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# Effects of context-based approaches on high school students' epistemological beliefs

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**ABSTRACT**

The current study aimed to examine the effects of context-based approaches on students' epistemological beliefs. The study used a quasi-experimental pre-post-test design with two treatment groups (TGs) and one comparison group (CG). A total of 131 grade ten students participated in the study. TG 1 received a relating, experiencing, applying, cooperating, and transferring (REACT) strategy of context-based teaching approach, whereas TG 2 received an instruction that was an integration of conventional instruction and context-based approach. Similarly, the CG received conventional instruction to teach the topic of heredity. The epistemological belief of students was measured using Colorado learning attitude science survey for biology version (CLASS-Bio) questionnaire. We analyzed the data using paired t-test and one-way ANOVA. The result indicated that a significant mean score differences was observed between the groups in favor of the TGs. However, a significant difference was not observed between TG 1 and TG 2. This implies that the context-based approach had a positive effect on students' epistemological belief shifts towards expertise than the conventional instruction.

**Keywords:** context-based instruction, conventional instruction, epistemological beliefs, heredity

## INTRODUCTION

It is suggested in science education that students should start their academic education with an understanding of what science is and how it is studied (Hansen & Birol, 2014; Semsar et al., 2011). These investigations of people's ideas about the nature of scientific knowledge and knowing are regarded as epistemic beliefs of the people (Hofer & Pintrich, 1997). Furthermore, epistemic beliefs are students' conceptions of the content and structure of a certain discipline, the source of knowledge about it, its connection to the real world, and their approaches to problem-solving. Students' naïve epistemic beliefs might be in conflict with experts' view (Hansen & Birol, 2014; Semsar et al., 2011). According to experts, science is tentative, changeable, and influenced by culture and experience (Lederman et al., 2014). In contrast, students often perceive science as a defined body of knowledge and experimental inquiry as a rigid process. Various disciplines, including biology, are prone to non-expert-like thinking by students (Hoskins & Gottesman, 2018).

A growing corpus of research has shown that epistemic beliefs may influence beliefs about education and learning (Schommer-Akins, 2004). In many ways, students' perceptions of their learning affect the way they learn and perform (Hofer & Pintrich, 1997). Additionally, students' simplistic and deeply ingrained epistemic views may prevent them from learning to think like scientists, which is a critical component of learning (Hoskins & Gottesman, 2018). This implies developed epistemic beliefs accelerate high level learning and critical thinking (Schommer-Akins, 2004). In general, and in biology education in particular, science education aims to guide students toward expert-like attitudes about scientific knowledge which helps them overcome cultural and societal prejudice (Jeffery et al., 2016).

Several studies have indicated that epistemic beliefs vary based on context and domain. For instance, Tsai (2006) indicated that biological information was perceived by high school pupils as being less certain than knowledge in other science fields, like physics. In contrast, Basu et al. (2017) found that most students believed that science was an impossible miracle that only highly qualified professionals could perform. The authors concluded that students' epistemic beliefs might have connection to their biology learning. Therefore, it may be essential to do discipline-based research in science education to comprehend epistemic views in more specialized areas (Mollohan, 2015; Schommer-Akins, 2004; Semsar et al., 2011).

However, studies reported contradicted results about the effects of different active learning methods on students' epistemic beliefs. Some studies reported that active learning methods might have positive effects on students' epistemic beliefs, but others reported no effects of teaching methods on students' epistemic beliefs. For instance, Lin et al. (2012) discovered that expert-like views have a favorable relationship with constructive conceptions but a negative relationship with reproduced conceptions. Hansen and Birol (2014) and Semsar et al. (2011) disclosed that learners develop more experts like beliefs about biology during their undergraduate careers from freshman to senior years. Whereas Ding and Mollohan (2015) study that opposed the findings of the studies previously cited, students' epistemic views may not evolve while taking courses in high school or college.

