer-Aikins, 2004). For instance, if a teacher only expects students to remember facts without any synthesis or application, it's possible that they'll start to think of knowledge as being made up of discrete facts. On the other hand, if a teacher assigns complicated, time-consuming tasks for students to do, it's likely that pupils would think knowledge is complex and that complex tasks take more time to accomplish (Schommer-Aikins, 2004).

Problem Solving Synthesis and Application - This category concerns application from one problem type to apply their knowledge in another new situation. In this study there was a significant shift in the continuum from novice to becoming more like experts in this category in both treatment group students. An example of a representative statement is Statement #3 *After I study a topic in biology and feel that I understand it, I have difficulty applying that information to answer questions on the same topic.* Most students in both treatment groups disagree with this statement, and this may be due to the activities given at different stages of the REACT instructional strategy at the application and transfer stages. This may help students shift their beliefs towards expertise when the same concept applies in different situations during group discussion. In the activity designed at applying and transfer stage of REACT strategy, students were asked to apply the concept to their real life and on transfer stage new problem was given for discussion to practice in applying information gained in the applying stage of the teaching strategy at a new situation. Similarly, in treatment group 2, the activities address the application of concepts to push students for the application of learned concepts in their daily life.

Expertise disapproves of statement #3, and students' disapproval of it might mean that, when the topic was finished, they felt more at ease using their problem-solving abilities to tackle a related problem type. Declaration #11, Agreement with this statement indicates memorization and using the same pattern to solve similar problems but not in another situation which needs the same concept. *If I want to apply a method or idea used for understanding one biological problem to another problem, the problems must involve very similar situations*. Disagreeing with the statement indicates a shift toward becoming more expert-like in this category, which shows growth in the concept application of pupils in solving various situations. Similarly, Westerlund and Chapman (2017) also found positive results in this category.

Problem-solving Strategies: This category concerns using different ways to solve a given problem. In this study, there were no significant shifts observed in all groups. The purpose of the genetics exercises was to enable students to apply various approaches to address or resolve genetic issues for both treatment groups. Following the intervention, the treatment group and the comparison group in the current study both displayed novice beliefs for this category. Nevertheless, Westerlund and Chapman (2017) noted a substantial difference between pre- and post-mean scores in this area among their students and suggested that since the course was community-based, students might have felt more comfortable approaching others in their groups for help solving challenges.

Problem-solving Effort: This area is for the amount of work pupils do to learn the material and make an effort to comprehend it. No noteworthy changes were seen in any of the groups in this investigation. The thirtieth assertion is a typical one. *When I'm stuck on a biology question, I usually give up after a few minutes or ask for assistance from someone else.* There was overlap between this issue and the problem-solving strategies category. Although the present investigation did not find a significant difference in their shift, the disagreement with this statement demonstrates the expert belief. On the other hand, Westerlund and Chapman (2017) discovered that their genetics students had more expert-like opinions about the value of daily study of genetics and this may have contributed to a shift. Students abandoned the exercise for the group leader based on the observation results, and the group leader requested assistance from other group leaders. "to save time" is how they justified asking for assistance, meaning they did not wait to get the idea.

The propensity to hold a less sophisticated view that learning ability is acquired and changeable is at odds with the long-standing tradition of effort-based beliefs, which encourages students to believe they can enhance their ability and performance through diligence and effort. Despite the conventional importance placed on effort and hard work in education, the study's findings suggested that learners had a weak tendency to believe that information is formed via effort and the process of learning. This indicates that the conventional wisdom that learning and education are linked to effort is incompatible with this discovery.

Problem-solving Reasoning: The statements in this category deal with reasoning in relation to daily life. In this study, there were no significant shifts observed in all groups. Similarly, Westerlund and Chapman (2017) found no significant improvement in this category. Research indicates that although EB in general appears to be rather stable, students' EB related to their domain is heavily impacted by classroom practices and norms and may change over time to conform to the nature of the learning environment (Duffy et al., 2016). For instance, assertion #16 claimed that the ability to reason in biology can be useful in day-to-day situations. The percentage agreements indicated some progress, but it was not substantial. Hansen and Birol (2014) discovered a substantial positive shift for the problem-solving: reasoning category (74–80%, F = 4.12, p = 0.0455), in contrast to the findings of this study. Students made an effort to clarify the purpose of the activity and make a personal connection during the intervention period.

Gilbert (2006) distinguished a number of context-based scientific education models; therefore it would seem obvious to choose the model of context-based biology education that appears to hold the greatest promise for boosting students' interest in biology (education). However, according to Van and Boersma (2018), selecting a context-based biology education model cannot be based solely on which model could best motivate pupils. Our understanding of the nature of biological knowledge in general will also play a significant role. Accepting or rejecting the idea that biologists learn the truth about biological objects and that biological knowledge is true or false or do we concede that biological knowledge is a product of social construction and only makes sense when put to use? According to Van and Boersma (2018), these two perspectives pertain to opposing epistemologies, a positivistic and a relativistic view.

In summary, a teacher in TG 1 supported students learning by engaging them in the interactive activities of context-based intervention material. Initially, at the training session, teachers told students that context-based material would be motivating. Most students found context-based material motivating and interesting because of visualization and practical activities, as found in their post-instructional interviews. Students in this group score higher than both TG 2 and comparison groups in epistemological belief than conceptual understanding and scientific reasoning. But they strictly said that it was time-consuming and mostly took the activity as a game rather than using it for concept learning.

The results of the students in the comparison group were significantly different from TG1. The comparison group students, overall and in each category of epistemological beliefs, nave beliefs were continued through the intervening period. This finding is consistent with Mulugeta's (2019) discovery. This might be because students in CG who were taught conventional approaches stacked on the questions that needed memorization and lacked conceptual connections in their text books. Another reason may be the type of activity. This is because traditional classroom instruction practices typically feature simple, closed activities that concentrate on a limited set of skills. A person would be less motivated to work hard or exert much effort to learn things if they had a more naive view of control over knowledge. Because they believe that learning ability is innate, such pupils are less inclined to adopt different learning tactics. This might be the case because students who hold naive views are more likely to rely on surface learning techniques or lower-order cognitive abilities like memorization, rote learning, and easy recall to help them understand the subject or body of knowledge (Mulugeta, 2019). Epistemological views underwent significant unfavorable alterations as a result of conventional training (Madsen et al., 2015).

4.2.4 Discussion on Associations of variables

The fifth research question was: What are the relationships among students' scientific reasoning skills, conceptual understanding, and epistemological beliefs after context-based intervention? In relation to this research question, according to the outcome, there was a moderate positive correlation between conceptual understanding and scientific reasoning. There was a moderate association because r =.433, which is found between 0.41 and 0.60. In other words, a student who understands the concept well is better at reasoning than one who does not, and vice versa, since reasoning requires domain-specific knowledge. This result is consistent with Lawson and Snitgen (1982) and Nnorom (2013), who emphasized that since science does not entail guesswork, students who reason logically perform admirably in science courses. According to those studies, students who use strong reasoning abilities outperform those who use weak reasoning skills. This has become vital because biology students perform better academically when their thinking abilities are used appropriately. Similar to this, growth in conceptual scientific knowledge has been linked to improvements in student scientific reasoning abilities (Stammen et al., 2018). In order for pupils to thrive in subsequent science courses, they also recommended that science professors put a strong emphasis on authentic practices that allow students to hone their scientific reasoning abilities.

According to research, curricular goals that emphasize scientific reasoning are consistent with those that emphasize conceptual knowledge, which are concurrent with and dependent upon one another (Bao & Koenig, 2019). Robust reasoning requires both depth and breadth of subject matter expertise to find relevant and influential information. On the other hand, people with excellent thinking abilities are also better at connecting ideas. Studies indicating higher conceptual comprehension is also present in people classified as having advanced reasoning skills suggest this (Schen, 2007; Zimmerman, 2005; Zohar & Nemet, 2002). Similar to this, Zohar and Nemets' (2002) research revealed that students increased the quantity of biological information they incorporated into their arguments. In the end, context-based socio-scientific issue debate develops specific reasoning abilities and skills in a way that enables students to comprehend scientific issues and content more deeply.

This finding is consistent with that of Bakar et al. (2018). They discovered that grasping fundamental mathematical ideas lays the groundwork for mastering more complex ideas as well (Bakar et al., 2018). The Spearman correlation coefficient between the capacity to understand mathematical concepts and mathematical reasoning was 0.801, and the significance level (p value) was 0.000. As a result, it could be inferred from the criteria of the connection that the capacity for understanding mathematical concepts and the capacity for mathematical thinking were substantially and positively connected. This meant that there was a correlation between high proximity and the capacity to comprehend mathematical ideas and use mathematical reasoning. Higher reasoning skills were more frequently seen in students who understood mathematical topics well. Thus, understanding genetics concepts and reasoning was established by the combination of context-based learning activities with conventional instruction.

However, numerous empirical studies have shown that knowing the sciences does not always translate into more sound scientific reasoning. For instance, Bao et al. (2009) evaluated the scientific reasoning and understanding of university students from China and the United States. They discovered that whereas Chinese students performed similarly to their American counterparts on the science reasoning test, they performed significantly better on the science knowledge test. For instance, there is research to suggest that reasoning skills as well as epistemological beliefs and beliefs toward a discipline may both be important influences on content learning (Adams et al., 2006).

In the current study, there is either little or no association between students' epistemological beliefs and their conceptual knowledge as well as their scientific reasoning abilities. Similar results were made by Jeffery et al. (2016), who discovered that students' individual views on scientific inquiry at the conclusion of the term were unrelated to their understanding. As a result, some have asserted that having a solid conceptual grasp does not necessarily translate into having better physics epistemological beliefs (Madsen et al., 2015). According to Flora (2014), there is no connection between conceptual comprehension and epistemological views. Hansen and Birol (2014) discovered no statistically significant association between the performance (cumulative GPA) of the students at the start of the program and the overall percent positive score in their cohort analysis. This indicates that students' epistemic ideas about biology are comparably novice when they enter a university biology program.

Mollohan (2015) investigated undergraduate students' association of scientific reasoning abilities with conceptual understanding and the epistemology of the study by using multiple years and majors in a large-scale descriptive study. The specific questions addressed included the association between quantity of content learning (rank/year) and context of content learning (major) in relation to student scientific reasoning abilities. Except for a possible weak relationship between reasoning and cumulative GPA, the results showed no correlation between scientific reasoning and cumulative GPA, epistemologies, a number of undergraduate courses taken, or standardized test score. Additionally, he determined student epistemologies are related to student scientific reasoning abilities with a smaller sample of intermediate and upper-level biology students by using both the CLASS-Bio instrument and the LCTSR questionnaire.

Hotulainen and Telivuo (2014) contended that the nature of epistemological beliefs is a result of scientific reasoning level, which is at odds with the results of the current study. It is beneficial to teach a subject while keeping in mind the epistemological views of students since positive student epistemological beliefs may enhance the probability that those notions will stick in the memory later (Westerlund & Chapman, 2017). According to Hansen and Birol (2014), students who perform better academically in biology also hold more positive epistemic views about the field. When Hansen and Birol (2014) used the CLASS-Bio to assess student epistemological views, they discovered that fourth-year college biology students who performed well exhibited more expert-like epistemological beliefs than those who did not. It is envisaged that students would continue to grow and remember genetics with more positive or expert-like epistemic attitudes. According to Jeffery et al. (2016), academic achievement and enrollment in a guided-inquiry lab course had a noteworthy and favorable impact on the proportion of expert-like student epistemic beliefs and opinions at the end of the term. In a large sample of college biology students, Fiedler et al. (2019) discovered that statistical reasoning and probabilistic thinking demonstrated significant and robust connections with knowledge of evolution.

Others found both negative and positive correlations between conceptual understanding and epistemological beliefs in a single study. For instance, sophistication in the certainty and justification dimensions is favorably correlated with conceptual understanding, whereas sophistication in the source dimention is adversely correlated. Furthermore, according to Bahcivan (2015), pupils' conceptual grasp of "force and motion" has not been significantly correlated with simplistic views.

The insignificant correlation between epistemological beliefs with both conceptual understanding and scientific reasoning may be affected by different factors, including the instrument, the age of students, and the topic itself. Before drawing any conclusions about how incoming beliefs affect learning, it is important to take into account a number of other factors, particularly those describing the students and the course. Other researchers discovered a weak but substantial relationship between students' pre-course conceptions about learning physics and their conceptual growth. This research implies that people who think more like experts do so when learning physics. If this were the case, it would suggest that even if your only concern is the learning of your pupils, developing expert-like beliefs in them could help them learn physics (Madsen et al., 2015).

In contrast to the present study results, relationships were found between conceptual understanding and scientific reasoning and epistemological beliefs (Alsumait, 2015). Epistemological beliefs can influence students’ ability to think scientifically, conceptual understanding, and reasoning skills during biology learning. Alsumait (2015) made the generalization that learners' motivation, academic performances and successes, self-regulated learning, thorough understanding, learning approaches, and more learning-related aspects are connected to the thoughts and beliefs they have about what they learn (knowledge) and how they learn (knowing).

In contrast to the current study, Yang and Tsai (2010) came to the conclusion that children's use of scientific reasoning in informal settings can be predicted by their viewpoints on epistemology, regardless of the domain specificity. This finding supports the notion that the development of scientific reasoning is parallel to the development of personal epistemology. It also supports the finding from a previous study that showed a higher success rate for scientific reasoning among 10th graders who were mostly identified as multiplists. These absolutists were later discovered to be less capable than multiplists of balancing theory and evidence. Additionally, individuals who held a plurality perspective on the nature of knowledge outperformed absolutist views in terms of the coordination of theory and evidence. Children's reflective thinking was found to be used in the land-subsiding debate to either confirm or seek specific answers, rather than to support assertions or personal views (Yang & Tsai, 2010).

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATION

Introduction

The key points of the study's methodology, conclusions, and next steps are discussed in this chapter. This mixed-methods study sought to determine the degree to which the use of a context based instructional approach with the REACT strategy and conventional instruction combined with context-based activities in comparison to conventional instruction had an impact on students' understanding of biology concepts, scientific reasoning abilities, and epistemological beliefs. A synopsis of the entire study is presented in the chapter's opening paragraph, and then the main conclusions and findings are discussed. The chapter ends with submitting some recommendations based on the study's findings to the relevant bodies.

5.1. Summary

This study's major goal was to look into how a context-based approach affected students' biology learning outcomes. Conceptual comprehension, scientific reasoning, and ideas about biological knowledge and learning are some of the biology learning outcomes included in this study. These outcomes are tested using a conceptual understanding test, a science reasoning test, and an epistemological belief questionnaire. The purpose of the study was to examine the impact of context based education using the REACT strategy and conventional instruction integrated with context-based activities on the mentioned student learning outcomes as compared to conventional instruction on the aforementioned student learning outcomes. Ethiopia's Debre Birhan 10th graders were the subjects of the study. For this study, an experimental, mixed-methods research approach was adopted. The comparison and treatment groups each consisted of three schools that were randomly selected. On one group from each of these schools, three distinct instructional approaches were developed and put into practice. The comparison group received conventional instruction, treatment group 2 received conventional instruction combined with context-based activities, and treatment group 1 received the REACT strategy.

Three 45-minute instruction sessions each week was used for the six-week duration. Training on the context based instruction and how to carry out the how to carry out the intervention was given to teachers in treatment groups 1 and 2. Additionally, prior to the execution of the intervention, pretests for conceptual comprehension, scientific reasoning abilities, and epistemological beliefs were administered. After the intervention was over, the same test was administered as a post-test. The researcher watched classes in each of the three groups during the six-week intervention period, and it was clear that the teachers felt confident in the guidelines since they had lesson plans that served as teacher guides. It was ensured that the teachers carried out the interventions as expected by the researcher since the techniques contained in the approaches offer a planned and clearly defined order of instruction. Additionally, information was gathered through focus groups and semi-structured individual interviews with the two treatment group students.

Along with additional descriptive analyses, paired t test, ANOVA, and MANOVA were used to investigate the data. Because there were two moderately correlated dependent variables, MANOVA was used to carry out both the descriptive and inferential statistics. The dependent variables in the MANOVA were the students' post-GCUT and post-SRST scores, whereas the independent variables were the teaching strategies. An ANOVA analysis was carried out to look at how instructional styles affected epistemological beliefs. Null hypotheses were examined to investigate the first five study questions. In order to explore the first five research questions, null hypotheses were tested. Additionally, analysis was done with the information gained from the observations and interviews. The data gathered from the learner interviews in the two treatment groups was used to answer the final study question.

Prior to the intervention, ANOVA findings revealed that there was no significant mean difference in the students' prior knowledge of biological topics, scientific reasoning and epistemological attitudes between the three groups. The percentage of pupils at each level was nearly identical when it came to scientific reasoning, and it was discovered to be at a lower level. As a result, it was assumed that all pre-intervention characteristics were equivalent for the three groups. We might therefore conclude that the six-week duration of the intervention was the cause of the variations that were seen at its conclusion.

Students in treatment group 2 greatly outperformed the other two groups in conceptual comprehension and scientific reasoning, according to the study's findings. But there was no discernible distinction between treatment group 1 and the control group. This suggests that combining conventional education with a context-based approach has an impact on students' conceptual understanding and scientific reasoning that is noticeably stronger than that of traditional instruction alone. According to the study's findings, pupils in treatment group 2 outperformed the other two groups in terms of conceptual understanding and scientific reasoning.

CLASS-Bio was utilized in this study to document the shift in students' perceptions about biology over the course of an intervention session. The study's main conclusion regarding epistemological beliefs was that although students in treatment groups made multiple significant shifts toward more expert-like perceptions of science than students in comparison groups, they started the biology lesson with similar epistemological beliefs toward biology. However, TG1 and TG2 did not significantly differ from one another. This shows that the context-based approach had a more positive effect on students' epistemological belief shifts toward expertise than traditional instruction did. Students also improved in terms of enjoyment, connection to the actual world, synthesis and application of problem-solving strategies, and connection of concept. On the other hand, the epistemological ideas regarding approach, logic, and effort in problem-solving remained unchanged. The information collected through in-class observations and interviews supported the findings obtained through the tests and questionnaires.

5.2 Conclusions

There is a continuous attempt to improve students' conceptual knowledge, scientific reasoning, epistemological views, and their applicability to daily life in primary and secondary schools as well as through higher education. Different creative curricular frameworks and instructional methods must be taken into consideration in order to improve students' scientific learning. There is a special need for educational strategies that assist students in comprehending science in general and using what they learn in daily life. The results of this study show that a activity combined with traditional instruction is more effective than other instructional approaches at improving student science learning (conceptual understanding, scientific reasoning, and epistemological beliefs).

In conclusion, the present study assured that a context-based approach integrated with conventional methods of teaching was effective in fostering students' scientific reasoning skills. Supporting the context-based approach with conventional methods of instruction is significantly better than both REACT and conventional methods of teaching alone. The activities designed based on the syllables of Ethiopia in order to facilitate students' reasoning by focusing on "how and why" questions instead of asking low-cognitive-level questions are recommended. This study was limited to one chapter on the topic of heredity for six weeks. It is recommended that semester- or annual-level intervention might be needed to maximize the impact of a context based strategy on the scientific reasoning skills of students.

For students to develop reasoning skills and higher-level thinking, reasoning skills must be exposed to them in the classroom or through teaching methods. The technique of a context based approach is extremely well matched to the biology topic as a result of the lectures to make students more focused and the reflection on making skills relevant to current concerns in their everyday lives. Discussion of context-based activities needs to be emphasized so that students are not only able to find solutions to problems and make decisions, but they can also practice them in their daily lives. It is hoped that these context-based activities might be included in biology curricula.

The overall results of the study indicate that by engaging in experience-based learning activities and classes, students can improve their scientific thinking and comprehension of the process by which scientific information is produced. Even though every student had the same epistemological ideas before the intervention, the results of the post-test showed a substantial difference between the groups. This implies that it is essential to highlight the application of biology to everyday life in order to help students develop attitudes befitting experts. The current study's findings highlight how crucial context-based methods are for creating the perfect learning environment and enhancing instruction facilitation. Similar to other active learning procedures that produce expert-like epistemic beliefs, the implementation of context-based learning led to expert-like alterations across many CLASS-Bio categories. This is why doing experience-based learning activities appears to benefit all students by fostering the development of better informed perspectives on science. As a result, if students have a top-notch education, their views on biology and the best ways to teach it will resemble or be on par with those of experts.

The secondary school level research that is now available is encouraging for the development and assessment of context-focused instructional materials that seek to alter students' conceptions of reality. According to the results, encouraging students to practice biology on a daily basis could help them become proficient in the real-world link category. When genetic terminology and concepts are taught starting in grade 10, it is anticipated that students would continue to enhance their knowledge of genetics and retain it with more comforting or expert-like epistemic beliefs. Most significantly, if they keep learning utilizing context-based methods, kids will debate and make decisions on social issues in society. It is conceivable to argue, however, that students will not be sufficiently persuaded to abandon their firmly ingrained starter views by a single subject intervention. Reiterating the fundamentals of science could be necessary to bring about long-lasting shifts in epistemic perspectives. To promote a culture of context-based learning, all disciplines should utilize their unique context.

5.3 Recommendation and future research

The results of this research suggest that activities based on students' experiences may be a more effective way to improve students' biology learning. The study suggests curriculum makers, teachers, and students use this method of teaching and learning to help their pupils grasp biology and other subjects better. The findings of this study also imply that appropriate content and pedagogy that fits constructivism—today's most popular learning theory—should be incorporated by policymakers, curriculum developers, textbook authors, and other stakeholders in order to maximize students' learning outcomes and prepare them for the twenty-first century. The ministry of education should revise the biology curriculum to assist teachers in relating their lessons to students' actual experiences by using examples from the students' immediate surroundings. It is possible to successfully integrate context-based teaching and learning methods with traditional instruction. Because the study's findings showed that the integrated approach—which combines traditional instruction with context-based activities—relatively well, educators are encouraged to try these types of integrated teaching strategies in their classrooms.