Furthermore, it has been argued that conventional instruction does not show positive effects on the development of students' epistemic beliefs. For example, an investigation of epistemological beliefs on introductory physics, chemistry and biology students found that students showed novice epistemological beliefs after they were taught the courses with conventional instruction (Adams et al., 2006; Barbera et al., 2008; Ding & Mollohan, 2015; Semsar et al., 2011). In contrast, in physics, expert shifts were seen using active learning strategies (Madsen et al., 2015). Similarly, in biology, there are an increasing number of research on how active learning strategies affect students' epistemological beliefs even if their results have contradicted each other. Some researchers that taught biology courses with an active learning methods and conventional instruction found no effects of the active learning method on students' epistemological beliefs (e.g., Beumer, 2019; Floro, 2014). Others found out that learning biology with active learning methods result in a shift in a more expert like students' epistemic beliefs (e.g., Connell et al., 2016; Hoskins & Gottesman, 2018; Jeffery et al., 2016; Westerlund & Chapman, 2017). This might be due to the nature of contexts (De Jong, 2008; Gilbert, 2006) or the nature of active learning methods and the nature of the curriculum materials with Gilbert et al.'s (2011) implementation model type (Kazeni & Onwu, 2013).

Therefore, systematically tailored teaching approaches that help students to attain expert epistemological belief might be important. The setting and a student's learning are interconnected in the field of biology education. Contexts are defined as circumstances that assist pupils in giving meaning to ideas, rules, laws, and other things (Gilbert, 2006). Contexts are techniques that assist students in giving meaning to laboratory activities in the classroom (De Jong, 2008). According to Bennett et al. (2005), in its broadest sense, context includes the social and cultural environment of the student, more specifically, it might refer to the use of a scientific theory. In context-based approaches, the creation of scientific concepts begins with the settings and applications of science. Unlike traditional instruction, which begins with factual facts rather than how to apply them (Bennett et al., 2007).

Context-based approaches' main objective is to illustrate scientific ideas with real-world experiences. To prevent isolating school from society and daily life, context-based approaches to education begin by focusing on the students' everyday experiences. An educational strategy called context-based learning concentrates on both the actual, concrete situation and the social context of the learning environment. Context-based teaching approach was founded on the belief of learning as a social activity (Bennett et al., 2005; Gilbert, 2006). The interaction between students might help them to gain new insights from their colleagues, to evaluate their own ideas, to test concepts that are important to solve specific contexts, and to have shared ideas on the concepts taught (Gilbert, 2006). Context-based instruction is anticipated to increase student motivation, foster natural curiosity, foster a favourable attitude toward science and the scientific worldview, and facilitate learning (Bennett et al., 2005; Wieringa et al., 2011). Context-based approach may be the solution to develop epistemological beliefs of students.

Four models were identified by Gilbert et al. (2011) for the creation of context-based curriculum. According to the first model, a context that directly applies a notion is only given as an example after an abstract concept has been acquired. The second model makes use of context as a means of connecting an idea to its applications. Due to its cyclical structure, many situations are offered more than once in order to apply previously revealed concepts and to introduce new concepts. When scientific concepts are connected to tales by individual mental activity, context is provided in the third model. Most of this paradigm is focused on the person. In the fourth model, learning happens as students and instructors collaborate to find a solution to a problem that arises in their local community. The fourth approach, according to the authors, is the most effective at integrating settings into science education, allowing it to address societal issues (Gilbert et al., 2011). Based on this recommendation, we were inspired to experiment the effectiveness of fourth model relative to conventional instruction and conventional instruction integrated with context-based approach (model two). Since the transmission instruction is common in the country, Ethiopia, we used the second model as a transition between conventional instruction and pure context-based approach (model four).

The effect of context-based teaching approach on students' motivation and attitudes in science, physics and chemistry fields has been widely investigated (Bennett et al., 2007; King, 2012). However, as our review result and Bennett et al. (2005) and Ozay Kose and Cam Tosun (2015) argument, there are few relevant studies that deal with context-based biology teaching and students' epistemological beliefs, at global level. Ozay Kose and Cam Tosun (2015) studied the impact of context-based biology learning on the enjoyment of students, which is one category of epistemological beliefs, and found significant improvement. On the other hand, Cabbar and Senel (2020) reported that context based approach intervention did not bring statistically significant effect on students' epistemological beliefs. Brist (2012) conducted action research using context-based approach and found out that epistemological beliefs of students was changed to expert like beliefs initially, but the delayed test indicated that their beliefs were slightly deteriorated.

Ethiopia is known for being a multilingual and multicultural nation, and Ethiopian culture and context are also different from other countries; however, empirical studies on the impact of context, students' experience and culture-oriented activities in the teaching-learning environment concerning students' epistemological belief was yet to be explored as specific context affects each outcome of a given variable (De Jong, 2008). Most research studies in Ethiopia focused on the type of pedagogy and found that most teachers use conventional instruction by ignoring the education and training policy of the country (Meskerem, 2017).