Nonetheless, in order to adequately enlighten these stakeholders, more study is needed. Therefore, more investigation is required to offer more concrete proof of the method's efficacy. Incorporating cultural, personal, and social experiences and practices into learning activities helps students use scientific knowledge to solve their everyday problems. Additionally, in light of the results, the researcher suggests additional study in the following fields:

Two-tier tests are regarded as a credible and trustworthy technique for better evaluating student ideas since they take into account the justifications and explanations provided by the students for their responses. Therefore, it is advised that school teachers employ two-tier assessments to determine how well their students understand the concepts they are teaching. Additionally, it is advised that others assess the students' degrees of understanding of the topic under research by using two- or three-tiered tests and a manageable sample size.

In order to develop learners' abilities to apply biology concepts to physical circumstances, reason with them, and solve various types of problems (including new ones that are not practiced in class), teachers and students should be knowledgeable about appropriate understanding in addition to using student-centered teaching and learning methodologies. Curriculum planners and authors of biology textbooks need to reevaluate why different approaches to real-world problem resolution are included in the examples in these texts. Therefore, rather than focusing on traditional education, teachers should be encouraged to use appropriate pedagogy that will lead to the building of epistemic views toward expertise beliefs.

Increasing the target population: This study was conducted in three Debre Birhan public schools over the course of about six weeks. Research may be conducted over a long period of time in a range of public and private schools, grade levels, and geographical areas in order to maximize the generalizability of the findings.

Increasing the range of topics and material areas: This study focused on inheritance, which is only covered in one unit in grade 10. The effectiveness of the applicable educational techniques can be tested by other researches on various biological themes as well as other science and mathematics disciplines.

Using a range of assessment methods: Research can be done using a range of assessment tools, including the Lawson classroom scientific reasoning skill test (Lawson, 2000), the Conley et al. (2004) epistemological belief questionnaire, and others, in order to improve the generalizability of this study.

A context based instructional approach should be used as an alternative to the conventional teaching approach in teacher education course delivery methods. In addition to guiding pre-service teachers through the context based instructional approach implementation process, biology instructors should help them find the right context-based resources.

It would be good to plan training for biology teachers and instructors on how to relate course material to students' real-world encounters. It is important for biology teachers to develop their knowledge and skills through ongoing professional development (CPD) on how to relate their lessons to students' real-world encounters by using concrete objects from the students' immediate surroundings as teaching aids. Biology teachers must give students enough chances to relate biological ideas to real-world situations.

Future study should look into the challenges biology students encounter when learning with context-based exercises.

In order to determine whether biology teachers need guidelines or not when creating context-based activities for their students, we need to conduct an experimental study in which one group of in-service biology teachers prepares context-based problem-solving tasks using guidelines while the other group does not use the guideline. The current researcher will carry out this task in a team with college biology instructors.

5.4. Limitations

All activities in the world, such as the economy, health, politics, sports, research in all dimensions, etc., were affected in 2020 by COVID 19. In the same way, the intervention mechanisms and data collection processes of this study were affected. This study involved three teachers from three separate schools. Even though the researcher made an effort to choose comparable schools and teachers from different perspectives, provided training on the instructional approaches and methods of implementation, and conducted classroom observations and discussions with the teachers during implementation to ensure the research protocols were followed, the teachers and the schools may still have an impact on the intervention because it is difficult to manage all teacher- and school-related variables. The number of teachers and classrooms at the school had an effect on how many students were in each class and how many minutes were allowed for instruction. This limits how much the findings may be applied to other institutions, unless they share some traits.

Furthermore, the study focuses only on one chapter of a biology textbook, which was taught for six weeks. This time frame could be too short to improve the students' reasoning skills and epistemological beliefs, which were reported to need longer. Besides, the two-tier multiple-choice exam questions could also be difficult for students who do not have previous experience with this kind of question. Another limitation of this study was that the factor analysis was not conducted due to the small number of students in the pilot for the two-tier CU and SRS developed by the researcher. The last limitation of this study was the lack of generalizations due to the small sample sizes.

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Appendixes

Appendix A

Conceptual Understanding and Reasoning test

Addis Ababa University
College of Education and Behavioral Studies
Department of Science and Mathematics Education

The main objective of this test is to gather information with regarding to "students' understanding and reasoning skills to heredity topic''. Your correct and complete answer to the following questions will provide great value for this study. Therefore, you are kindly requested to answer all the questions after reading thoroughly.

Thank You in Advance for Your Cooperation!

Direction: -1. Do not write your name

2. Make a Circle on your choice
3. Respond all questions precisely, clearly and genuinely.
4. Write any different reasons if you have other than listed on the space provided.

Background information

1.1. Name of school ____

1.2. Student's code ______________________

1.3. Sex: Put a tick mark (√) Male ☐ Female ☐

1.4. Age _____________

1.5. Grade ___________ section ____________

DURATION: 50 Minute

Instruction: This test consists of 25 pairs of questions from grade 10 heredity topics. Each question has two parts. The first part is a multiple choice response. The second part is a multiple choice reason. Choose the best answer from both response and reason parts and make a Circle on your letter of choice.

1. Which plants are selected by Mendel for his experiment?

A. Wheat B. Pea C. Bean D. Barley

The reason for my answer is:

A. the plant is a monocot plant and easily breeds.
B. the experimental plant has inherited traits.
C. the plant has many easily observable contrasting traits.

D. the plant is a dicot plant.

E. Other reason: ____.

2. How can you distinguish the genotypic composition of a certain tall pea plant whether it is pure or hybrid tall?

A. Conducting a test cross C. simply by looking their phenotype

B. By crossing each tall plant with dominant trait D. By doing back cross

The reason for my answer is:

A. It is crossing an unknown genotype individual with homozygous dominant for a given trait.

B. It is crossing an unknown genotype individual with a homozygous recessive for a given trait.

C. Phenotype indicates genotype.

D. Phenotypically and genotypicallyall are the same.

E. Other reason: ____.

3. A woman is married for the second time. Her first husband was blood type A, and her child by that marriage was blood type O. Her new husband is type B and their child is type AB. What is the woman's genotype and blood type?

A. Homozygous A C. Homozygous B

B. Heterozygous A D. Heterozygous AB

The reason for my answer is:

A. Homozygous A mother cross with heterozygous A1st father gives blood type O child.
B. Homozygous B mother cross with heterozygous A1st father gives blood type O child.
C. Heterozygous A mother cross with homozygous B2nd father gives blood type AB child.
D. Heterozygous AB mother cross with heterozygous B2nd gives blood type AB child.
E. Other reason: ____.

4. The type of breeding used to improve a breed of organisms through combining good trait from two different breeds is known as__________

A. In breeding C. Selective breeding

B. Out breeding D. Cross breeding

The reason for my answer is:

A. In breeding increases homogeneity for coping up hazards.

B. Breeding different species (plants with animals) increase fertility.

C. By combining desirable traits we can increase the quality and quantity of products.

D. It is breeding of plants or animals with desirable or particular traits.

E. Other reason: ____.

5. Meiosis is a type of cell division that takes place in_______

A. germ cells B. somatic cells C. body cells D. sperm cells

The reason for my answer is:

A. meiosis is responsible for producing haploid gametes.

B. meiosis occurs in the reproductive (sperm or egg) cells.

C. meiosis produces four identical diploid cells for sexual reproduction.

D. meiosis is important for the division of sperm cell to produce another four sperm cells.

E. Other reason: ____.

6. Some dogs bark when following a scent, others are silent and are called silent trackers. Barking is dominant (allele B) to non-barking (allele b). A hunter owns a barker which he wants to use for breeding purposes. However, he wants to be sure it has a genotype of BB. What is the genotype of the bitch he should mate with this dog?

A. BB B. Bb C. bb D. Bb and bb

The reason for my answer is:

A. If any silent tracker appears in the offspring, the hunter can be sure that his dog's genotype is Bb.

B. If no silent trackers appear in the offspring, he can be sure that his dog's genotype is BB.

C. If the dog is Bb, the chances of getting silent trackers in the offspring are zero.

D. If the dog bb crosses with one dominant allele there is a possibility of having BB offspring.

E. Other reason: ____.

7. Mitosis is a process of cell division that occurs in ______.

A. germ cells B. zygote formation C. somatic cell D. egg cell

The reason for my answer is:

A. mitosis is important for sex cell formation for sexual reproduction.

B. mitosis is important for the formation of zygote after gamete formation.

C. mitosis is important for growth and replacing of damaged cells.

D. mitosis is important for reducing number of chromosomes for sexual reproduction.

E. Other reason: ____.

8. The correct order of the cell cycle in mitosis is _____

A. Telophase →Anaphase→ Prophase →Metaphase

B. Metaphase→ Anaphase→ Telophase →Prophase

C. Anaphase →Metaphase→Prophase → Telophase

D. Prophase →Metaphase →Anaphase →Telophase

The reason for my answer is:

A. At Telophase nuclear membrane reappears and at metaphase chromosomes become double.

B. At Metaphase chromosomes align at center of the cell at prophase the nucleolus disappear.

C. At anaphase nuclear membrane reappear and at telophase chromatids separated.

D. At prophase the chromosomes becomes condensed and form paired chromatids and ending with telophase which reappears the nuclear membrane.

E. Other reason: ____.

9. The trait, curly hair, is dominant to straight hair. If we use “C” to represent the dominant allele (gene) for curly hair and “c” for the recessive allele, what type of hair a person would have with genotype Cc?

A. curly hair B. Straight hair

C. Based on the probability it can be strait or curly D. Cannot determine

The reason for my answer is:

A. The person needs to have CC for curly hair.

B. The dominant allele C is expressed in a Cc condition.

C. The person may or may not have curly hair.

D. The recessive allele c is expressed.

E. Other reason: ____.

10. In which phase of meiosis DNA is replicated?

A. At Metaphase I not Metaphase II.
C. At Interphase before meiosis I but not meiosis II at all.
B. At Interphase II but not Telophase II.
D. At Interphase I and interphase II.

The reason for my answer is:

A. DNA replication occurs between meiosis I and meiosis II.
B. Meiosis is important to increase genetic variability.
C. Meiosis reduce the chromosome number to haploid in the resulting daughter cells.
D. The chromosome duplicates twice during meiosis I.
E. Other reason: ____.

11. In a DNA double helix the upright strands are made from which structures?

A. Deoxyribose sugar and phosphate
C. Base and Phosphate
B. Deoxyribose sugar and base
D. Deoxyribose sugar, phosphate and bases

The reason for my answer is:

A. The two DNA upright strands made from Deoxyribose sugar and phosphate are linked by bases to form a double helix.
B. Adenine pair with thiamine and guanine pair with cytosine to form upright strand.
C. Four bases are attached with phosphate group to form the upright strand of DNA.
D. DNA is made from a single nucleotide to have a double helix.
E. Other reason: ____.