One of the frequent challenges teachers in Ethiopia face is making science learning relevant to the students' everyday life (Meskerem, 2017). This might be due to the fact that teachers might not be competent enough to address context-based teaching learning in the classrooms. Teshager et al. (2021) revealed that science teachers in Ethiopia could not lead children's context-based inquiries; besides, they failed to understand how knowledge in science evolves (i.e., with uncertainty) and is subjected to cultural and societal influences. Teachers themselves are unwilling to incorporate curriculum relevance into their research, and they place unreasonably high expectations on their students to exhibit certain traits and behaviors in their instruction (Meskerem, 2017). Besides, Ethiopian science curriculums are overloaded with contents, facts, principles, and theories. This could encourage pupils to recall information, but not to relate the knowledge they gained with their everyday experiences. This demonstrates that Ethiopian schools' attempts to enhance students' engagement, meaningful learning, and epistemological ideas appear to have been ineffective (Negassa, 2014). Scholars suggest that science learning, in whatever method delivered, should be context and culture based (Bennett et al., 2007; Gilbert et al., 2011). In other words, it has been argued that for students to see the connections between biology and real-world contextual examples must either be provided or students or must be led to these examples.

However, in Ethiopian context, the effort to make learning context-based is minimal. As far as our reading is concerned, there was no study that links context-based approach with epistemological beliefs and no research was conducted in relation to context-based intervention in biology education in Ethiopia. Thus, we were interested to fill this research and practice gap.

Thus, contextualization of a delegated biology curriculum was made and enacted in ways that link the concept of biology with students' real world local contexts, to make the concept of biology meaningful to the students. Hence, learning takes place within social, cultural, and local context from which students draw their everyday life experiences; the researcher adopted the social and sociocultural learning theories as a tool to guide the present study. Therefore, we implemented context-based approach for biology learning with two treatment groups (TGs) that were compared to conventional instruction. Then, in this study, Gilbert et al.'s (2011) second and fourth models of context-based implementation were used. Thus, our study aimed to answer the research questions listed, as follows:

1. What was the difference between the TGs and comparison groups (CGs) on epistemological beliefs with regards to novice to expert-like thinking?
2. How and to what extent epistemological beliefs of students in TG 1 and TG 2 were developed during treatment period?

**Table 1.** Symbolic representation of research design

| Groups | | Pre-test | Treatment | Post-test |
|---|---|---|---|---|
| TG 1 | n | $O_1$ | $X_1$ | $O_2$ |
| TG 2 | n | $O_1$ | $X_2$ | $O_2$ |
| CG | 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 combined strategy

## METHODOLOGY OF THE STUDY

### Research Design

A quantitative dominant mixed method approach was used in the current study. Multiple group quasi-experimental pre-post-test design was used to compare the epistemological beliefs of students who were taught using context-based approaches with those who were taught using conventional instruction. We included two TGs and one CG in our design. Accordingly, **r**elating, **e**xperiencing, **a**pplying, **c**ooperating, and **t**ransferring (REACT) instructional strategy (X1) was implemented in group 1, combined method (X2) was implemented in group 2, and conventional instruction was implemented in group 3 (**Table 1**). The combined method used both conventional instruction and context-based approach.

### Sampling

Our study population included all grade 10 students in government secondary schools in Debre Birhan, Ethiopia. Three schools were selected randomly, and three teachers were also assigned purposely based on the suggestions given by the school principals regarding the commitment of teachers. The researcher used the existing intact classes for both treatment and CGs; hence, there was no random assignment of students to groups. The schools and intact classes were assigned as treatment and CGs randomly. Before we administered the pre-test (epistemological beliefs questionnaire [EBQ]), we used lottery method and assigned classrooms from three schools to TG 1, TG 2, and the CG. A total of 131 students; 38(20 male; 18 female) in TG 1, 43(8 male; 35 female) in TG2, and 50 (18 male; 32 female) students in CG were engaged in the study.

### Data Collection Instruments

A questionnaire adapted from Colorado learning attitude science survey for biology (CLASS-Bio), semi-structured interviews, and classroom observations were used as a data collection instruments. We administered the EBQ before and after intervention; interview was conducted during and at the end of the intervention; classroom observation was made throughout the intervention.

We used the CLASS-Bio questionnaire developed by Semsar et al. (2011) to examine students' belief about biology, its nature, and biology learning. The CLASS-Bio developers argue that experts and novices have different beliefs regarding:

1. content and structure of knowledge,
2. source of knowledge, and
3. problem-solving approaches in biology.

**Table 2.** Cronbach's alpha value of pilot test for overall and each category

| EBQ constructs | CC | Enjoy | PSR | PSE | PSS | PSSA | RWC | Overall |
|---|---|---|---|---|---|---|---|---|
| Cronbach's alpha | .525 | .749 | .547 | .607 | .630 | .538 | .595 | .878 |

Furthermore, CLASS-Bio questionnaire informs the impacts of teaching approaches on students' epistemological beliefs (Semsar et al., 2011). Therefore, CLASS-Bio is an appropriate instrument to measure the epistemological shifts of students from novice to expert due to instructions. In the instrument, there were even categories, such as conceptual connection and memorization (experts think that knowledge is organized around a coherent framework of concepts, while beginners think that knowledge is made up of unconnected facts), enjoyment (whether a student likes or has a personal interest in solving the problem for the topic), four categories were related with problem solving (problem-solving reasoning, problem-solving effort, problem-solving strategy, and problem-solving synthesis and application). Regarding problem solving approaches, (experts frequently use concept-based tactics that are broadly applicable to a variety of problem-solving scenarios, while beginners frequently use pattern-matching to solve issues they have memorized and concentrate on surface aspects rather than underlying concepts). The seventh category was real-world connection (experts think experiments that mimic nature can establish knowledge about the world, whereas novices think knowledge is passed down by authority and has little application to the real world).

The CLASS-Bio questionnaire was translated into students' mother tongue, Amharic. It was reviewed by language experts, and the clarity and suitability of each item to determine students' belief about learning biology and knowledge construction in biology were checked by biology experts. Items that did not receive the reviewers' approval were reworded.

Reliability coefficient of overall EBQ was calculated using SPSS program to get Cronbach's coefficient alpha using pilot test and found to be .878 (**Table 2**). The Cronbach's coefficient alpha values of all instruments were within acceptable ranges. Categorical reliability was also calculated; however, since each category had only a few items (ranging from four to eight) the α level for each category was low. Accordingly, Schommer-Akins (2004) categorize the values of Cronbach's alpha in between .54 and .76 as fair internal consistencies. She also concludes that when the number of statements decreases, the value of Cronbach's alpha will decrease even below the mentioned value (.54).

## School and Classroom Contexts

The three schools were located in one of the towns in Ethiopia. The schools were a minimum of 13 km far from each other. The students in the schools came from town and the rural areas around the town. The families of the students were living on cattle breeding, crop production, trade, and government jobs. Thus, the students had different experience that might be helpful for context-based learning. In the classrooms, there were 38 (TG1), 48 (TG2), 50 (CG) students. The students were seated on benches. They used one desk for three students. However, they only shared the desks; they usually did not share ideas in the usual teaching learning process. There was one blackboard on one of the walls of the classrooms. The students' desks were arranged traditionally, in columns and rows facing the blackboard. The arrangement was changed for the study to a group setup in the TGs to favor group learning.

## Instructional Strategies

The teaching learning process took six weeks. Teachers who taught the TGs received training before implementing the treatment. In this study, context domains related to appreciation of nature and usefulness in daily life were considered motivators for learning. Personal, environmental, and community issues were addressed in the chosen situations. Identifying concepts, ideas, and principles related to genetics was accomplished by reviewing the Ministry of Education (2009) national curriculum statement for grade 10 biology. We organized genetics contents into themes, as follows:

1. Chromosome, DNA, and gene
2. Mitosis and meiosis
3. Mendelian inheritance of characteristics
4. Mendelian inheritance and variations in the characteristics of individuals, and
5. Heredity and breeding.

To teach each of these themes in TG 1, carefully selected narratives were woven into stories, based on the contexts chosen by the researcher. For TG 1, REACT strategy was used. The context presented in this study served as a social circumstance, which was explained by Gilbert et al. (2011).