12. Which one of the following is **NOT** the difference between mitosis and meiosis?

A. Number of daughter cells produced
C. The type of cell where it occurs
B. Variety of daughter cells produced
D. Needs DNA replication

The reason for my answer is:

A. Two daughter cells produced in mitosis while four daughter cells in meiosis.
B. Mitosis occurs in body cells while meiosis occurs in germ cells.
C. Both mitosis and meiosis cell division needs DNA replication.
D. Two identical daughter cells produced after mitosis and four different cells produced after meiosis.
E. Other reason: ____.

13. How many chromosomes are there in a nerve cell of an organism which has 16 chromosomes in its egg cell (ovum)?

A. 32   B. 16   C. 8   D. 23 pairs

The reason for my answer is:

A. A somatic cell has twice the number of chromosomes as a sex cell.

B. The number of chromosomes is the same in each cell of an organism.

C. Egg cells include $2n$ chromosomes and somatic cells include n chromosomes.

D. Sex cells undergo meiosis and the number of chromosomes is halved. Because of this, a nerve cell carries 8 chromosomes.

E. Other reason: ____.

14. In Ethiopia, the most important practices that represent genetic heritage and essential for the society is/are________

A. cross breeding   C. genetic engineering

B. selective breeding   D. both cross breeding and selective breeding

The reason for my answer is:

A. It gives us the best possibilities to use our resource.   C. To feed our population

B. Provide new genes for international community   D. All

E. Other reason: ____.

15. Information about your body like eye color, height and hair color is inherited from your parent through________

A. body cells   B. somatic cells   C. autosomal chromosomes   D. sex chromosomes

The reason for my answer is:

A. Body cells transfer all information with the exception of sexes.

B. Somatic cells contain sex chromosomes to transmit eye color.

C. Autosomal chromosomes found in gametes are responsible for those listed information inheritance.

D. Sex chromosomes are responsible for those listed inheritance.

E. Other reason: ____.

16. In a family of four all the children are girls. Which combination of chromosomes would result in children?

A. XY   B. XX   C. YY   D. XXY

The reason for my answer is:

A. The women cannot produce X bearing gamete cells which determine male sex.

B. The man has a low sperm count.

C. The Y component of the man's sex chromosome was always involved during fertilization.

D. The X component of the man's sex chromosome was always involved during fertilization.

E. Other reason: ____.

17. From which of the following generations did Mendel formulate his principle of dominance?

A. F1 generation B. F2 generation C. P1 generation D. Pure breeding

The reason for my answer is:

A. A cross between phenotypically similar organisms gave rise two phenotypic features.

B. A cross between phenotypically different organisms gave rise similar features.

C. A cross between homozygous dominant organisms gave rise the recessive traits.

D. It is a breed between homozygous dominant and recessive alleles.

E. Other reason: ____.

18. The main aim of Gregor Mendel's work was to proof how _______

A. cell division works. C. co-dominance appears.

B. inheritance works. D. blood circulation works.

The reason for my answer is:

A. He explained the patterns of inheritance traits experimentally.

B. He described how mitosis and meiosis occurs.

C. He had justify how two alleles dominant equally.

D. He explained ABO blood grouping.

E. Other reason: ____.

19. An allele for dangly ear lobes 'D' is dominant over an allele for attached ear lobes. A woman with dangly ear lobe is married a man with attached ear lobe. Which of the following shows the possible genotype of their offspring?

A. DD and dd B. Dd and dd

C. DD D. DD and Dd

The reason for my answer is:

A. All their children have homozygous dangly ear.

B. Children may have a heterozygous dangly and attached ear.

C. Children may have homozygous and heterozygous dangly ear.

D. Children may have a homozygous dangly and attached ear.

E. Other reason ____.

20. Which one of the following statement is correct about the work of Mendel? Mendel:-

A. Pollinate his plants before the pollen matured.

B. Observed that round shape was a recessive trait.

C. Observed that if all members on both sides of a family is tall, the offspring are going to be tall

D. Removed either the stigma or an anther before matured.

The reason for my answer is:

A. Self-pollination is important to make pure breed.

B. All F1 generations showed recessive traits.

C. All F1 generations showed both dominant and recessive traits

D. Prevent self-fertilization and he himself allows a cross.

E. Other reason ____

21. Which one of the following is a unit of inheritance?

A. Chromosome B. DNA C. Gene D. Trait

The reason for my answer is:

A. It controls the development of a set of hereditary characteristics.

B. It contains both DNA and histone protein.

C. It is made up of deoxy ribose sugar, four nitrogen containing base and phosphate.

D. It is a character observed on an organism.

E. Other reason ____

22. A 10th grade student skin injured by acid while conducting an experiment. But after certain time his skin healed and the same as before. This is because of:-

A. Meiosis C. Chromosome replication

B. Mitosis D. Fertilization

The reason for my answer is:

A. It is important for gamete formation for sexual reproduction.

B. It is responsible for replacing damaged cells.

C. The number of chromosomes becomes double before cell division.

D. A process of fusion of male and female gametes.

E. Other reason ____

23. Which one of the following is **NOT** an importance of breeding?

A. Increase resistance to environmental stress like drought and cold

B. Resistance to disease and pastes C. Increase yield

D. Reduce genetic diversity.

The reason for my answer is:

A. Breeding upgrades important traits.

B. Breeding combine good traits from different breeds.

C. Breeding increase the amount of product.

D. Breeding increase genetic variability.

E. Other reason____

24. Which one of the following is true about meiosis?

A. Meiosis starts in testes before a baby is born.

B. Meiosis starts in the ovary during puberty of girl but not before.

C. Meiosis produces four daughter cells which are slightly different.

D. Meiosis produces for identical daughter cells which contain half chromosomes.

The reason for my answer is:

A. Sperm is divided by meiosis.

B. The firs meiosis is important for ova formation.

C. During meiosis process chromosomes exchange some genes to cause variation.

D. The number of chromosomes are reduced by half.

E. Other reason ____

25. Abebe is an albino who was born without the ability to make a pigment in the skin. Albinism is a recessive characteristic. Suppose we use “A” for the dominant gene (allele) and “a” for the recessive gene, what would be Abebes’ genotypes (genes) for albinism? A. AA B. Aa or aa C. aa D. Aa

The reason for my answer is:

A. Because Abebe must have at least one recessive allele “a”.

B. Because one recessive allele “a” does not make Abebe an albino.

C. Because recessive allele “a” is only expressed in Abebe when present in “Aa” forms.

D. Dominant traits “AA” are the most common traits in a population.

E. Other reason ____

Appendix B

The Colorado Learning Attitudes about Science Survey for Biology (CLASS-Bio)

Addis Ababa University

College of Education and Behavioral Studies

Department of Science and Mathematics Education

Dear students,

I am conducting a PhD dissertation research. Thus, the purpose of this questionnaire is to collect data from grade 10 students about biology learning and knowledge about biology. The information obtained from this questionnaire will serves as an input in enhancing students' biology learning. The questionnaire consists of 32 statements. Therefore, you are kindly requested to give genuine response to the statements. The responses to the questions will be kept confidential. Do not write your name.

Thank You for Your Cooperation

Section A: Background Information

1. Name of School ____

2. Gender: Put a tick mark (√) Male ☐ Female ☐

3. Grade Level ______________ Section __________

Section B: Items

Instruction: The following table contains list of statements. There is no right or wrong answers to the statements. It is simply what is true for you to express your own beliefs. Therefore, read every statements carefully and choose the one that best describes your feeling about biology learning and knowledge in the table using the scale below and put a tick mark (√) using the Scale below.

Scale: 1 = Strongly Disagree 2 = Disagree 3 = Neutral

4 = Agree 5 = Strongly Agree

		Likert scale				
		1	2	3	4	5
No	**Statement**					
1	My curiosity about the living world led me to study biology					
2	I think about the biology I experience in everyday life.					
3	After I study a topic in biology and feel that I understand it, I have difficulty applying that information to answer questions on the same topic.					
4	Knowledge in biology consists of many disconnected topics.					
5	When I am answering a biology question, I find it difficult to put what I know into my own words.					
6	I do not expect the rules of biological principles to help my understanding of the ideas.					
7	To understand biology, I sometimes think about my personal experiences and relate them to the topic being analyzed.					
8	If I get stuck on answering a biology question on my first try, I usually try to figure out a different way that works.					
9	I want to study biology because I want to make a contribution to society.					
10	If I don’t remember a particular approach needed for a question on an exam, there’s nothing much I can do (legally!) to come up with it.					
11	If I want to apply a method or idea used for understanding one biological problem to another problem, the problems must involve very similar situations.					
12	I enjoy figuring out answers to biology questions.					
13	It is important for the government to approve new scientific ideas before they can be widely accepted.					
14	Learning biology changes my ideas about how the natural world works.					
15	To learn biology, I only need to memorize facts and definitions.					
16	Reasoning skills used to understand biology can be helpful to my					

	everyday life.					
17	It is a valuable use of my time to study the fundamental experiments behind biological ideas.					
18	If I had plenty of time, I would take a biology class outside of my major requirements just for fun.					
19	The subject of biology has little relation to what I experience in the real world.					
20	There are times I think about or solve a biology question in more than one way to help my understanding.					
21	If I get stuck on a biology question, there is no chance I'll figure it out on my own.					
22	When studying biology, I relate the important information to what I already know rather than just memorizing it the way it is presented.					
23	There is usually only one correct approach to solving a biology problem.					
24	When I am not pressed for time, I will continue to work on a biology problem until I understand why something works the way it does.					
25	Learning biology that is not directly relevant to or applicable to human health is not worth my time.					
26	Mathematical skills are important for understanding biology.					
27	I enjoy explaining biological ideas that I learn about to my friends.					
28	We use this statement to discard the survey of people who are not reading the questions. Please select agree (not strongly agree) for this question to preserve your answers.					
29	The general public misunderstands many biological ideas.					
30	I do not spend more than a few minutes stuck on a biology question before giving up or seeking help from someone else.					
31	Biological principles are just to be memorized.					
32	For me, biology is primarily about learning known facts as opposed to investigating the unknown					

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አዲስ አበባ ዩኒቨርስቲ

የስነ-ትምህርትና ባህርይ ጥናት ኮሌጅ

የሳይንስና ሂሳብ ትምህርት ክፍል

የስነ-ህይወት ትምህርት የመማር አመለካከትን በሚመለከት የቀረበ የፅሁፍ መጠይቅ

ውድ ተማሪዎች:

እኔ የድህረ ምረቃ 3ኛዲግሪ(PHD) መመረቂያ ጥናትና ምርምር በማካሄድ ላይ እገኛለሁ፡፡ የዚህ መጠይቅ ዋና ዓላማ የ10ኛ ክፍል ተማሪዎች የስነህይወት ትምህርትን በሚማሩበት ወቅት ለትምህርቱ ያላቸውን አመለካከት ምን እንደሆነ መረጃ ለመሰብሰብ የቀረበ መጠይቅ ነው፡፡ ከመጠይቁ የሚገኘው መረጃ የስነህይወት ትምህርትን የመማሪያ ዘዴዎችን ለማጎልበት የሚረዱ ግብዓቶችን ለመጠቆም ይረዳል፡፡ መጠይቁ 32 ጥያቄዎችን ይዟል፡፡ ስለዚህ ለቀረቡልህ/ሽ መጠይቆች ትክክለኛውን መልስ በቅንነት እንድትመልስ/ሺ በታላቅ ትህትና እጠይቃለሁ፡፡ ከዚህ መጠይቅ የሚገኘው መረጃ በሚስጥርየሚያዝ ሲሆን ለእያንዳንዱ የምላሽ ወረቀት ኮድ ይሰጠዋል፡፡ በመሆኑም በመጠይቁ ላይ ስም መፃፍ አያስፈልግም፡፡ ስለትብብርህ/ሽ በቅድሚያ አመሰግናለሁ፡፡

ክፍል 1: ግለሰባዊ መረጃ

1. የትምህርት ቤቱ ስም________________________________
2. የተማሪው/ዋ መለያ ኮድ______________________________
3. ፆታ የ "√" ምልክት አስቀምጡ ወንድ ☐ ሴት ☐
4. እድሜ __________
5. የክፍል ደረጃ_________________ሴክሽን _______________

ክፍል 2: ጥያቄዎች

መመሪያ፡- ከዚህ በታች ያለው ሰንጠረዥ 32 ጥያቄዎችን ይዟል፡፡ ለጥያቄዎቹ ትክክል ወይም የተሳሳተ መልስ የለም፡፡ ለአንተ/ቺ ትክክል መስሎ የተሰማህን/ሽን መልስ/ሺ፡፡ ስለዚህ ስለ ስነህይወት ትምህርትህ/ሽ ምን አይነት አመለካከት እንዳለህ/ሽና ምን እንደምታስብ/ቢ ለመረዳት ይቻል ዘንድ ጥያቄዎች ቀርበውልሀል/ሻል፡፡ ጥያቄዎቹን በጥንቃቄ በማንበብ ከተሰጡት 5

አማራጭ ልኬቶች መካከል የምትስማማበትን/ሚበትን የ “√” ምልክት በመጠቀም ቁጥሩን አመልክት/ቺ፡፡

አማራጭ ቁጥሮቹ የሚወክሉትም (1) በጣም አልስማማም፣ (2) አልስማማም፣ (3) ገለልተኛ (4) እስማማለሁ፣ (5) በጣም እስማማለሁ ናቸው፡፡

ቀጥሎ በተሰጠው ሰንጠረዥ ከላይ ከቀረቡት አምስት አማራጮች መካከል አንዱን በመጠቀም የራስህን/ሽን ስሜት የሚገልፀው ቁጥር ላይ የ“√” ምልክትን አስቀምጥ/ጪ፡፡ አጥኚዋ ይህንን ጥናት የምትፈልገው ትክክለኛውን መረጃ ከአንተ/ቺ ለማግኘት ነው፡፡ ለዚህ ጥናት የምትሰጠው/ጪው መልስ ከምትማረው/ሪው የትምህርት ውጤት ጋር ምንም አይነት ግንኙነት የሌለው መሆኑን አረጋግጥልሀለሁ/ሻለሁ፡፡ የምትሰጠው/ጪው መረጃ በተሻለ መልኩ የስነህይወት ትምህርትን ለመንደፍና ለማስተማር ያገለግላል፡፡

ተ.ቁ	ጥያቄዎች	አማራጭ ልኬቶች				
		1	2	3	4	5
1	ህይወት ስላላቸው ነገሮች ለማወቅ ያለኝ ፍላጎት የስነህይወት ትምህርትን እንድወድ መነሻ ሆኖኛል					
2	ስነህይወትን የማስበው እንደ እለት ከእለት እንቅስቃሴዬ ነው					
3	አንድን የስነህይወት ርዕሰጉዳይ ከተማርኩ በኋላ የገባኝ ቢመስለኝም ሀሳቡን ስጠየቅ ለመመለስ እቸገራለሁ					
4	የስነህይወት እውቀት ብዙ እርስ በእርሳቸው ያልተያያዙ ርዕሶችን ይይዛል					
5	የስነህይወት ጥያቄዎችን ስመልስ የማውቀውን በራሴ አባባል ለመግለፅ እቸገራለሁ					
6	የስነህይወት ህግና መርሆዎች ሀሳቡን ለመረዳት ያግዙኛል ብዬ አልጠብቅም					
7	ስነህይወትን ለመረዳት አንዳንድ ጊዜ የግል ተሞክሮዬን ከምማረው ርዕስ ጋር አዛምዳለሁ					
8	የስነህይወት ጥያቄዎችን ለመመለስ በመጀመሪያው ሙከራዬ ከተቸገርኩ ሌሎች አማራጮችን ለመጠቀም እሞክራለሁ					
9	የስነህይወት ትምህርትን የምወደው ለማህበረሰቡ አስተዋፅዖ ለማበርከት ስለምፈልግ ነው					
10	በፈተና ወቅት ጥያቄውን ለመመለስ የሚያስችለኝን ስልት ማስታወስ ካልቻልኩ ሌላ አማራጭ አልጠቀምም					
11	አንድን የስነህይወት ችግር የምፈታበትን ዘዴ ወይም ሀሳብ ለሌላ ችግር መፍትሄ ለመፈለግ የምጠቀም ከሆነ ችግሮቹ ተመሳሳይ ሁኔታ ሊኖራቸው ይገባል					
12	ለስነህይወት ትምህርት ጥያቄዎች መልስ መፈለግ ያስደስተኛል					

13	አዳዲስ ሳይንሳዊ ሀሳቦች በሰፊው ተቀባይነት ከማግኘታቸው በፊት መንግስት ትክክለኛነታቸውን ሊያረጋግጥ ይገባል					
14	ስነህይወት መማሬ ስለተፈጥሯዊ ክንዋኔዎች የነበረኝን ግንዛቤ አስቀይሮኛል					
15	ስነህይወትን ለመማር እውነታዎችንና ትርጉሞችን መሸምደድ ብቻ በቂ ነው					
16	ምክንያታዊ ክህሎቶች ስነህይወትን ለመረዳትና ለቀን ተቀን ህይወቴ ያግዘኛል					
17	ከእያንዳንዱ የስነህይወት ፅንሰሀሳብ በስተጀርባ ያለውን ተግባራዊ ሙከራ ለማጥናት ጊዜዬን በአግባቡ እጠቀማለሁ					
18	ትርፍ ጊዜ ቢኖረኝ ከሚጠበቅብኝ በተጨማሪ የስነህይወት ትምህርትን ብማር ደስ ይለኝ ነበር					
19	የስነህይወት ትምህርት በእለት ተእለት ከሚያጋጥሙኝ ሁኔታዎች ጋር ምንም ግንኙነት የለውም					
20	የሚሰጡኝን የስነህይወት ጥያቄዎች የበለጠ ለመረዳት ከአንድ በላይ መንገዶችን የምጠቀምበት ጊዜ አለ					
21	የስነህይወት ጥያቄን ለመመለስ ከተቸገርኩ በራሴ መንገድ ሌላ አማራጭ በመጠቀም ለመስራት እድሉን አልጠቀምም					
22	የስነህይወት ትምህርትን ሳጠና የተሰጠውን ሀሳብ እንዳለ ከመሸምደድ ይልቅ ሀሳቡን ካለኝ ልምድ ጋር ለማገናኘት እሞክራለሁ					
23	የስነህይወት ጥያቄን ለመስራት በአብዛኛው ያለው አንድ ትክክለኛ ስልት ነው					
24	የጊዜ እጥረት ከሌለብኝ አንድን የስነህይወት ጥያቄ ስሰራ በሚገባ እስከምረዳው ድረስ መስራቴን እቀጥላለሁ					
25	ከሰው ጤና ጋር ግንኙነት የሌለው የስነህይወት ፅንሰሀሳብ መማር ጊዜዬን እንደሚያባክንብኝ እቆጥረዋለሁ					
26	የስነህይወት ፅንሰ ሀሳብን ለመረዳት የሂሳብ ክህሎት አስፈላጊ ነው					
27	የተማርኩትን የስነህይወት ፅንሰ ሀሳብ ለጓደኞቼ ማብራራት ያስደስተኛል					
28	ይህን ጥያቄ የምጠይቅህ/ሽ ጥያቄዎቹን ሳታነብ/ቢ መመለስህን/ሽን ለማወቅና ውጤቱን ውድቅ ለማድረግ ነው፤ በመሆኑም ውጤቱ እንዳይጣል ለዚህ ተራቁጥር እስማማለሁ የሚል መልስ ብቻ መልስ/ሺ					
29	አብዛኛው ማህበረሰብ ብዙውን የስነህይወት ፅንሰ ሀሳብ በአግባቡ አይረዳውም					
30	የስነህይወት ጥያቄ ከከበደኝ መስራቴን ከማቆሜ በፊት ከሌሎች እርዳታ እጠይቃለሁ እንጂ ከጥቂት ደቂቃዎች በላይ አላባክንም					
31	የስነህይወት መርሆዎች መሸምደድ አለባቸው					
32	ለእኔ ስነህይወት ማለት የማይታወቅ ነገርን ከመመርመር ይልቅ የሚታወቁ እውነታዎችን መማር ነው					

Appendix C

Interview Sample Questions for Epistemological belief

1. Is scientific knowledge changing and tentative, or fixed?
2. How has "real life" based activities helped your understanding? Do you think the study of genetics relates to your daily life? Why do you say so?
3. How do you usually study for exams in biology?
4. How does knowledge in biology form, and how does it become "accepted"?
5. Does learning biology change your views of how the world works?
6. Do you see any connections between what you learn in biology class and what you learn in other science classes?
7. Do you see any connections between what you've learned in class and the real world, or your everyday, non-academic life?

Interview Sample Questions for conceptual understanding and scientific reasoning

1. What is mitosis? What phenomenon are occurred in each phases of mitosis? Why we need mitosis?
2. What is meiosis? What phenomenon are occurred in each phases of meiosis? Why we need meiosis and how meiosis differs from mitosis? What is the relationship between cell divisions and inheritance?
3. What Mendel did on pea plant? Why he select garden pea for his experiment?
4. How the work of Mendel related with inheritance? Is there any relation between Mendel's principles of inheritance with human? How?
5. Why the characteristics of the family member similar and why some are different? How are genetic characteristics inherited by offspring?
6. What is the relationship between chromosome, DNA and gene? Where do we found these materials? How can you define chromosome?
7. What are the components of DNA? How these components organized in order to form double helix?
8. What is the genetic material? Which material in your body is a genetic material? What is the unit of inheritance in your body?
9. What is breeding? How breeding is takes place? Why breeding is important for the society?
10. What are the practices of breeding in your society? Why they do this practice?

Appendix D

Common misconceptions identified in the instrument development process

1. Dominant traits are the most common traits in a population.
2. If a couple has a “one-in-four” risk of having a child with a disease, and their firstborn has the disease, the next three children will have a reduced risk.
3. Diploid (2n) cells are formed as a result of meiosis.
4. Meiosis occurs in the reproductive (sperm or egg) cells.
5. Chromosomes are formed as a result of shrinkage and thickening of spindle fibers.
6. DNA replication occurs in cytokinesis during the process of cell division.
7. DNA replication occurs in the prophase during the process of cell division
8. DNA replication occurs between prophase and metaphase during cell division
9. DNA replication occurs between meiosis I and meiosis II
10. Interphase is the first phase of mitosis cell division.
11. Dominant alleles will take over a population and create the prominent phenotype.
12. If all members on both sides of a family is tall, the offspring are going to be tall.
13. The sister chromatids are homologous chromosomes
14. Genes that determine an individual’s inherited characteristics are only found in sex cells
15. The gene for eye color is located in the iris because iris is the part of the eye responsible for eye color.
16. The X and Y chromosomes, which are found in a sperm cell, carry all the genes.
17. Sex chromosomes are only found in sex cells.
18. DNA is made of chromosomes.
19. Chromosomes make up genes.
20. Chromosomes, which carry genes, are located in DNA
21. Gene contains chromosomes and DNA.
22. Inherited characteristics are carried only by sex chromosomes.
23. Parent’s genes are transferred to the offspring by sex chromosomes of the father and the mother at fertilization.
24. The number of chromosomes is the same in each cell of an organism.
25. Egg cells include $2n$ chromosomes and somatic cells include n chromosomes.
26. Recessive alleles are the least abundant in a population
27. Dominant conditions are inherited from the father.
28. Sons take more characteristics from their father and girls from their mother hence they have the same sex.

Appendix E

Sample instructional method used for teaching Treatment group 1 students in the form of daily Lesson Plan

Teacher`s Name: - **______________**

Duration: - 40 min

Grade & Section: - 10 D

Subject: - Biology

Unit 2: - Heredity

Date: 28/03/2013 E.C

Objectives: - At the end of this lesson, students will be able to:

- ✓ Describe methods of breeding farm animals and crops.
- ✓ Explain the importance of selective breeding for society.
- ✓ Explain the difference between selective breeding and cross breeding

Topic	Stage of the method	Teachers activity	Student activity	Remark
Heredity and breeding	Relating	Start the lesson through reminding the previous lesson. Then introducing the lesson of the day. “Beza is a grade 10 student and she has the best sheep to support her parents by gaining income. Many people asked beza to sell her sheep to them because her sheep are twin givers and give a large amount of meat. Are there animals known as best and poor in your house or your neighbor? What characteristics of these animals make them best? How can you increase the number of these animals? Can you increase the quality of poor animals to make them best? How?” The teacher needs to identify his learners‟ misconception about the topic.	Listening Participation Asking Answering	
	Experiencing	If one family live in afar region has a herd of goats which give good milk yields, but do not cope well without shade. Another family has goat	Participation Group	

		which give less milk but are very hardy and resistant to the heat of the sun. Each family wants the solution for their goat weaknesses. a. Is there any possibility of increasing the weaknesses of those goats? Explain how? b. Mendel uses true breeding in his experiment because the F1 generations are not pure breeding. Would farmers have chance to get pure breed? Explain how.	discussion	

	Applying	☐ The students are provided with examples like the ones shown below to enable them to apply the new concepts. Bekele is a grade 11 student and help his parents at his free time. His parents' job is animal farming. Their cow is giving plenty of milk and their chicken gives a large number of egg. After Bekele learns grade 10 genetics topic he think how those animals increase in both high meat production, large number of egg production and plenty of milk production. Can you help him? a. Is the idea of Bekele possible? Explain how? b. Explain how cross breeding and selective breeding carried on. c. Explain the result of cross breeding and selective breeding in Ethiopia. ☐ After solving the problems, the learners are required to interpret their results and create concepts by connecting it with real life or context	☐ Applying the new knowledge to real world situations ☐ Participation & discussion	

	Cooperating	☐ The students are given time to think about and discuss in groups through sharing, communicating and responding to the important concepts and reasoning skills.	☐ Participation ☐ Group discussion	

	Transferring	Here the teacher encourages his students to use explanations in new situations, i.e., by providing another application allowing students to use their new knowledge. For instance, they may give them a problem like the one shown below allowing students to use the concept in a new situation. "In human society the religious ethics and modern social norms consciously have judged and forbidden the marriages of brothers with sisters. What do you think in principles of genetics? a. Is genetics support or oppose the rules of religion, norm and cultures of the society in relation to this idea? Why? b. Do you think cross breeding and selective breeding have disadvantage? How?"	Participation Asking Answering Doing class work and homework	

Teacher`s Name:__________Dep`t head Name:_______ Vice Director name:_______
Signature:_________ Signature:_________ Signature:________
Date: ____________ Date:__________ Date:________

Sample instructional method used for teaching Treatment group 2 students in the form of daily Lesson Plan

Teacher`s Name: - _____________

Duration: - 40 min

Grade & Section: - 10 Q

Subject: Biology

Unit 2: Heredity

Date: 25/03/2013E.C

Objectives: - At the end of this lesson, students will be able to:

- ✓ Describe methods of breeding farm animals and crops.
- ✓ Explain the importance of selective breeding for society.
- ✓ Explain the difference between selective breeding and cross breeding

Topic	**Stage of the method**	**Teachers activity**	**Student activity**	**Remark**

	Revision	☐ Start the lesson through reminding the previous lesson. ☐ Then introducing the lesson of the day.	☐Listening ☐Participation ☐ Asking ☐ Answering	
	Presenting	☐ Presenting the concept of heredity and breeding to the students through lecturing ☐Explain about selective breeding and cross breeding ☐Teachers explanation allowing students to discover new knowledge	☐ Listening ☐ Taking notes	
Heredity and breeding	Applying	☐ Linking the new concepts with students“ real life or context through experiencing the learners with the selective and cross breeding. Bekele is a grade 11 student and help his parents at his free time. His parents’ job is animal farming. Their cow is giving plenty of milk and their chicken gives a large number of egg. After Bekele learns grade 10 genetics topic he think how those animals increase in both high meat production, large number of egg production and plenty of milk production. Can you help him? ☐Is the idea of Bekele possible? Explain how? ☐ Explain how cross breeding and selective breeding carried on. ☐ Explain the result of cross breeding and selective breeding in Ethiopia.	☐ Applying the new knowledge to real world situations ☐ Participation ☐ Discussion	

		The students are provided with examples that enables them to apply the new concepts.		
	Transferring	Here, the teacher encourages his students to use explanations in new situations, i.e, by providing another application allowing students to use their new knowledge. For instance, they may give them a problem like the one shown below allowing students to use the concept of heredity and breeding. “In human society the religious ethics and modern social norms consciously have judged and forbidden the marriages of brothers with sisters. What do you think in principles of genetics? **a**. Is genetics support or oppose the rules of religion, norm and cultures of the society in relation to this idea? Why? **b**. Do you think cross breeding and selective breeding have disadvantage? How?”	Participation Group discussion	
	Evaluating	Measuring whether the students understood the new information correctly Oral questions, class work, etc. As homework, a problem like the one shown below is given to them. If one family live in afar region has a herd of goats which give good milk yields, but do not cope well without shade. Another family has goat which	Participation Asking Answering Doing class work and homework	

		give less milk but are very hardy and resistant to the heat of the sun. Each family wants the solution for their goat weaknesses. Is there any possibility of increasing the weaknesses of those goats? Explain how? Mendel uses true breeding in his experiment because the F1 generations are not pure breeding. Would farmers have chance to get pure breed? Explain how.		

Teacher`s Name:_____ Dep`t head Name:_________ Vice Director name:________
Signature:________ Signature:_________ Signature:________
Date:_________ Date:_________ Date:________

Sample instructional method used for teaching comparison group students in the form of daily Lesson Plan

Teacher`s Name: - _____________

Duration: - 40 min

Grade & Section: - 10 E

Subject: - Biology

Unit 2: - Heredity

Date: 29/03/2013 E.C

Objectives: - At the end of this lesson, students will be able to:

- ✓ Describe methods of breeding farm animals and crops.
- ✓ Explain the importance of selective breeding for society.
- ✓ Explain the difference between selective breeding and cross breeding

Topic	**Stage of the method**	**Teachers activity**	**Student activity**	**Remark**
Heredity and breeding	Introduction	☐ Start the lesson through reminding the previous lesson. ☐ Then introducing the lesson of the day.	☐ Listening ☐ Participation through giving answers	
	Presentation	☐ Giving lectures about the inbreeding and cross breeding ☐ Solving problems related to breeding like those found in their text book	☐ Listening ☐ Taking notes	
	Summarization	☐ Summarizing the main points of the lesson	☐ Listening ☐ Participation to some extent	
	Evaluation	☐ Measuring whether the students understood the new information correctly ☐ Oral questions, class work, homework, etc	☐ Participation ☐ Asking ☐ Answering ☐ Doing class work and homework	

Teacher`s Name:________Dep`t head Name:________ Vice Director name:________

Signature:_________ Signature:_________ Signature:________

Date: _________ Date: _________ Date:________

Appendix F

Classroom Observation Checklist

i. For REACT strategy

School ________________________ Date __________________________

Section ________________________ Time __________________________

Questions	Yes	Partially	No
Does the teacher start the lesson with the context or a question?			
Are new concepts presented in contexts and experiences that are familiar to the students?			
Are concepts in examples and student exercises presented in the context of their use?			
Do examples and student exercises include many real, believable problem-solving situations that students can recognize as being important to their current or possible future lives?			
Do lessons and activities encourage the student to apply concepts and information in useful contexts?			
Are students expected to participate regularly in interactive groups where sharing, communicating, and responding to the important concepts and reasoning occur?			
Do lessons and exercises improve students' beliefs and other skills in addition to scientific reasoning and understanding?			
Do students follow their worksheets during the activities?			
Do students read the student text before coming to the class?			
Do students handle the new knowledge in the context presented at the beginning of the lesson?			
Did the teacher provide an environment where the students are required to show how they transfer their knowledge to real life?			
Did the teacher answer the questions in the new application?			
Did the teacher demand evidence from the students for the explanations?			
Did the teacher provide another application that allows students to use their new knowledge?			

Did the teacher encourage students to use scientific explanations in new situations?			
Did the teacher make the students to learn by themselves instead of directly teaching the course?			
Did the teacher ask the students for deliberate questions in order to redirect students' to learn through themselves?			
Did the teacher give them enough time to investigate?			
Has the teacher acted like a guide and counselor for students?			
Did the target concept be constructed and connected with real life?			
Did the teacher ask the students questions about the context?			
Did the teacher revealed the ideas and thoughts that students have about the topic?			
Did the teacher give answers to the questions asked?			
Did the teacher provide a suitable learning environment in which the students can compare the target concept with their own experience?			
Did the teacher give students exclusive learning activities to gain experience related to the target concept?			

ii. For conventional instruction integrated with context based activities

Questions	**Yes**	**Partially**	**No**
Did the teacher revealed the ideas and thoughts that students have about the topic?			
Did the teacher start teaching in an interesting context?			
Does the context fit the issue to be addressed?			
Did the teacher lecture the topic to the students?			
Are new concepts presented in contexts and experiences that are familiar to the students?			
Was the transition from concept to context appropriate?			
Did the teacher solve sample questions about the topic?			
Do lessons and activities encourage the student to apply			

concepts and information in useful contexts?			
Is there an opportunity for students to participate in solving sample questions?			
Was the topic addressed in the context given at the beginning of the lesson?			
Did the teacher provide an environment where the students are required to show how they transfer their knowledge to real life?			
Did the teacher provide another application that allows students to use their new knowledge?			
Did the teacher evaluated students understanding of concepts?			
Did the students participated regularly in interactive groups where sharing, communicating, and responding to the important concepts and reasoning?			

iii. For conventional instruction

Questions	**Yes**	**Partially**	**No**
Did the teacher solve sample questions about the topic?			
Is there an opportunity for students to participate in solving sample questions?			
Was the course teacher-centered?			
Is the course done using pictures or images from textbook?			

Appendix G

REACT Strategy: Lesson Plan Examples

The strategy used in this study was the REACT strategy. There are five phases in this model: (1) **R**elating, (2) **E**xperiencing, (3) **A**pplying, (4) Cooperation and (5) **T**ransferring.

The five phases of the contextual teaching strategies used in the study were presented in this order:

1. **Relating** – learning in the context of one's life experiences or preexisting knowledge
2. **Experiencing** – learning by doing, or through exploration, discovery, and invention
3. **Applying** – learning by putting the concepts to use
4. **Cooperating** – learning in the context of sharing, responding, and communicating with other students and
5. **Transferring** – using knowledge in a new context or novel situation one that has not been covered in class (Crawford, 2001).

Lesson topic: Chromosomes, DNA and genes

Lesson Objectives: Students will be able to;

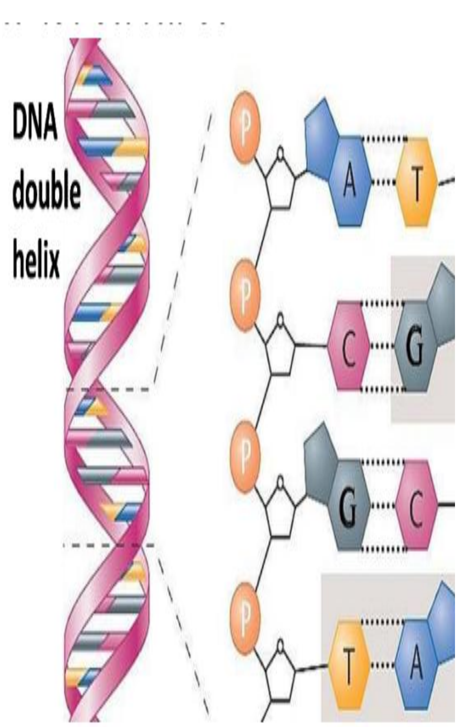
- Describe the structure of chromosomes, DNA and Gene.
- Relate chromosome, DNA and genes with the specification of gene as a unit of hereditary material located in the chromosome.
- Synthesize the model of double helix of DNA.

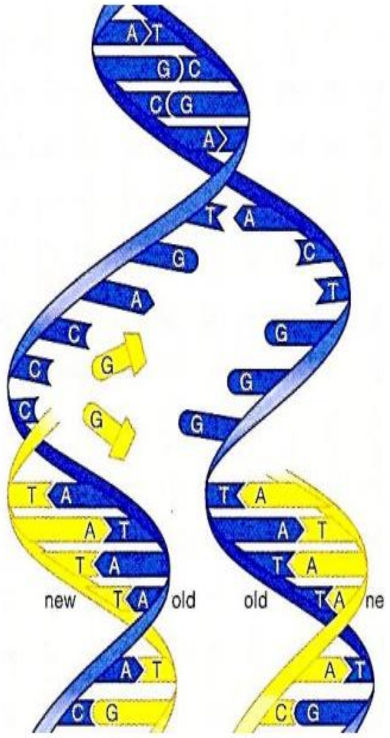
Phase 1: Relating

You have different seeds in the container like wheat, barley, pea, bean and cabbage. When you plant them to what plant each seed grows? Why not barley seed grow to wheat plant? Why child and parents share common characteristics? To whom you resemble among the family members? Why?

Phase 2: Experiencing

Use Chromosome and DNA model, chart and thread to show the relationship between Chromosome, DNA and genes.





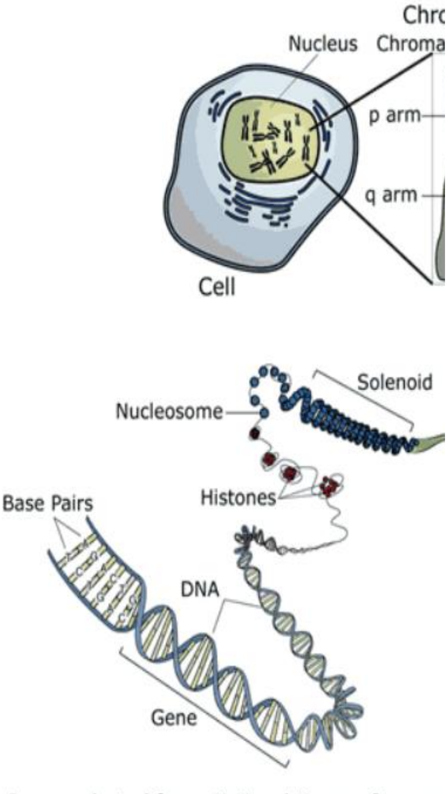
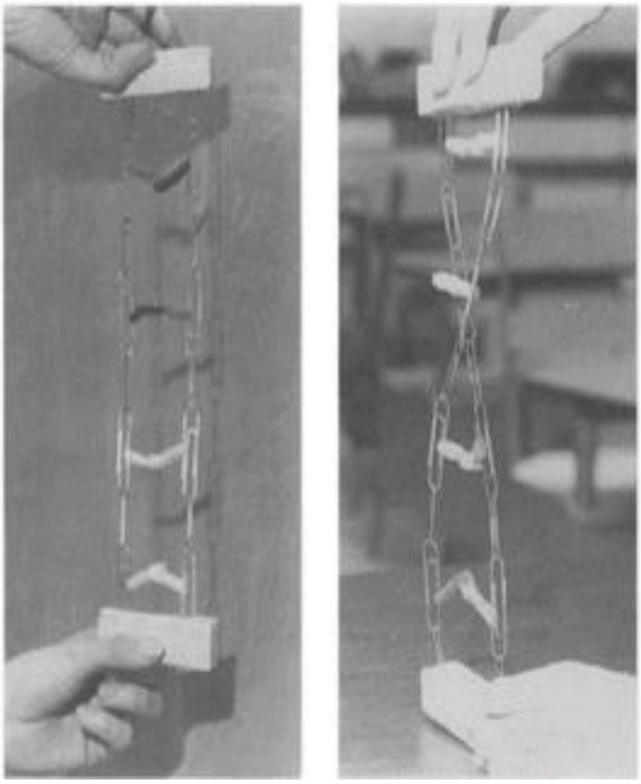


Image adapted from: National Human Genome



DNA Replication activity (whole class as 1 group, need space for four lines of about 8 students or ¼ of the class) – Let’s demonstrate what DNA looks like,

We are going to pass out some placards with string on them, they each have a letter, and a number on them! The letter is the DNA base, and the number is which group you are in. Group 1, please stand up! (Arrange students in a group where there is space). Listen carefully! Your first task is to find the DNA letter that matches with your card, so A’s find T’s, T’s find A’s, G’s find C’s and C’s find G’s. Once you find them, shake their right hand and hold on! While still holding the hand of your DNA partner, line up so that your left hand is on the left shoulder of someone who is not your partner. Got it? Now, let’s write down the order of the letters, and the direction they are facing. (Write on the white board) Now, group 1, let go of your right hands, but not your left, and step a few steps apart from each other. Group 2, it’s almost your turn! In a second, you are going to find the DNA letter that matches with your card, so A’s find T’s, T’s find A’s, G’s find C’s and C’s find G’s. Once you find them, shake their right hand and hold on! Now, let’s write down the order of the letters, and the direction they are facing. (Write on the white board) Everyone please take their seats, great job! So what did you notice about the first piece of DNA we made? Were all A’s with T’s and C’s with G’s? Which direction were the two lines facing? Now, what happened when we added group 2? How were the two pieces of DNA that we made similar or different? (They were exactly the same). In your bodies, DNA twists upon itself to forma structure seen here, the double helix, but if you were to unwind it, the structure would resemble the shape you all just made: connections to the right partner, and the two strands facing different ways. And the DNA code is how the molecule is able to perfectly replicate itself, because a copy of DNA can be formed from either half of the original (Community resource for science)

Phase 3: Applying

Parents and their children generally have related characteristics. Everyone tells Yonas looks so much like his father. Yonas has dangly ear, blood type B, dimple, fair skin, blonde hair, and blue eyes just like his father. Yonas’s mother, who has attached ear, no dimple, brown hair, brown eyes, and dark skin, wonders why her son does not look like her. Can you help her understand?

a. Why do you think Yonas looks more like his father than his mother?
b. If Yonas has a sister, do you think she will look more like her father or mother?
c. What contribute to the similarities and differences between family members?
d. Why do some children look like their uncles, aunties or grandparents, but may not look like their own parents?

Phase 4: Cooperating

Allow students to share, respond and communicate with other learners what they have discussed at phase three.

Phase 5: Transferring

In our country Ethiopia, car accident is increase from time to time. Abel is the one who suffer from car accident and he lost his left arm. He is getting married last April to a woman with two normal arms and he wants to have children. But he is afraid about his children may born with one arm.

a. Do you think Abel should be worried his children might have the same arm as he has? Explain why or why not?

b. How many children will have two normal arm?

Lesson Topic: Mitosis

Lesson Objectives: Students will be able to;

- Define mitosis as division of somatic cells with specific activities occur at each stages of mitosis
- Give different examples of activities that occur in living things which uses the concept of mitosis.

Phase 1: Relating

How a little baby become longer while growing? How a thin person increases their weight and becomes fat? In order to perform an activity by yourself you must grow enough. Likewise what activities are performed in the cell before the cell is dividing?

Phase 2: Experiencing

Use students to show the replication of DNA and the number of cells produced after cell division is completed.

Steps to perform the activity

The instructor begins the exercise with a question:

QUESTION - If this is a diploid cell with 2N=6, how many chromosomes are we going to need? The expected student's answer is "6, there will be three paternal and three maternal chromosomes." The instructor asks for volunteers, three men and three women, to represent paternal and maternal chromosomes.

QUESTION - The student chromosomes represent the nucleus at what stage in the cell cycle? The expected student answer, "Since the DNA has not replicated, this represents Interphase G1."

QUESTION: What event would take place before the cell can begin mitosis? The expected student answer is "The cell replicates its DNA."

QUESTION: How do we represent the cell with replicated DNA? The expected student answer is "Add six additional volunteers." Therefore, the instructor asks for six additional volunteers and gives them a chromosome label as well as a piece of rope. The students are then paired up according to their chromosome color and number, and then they hold the rope between them.

QUESTION - What does the rope represent? The expected student answer, "The rope is the centromere." The instructor calls on a student in the audience to describe the action of the chromosomes at the various steps of mitosis—prophase, metaphase, anaphase and telophase. The volunteers then go through the steps of mitosis while the audience monitors the choreography and provides suggestions and corrections. When the choreography is finished, the instructor asks:

QUESTION - So what is the end result of mitosis? The expected student answer, "Two cells with an identical complement of chromosomes".

Phase 3: Applying

You were start your life as a single cell which is a fertilized egg. Your body is grow and develop different tissue, organ and organ systems. After fully developed you were born at 9 month and continue to grow until you reach at adult age. Some times on both fully grown adult and growing child, an accident may cause an injury on different parts of the body like skin. But after certain time the wounded part of the body will healed and the same as before.

a. How a single cell develops in to the trillions of cells in a human body.
b. Why is cell division useful in an adult who is no longer growing?
c. Explain specific activities performed at each phase of cell division.

Phase 4: Cooperating

Allow students to share, respond and communicate with other learners what they have discussed at phase three.

Phase 5: Transferring

a. How DNA replication and mitosis ensure that each new cell gets a complete set of chromosomes with a complete set of genes.

b. Why each cell needs a complete set of genes and how genes influence phenotypic characteristics.

Lesson Topic: Meiosis – First and second meiotic divisions – Spermatogenesis – Oogenesis

Lesson Objectives: Students will be able to;

- Define meiosis as division of sex cells with specific activities occur in each stage of meiosis
- Relate meiosis with sexual reproduction.
- Compare mitosis and meiosis in terms of importance, process and product.

Phase 1: Relating

What is sexual and asexual reproduction? By which type of reproduction human being reproduce? How a man and woman produce a child? Do you think a girl and a boy whose age is 6 years old ready to reproduce? Explain why?

Phase 2: Experiencing

Use students themselves to show the replication of DNA and the number of cells produced after cell division is completed.

Steps to perform the activity

The instructor begins with a series of questions addressed to the volunteers and the audience. **QUESTION** - How is prophase I of meiosis different from prophase in mitosis? The expected student answer is “Homologous chromosomes align. This is called synapsis. Then they move together to the metaphase plate.”

QUESTION - What do we call these paired homologous chromosomes? The expected student answer, “A tetrad.” This is another occasion when acting out the movement of the chromosomes provides a visual meaning to the definition of tetrad.

QUESTION - What important event takes place while the homologous chromosomes are synapsed? The expected student answer, “There may be the actual exchange of genetic material between chromosomes. This action is called recombination or crossing over.”

QUESTION - Is there any particular order to how the chromosomes align on the metaphase plate? The expected answer, “No. Each chromosome moves independently of the others. This is the basis for Mendel's Law of Independent

Assortment.” The volunteers then proceed through anaphase I and telophase I where the tetrads have separated.

QUESTION - What are the end products at this point? The expected student answer, “Two cells with dyads that equal the haploid number of the cell. In this case there are three dyads in each cell. This is known as the reductional division.” At this point the instructor explains the significance of the reductional division.

QUESTION - In preparation for the next stage of meiosis, does DNA synthesis occur again? The expected student answer, “No.” Finally, a student in the audience is asked to describe the movement of the chromosomes at prophase II, metaphase II, anaphase II and telophase II. The volunteers proceed through the second division in meiosis while the audience monitors the choreography and makes corrections when necessary.

QUESTION - What is the end product of meiosis? The expected student answer, “Four haploid cells (N=3). This last part of meiosis represents the equational division.” At this point, the students note the genetic composition of each cell. Each cell represents a mixture of paternal and maternal chromosomes. Also, crossing over has produced variability among these chromosomes. Four groups of students represent the end products of meiosis. Note that recombination between homologous chromosomes in Prophase I is evidenced by the four students holding chromosome labels that do not match their gender.

Phase 3: Applying

Your mother ovary cell which is responsible for ova or egg cell formation has 46 chromosomes and in the same way your father gonad cells contains 46 chromosomes. But you are the product of the fusion of those two gametes also have 46 chromosomes.

a. How could this happen? Why not the number of chromosomes in your cells are 92?

b. Explain somatic or body cells and sex cells. What is the difference between them?

c. Differentiate between spermatogenesis and oogenesis.

Phase 4: Cooperating

Allow students to share, respond and communicate with other learners what they have discussed at phase three.

Phase 5: Transferring

Henok and his wife Marta have six children all of which are boys. They both really want to have a daughter, but they cannot understand why they always have boys. Marta thinks that maybe it is her fault that she can only bear sons. The couple decides to divorce and take on a second marriage.

a. Who do you think is responsible for determining the sex of the children (Marta, Henok, or neither)? Explain.

b. Do you think Henok and Marta might have a better chance of having a daughter with another woman and man respectively? Explain.

c. Explain how different gametes produced by the same person can have different combinations of alleles for genes that are located on two different chromosomes.

d. If siblings have the same biological mother and father, what explains any differences in the siblings' characteristics?

Lesson Topic: Mendelian inheritance

Lesson Objectives: Students will be able to;

- Explain the works of Mendel on garden peas
- Distinguish between heterozygous/homozygous, dominant/recessive traits and phenotype /genotype.
- Relate Mendel's work to the principles of inheritance**.**

Phase 1: Relating

Why some girls looks like their mother? Is it related with number of chromosome inherited from mother and father? Why? In your 1 to 5 group who always talk and take the turn of others? What you call those group members? When other students get the chance of talking while discussion? Why? Can you see all of the characteristics of an individual on their physical appearance? Why?

Phase 2: Experiencing

Using black and red seeds of pea for showing the pairing of dominant and recessive alleles, homozygous and heterozygous alleles. Use a chart which shows different contrasting observable characteristics of pea plants**.**

Steps to perform the activity

1. The teacher prepare 50 red and 50 black seeds of pea.

2. The teacher inform the student black seed color is dominant over red seed color which is recessive.

3. Put all the seeds in to the container and mix them.

4. One student takeout two seeds from the container without observing them and the class students categorized the seeds whether black or red? Heterozygous or homozygous? And made a ratio.

Phase 3: Applying

A farmer who planting a pea plant wants to grow round seed and ask an advice from you to buy seeds. The farmer wants to get seed which produces round seed confidently. Please help the understanding of the farmer.

a. What is the genotype of a seed which produces round seed in F1 generation? Is there the possibility of using pure breed to get round seed?
b. If the farmer implant the seed from F1 generation what will have the percentage of getting the round seed?

Phase 4: Cooperating

In a group of four discuss the following questions, communicate with other students and critique the idea of each other.

a. Why pea plants are a good choice for Mendel's experiments?
b. Why did Mendel use pea plants with different characteristics for the parental generation?
c. Why do you think he only tested one characteristic at a time?
d. Why did he allow the plants in the F1 generation to self-pollinate?
e. Explain the laws of Mendel by giving examples.

Phase 5: Transferring

We Africans are black. A man and a woman who are living in Gambela region Ethiopia, are both black. They got married last year and have a baby girl who is with pale skin. They worried, confuse and ask themselves why our child has white skin hence we are black. Can you help their understanding?

a. What is this condition and how it happens? Explain your answer.
b. Explain possible genotypes of the man and woman.
c. Explain homozygous and heterozygous alleles.

Lesson Topic: Mendelian genetics in human

Lesson Objectives: Students will be able to;

- Relate Mendelian genetics with human inheritance.
- Give examples of physical traits in human inherited by single gene.

Phase 1: Relating

Observe your friends' thumb and ear in your class. Is there any difference in thumb and ear shape? Why? Ask your friends weather their mother or father has the same characteristics as your friend or not at all? Where do they get this shape of thumb and ear?

Phase 2: Experiencing

Look at your thumb, are they straight or curved this is the characteristics inherited on a single gene. The allele for straight thumbs is dominant(S) to the allele for curved(s) thumbs. In the same way the allele that gives you dimples is dominant (D) over the allele for no dimples (d). By using punnett square explain your answer for the following questions.

a. Show the possible children thumb shape if both mother and father are heterozygous straight thumb.

b. One partner in a couple has dimples and the other has no dimples. Would you expect their children to have dimples?

Phase 3: Applying

Please look at your friends' physical appearance such as eye color, hair color and other physical features. You have probably noticed that different people have different traits. If your friend has blue eyes and she said both of her parents have brown eyes.

a. Where do people get these different traits from? Explain your reasoning.

b. Is there any possibility of having blue eyed child from brown eyed parents? Explain how.

c. Why is there a difference between parent and offspring?

Phase 4: Cooperating

In a group of four discuss the following questions, communicate with other students and critique the idea of each other.

a. In the shape of an ear dangly is dominant over attached ear. If a heterozygous dangly ear mother married a man who has attached ear, list possible ear shape of children by using Punnett square in terms of genotype and phenotype.

b. Mendel clearly explain about dominant and recessive alleles. Is there any possibility of presence of equally dominant alleles? Explain your answer by using examples.

Phase 5: Transferring

W/o Almaz and W/o Mulu born at a time in DebreBirhan hospital and both born girls. Unfortunately the nurses did not label the babies properly and they were mixed up. All the other babies born on that day were boys. The hospital staff is not sure which baby belongs to which parent. Both W/o Almaz and W/o Mulu have blood type A. W/o Almaz's husband blood type is A whereas W/o Mulu's husband blood type is AB. The blood type of baby girl 1 is O, and that of the baby girl 2 is B. The parents want to know which baby is their real child. Use at least two Punnett square to explain your answer.

a. How can this situation be resolved?

b. Which girl is belongs to W/o Almaz and which one is belongs to W/o Mulu.

Lesson Topic: Heredity and breeding

Lesson Objectives: Students will be able to;

- Explain the methods of breeding and its importance for the society.
- Give examples for breeding from their own experience.

Phase 1: Relating

Have you heard about best animals in your house or in your neighbor? What characteristics of this animals make them best? How can you allow these animal to increase their number? On the other hand there are animals which has poor characteristics. Can you increase the quality of those animals? How?

Phase 2: Experiencing

If one family live in afar region has a herd of goats which give good milk yields, but do not cope well without shade. Another family has goat which give less milk but are very hardy and resistant to the heat of the sun. Each family wants the solution for their goat weaknesses.

a. Is there any possibility of increasing the weaknesses of those goats? Explain how?

b. Mendel uses true breeding in his experiment because the F1 generations are not pure breeding. Would farmers have chance to get pure breed? Explain how.

Phase 3: Applying

Bekele is a grade 11 student and help his parents at his free time. His parents' job is animal farming. Their cow is giving plenty of milk and their chicken gives a large number of egg. After Bekele learns grade 10 genetics topic he think how those animals increase in both high meat production, large number of egg production and plenty of milk production. Can you help him?

a. Is the idea of Bekele possible? Explain how?

b. Explain how cross breeding and selective breeding carried on.

c. Explain the result of cross breeding and selective breeding in Ethiopia.

Phase 4: Cooperating

Give chance for the students to discuss, present, communicate and comment with each other on the idea of cross breeding and selective breeding.

Phase 5: Transferring

In human society the religious ethics and modern social norms consciously have judged and forbidden the marriages of brothers and sisters. What do you think in principles of genetics?

a. Is genetics support or oppose the rules of religion, norm and cultures of the society in relation to this idea? Why?

b. Do you think cross breeding and selective breeding have disadvantage? How?