### *Relating*

Relating is concerned about students' learning in the context of their experience or pre-existing knowledge. At this stage, we provided relevant authentic situations (contexts) related to the genetics concepts to the students. We presented an example of narrative below that we prepared it from the students' social environment. The narrative needs an understanding of concepts in heredity:

> You have different seeds in the container like wheat, barley, pea, bean, and cabbage. When you plant them, barley seed grows to barley plant and in the same way all seeds grow to their type of plant. Why not barley seed grows to wheat plant hence they are found in the same container? Why children and parents share common characteristics? Whom do you resemble among your family members? Why do you think that happens?

### *Experiencing*

At this stage, students are expected to learn by doing, or through exploration, discovery, and invention. We included hand-on activities to implement manipulative and problem-solving activities:

> For DNA topic, for example, students were requested to exercise the process of DNA replication by using letters of nitrogen bases (A, T, G, and C) and clearly identify which nitrogen bases combined each other based on fitting shapes like that of a socket.

### *Applying*

At this phase, students are expected to use the concepts from classroom to their environment. It is true that students who got an opportunity to engage in minds and hands-on problem-solving activities could apply the concepts during their engagement. In this stage, there were also other narratives to realize the concept of inheritance. In these activities, students were expected to apply concepts from classrooms to the new situations, which were in fact similar to studied concepts. For example:

> In our country Ethiopia, car accident is increasing from time to time. Abel is one of the victims who has been suffering from car accident and lost his left arm. He has got married in April to a woman with two normal arms and he wants to have children. But he is afraid that his children may be born with one arm because he lost his arm in the accident.
>
> a. Do you think Abel should be worried about his children that they might not have the same arm as he has? Explain why or why not?
>
> b. How many children will have two normal arms?

### *Cooperating*

At this phase, students are expected to share, respond, and communicate each other to internalize the concepts. We designed activities at this phase to encourage students to use the studied contents to explain and resolve the issues under consideration. Students were expected to work in small groups to handle these complex problems since they did not receive much outside help.

### *Transferring*

At this stage students are expected to use the knowledge they got from classrooms in a newer context or novel situation than been covered in class (Crawford, 2001):

> In human society, the religious and modern social norms consciously forbid the marriages of brothers and sisters. What do you think of this in terms of the principles of genetics?
>
> a. Does 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 disadvantages? How?

It is argued that choosing appropriate genetics content to depict such cases bring more linkage between contexts and the concept of hereditary material. Further, we used practical activities to connect genetics concepts and ideas to contexts through students' manipulation of real-life genetics processes. We designed the experienced-based activities to encourage students to use their prior knowledge and apply genetics concepts, ideas, and principles to the new situations. The activities were, therefore, arousing students' interest in the study of genetics since they were actively involved in performing them.

For TG 2, the teacher started the lesson with the introduction of concepts followed by the presentation of contexts. We used model two of Gilbert et al. (2011) context based approach. In chromosomes, DNA, and gene topic, first the teacher introduced the continuity of generation and explained about the genetic material, second, the teacher gave the same activity given at relating phase of TG 1 for discussion, and finally, the teacher explained the concept by giving another context-based example.

In the conventional instruction, the teaching learning process was more of teacher centered. The teaching was accompanied by mainly lecturing and questioning. Sometimes group discussions were also carried by students around the questions asked by the teachers. Mostly, at the beginning of the lesson, the teacher gave a short note to the students about heredity. And the students copied the short notes from the blackboard. Then, the teacher clarified the contents in detail by reading the notes from the blackboard, and students followed the teacher attentively. The real-life contexts were not introduced to students. Even the contexts that rarely presented on the students' textbook were not considered at all. Instead, after introducing main concepts the teacher generally focused on the question written on the textbook which focuses on memorizing facts.

## Data Analysis

We used descriptive and inferential statistics to analyze the data obtained from the CLASS-Bio questionnaire. We took a p-value less than 0.05 ($p<0.05$) statistically significant at 5% significance level in our statistical testing. We analyzed the data obtained from CLASS-Bio questionnaire by dividing up the statements' responses into the seven categories. The replies of the given statements were collapsed and categorized as disagree, neutral and agree. Replies, which were in conformity with experts' responses were referred to as favourable, whilst responses that were in divergence with experts' responses were referred as unfavourable (Semsar et al., 2011). Descriptive analysis was used to analyze the data from semi-structured interview and observation.

CLASS-Bio scores represent the proportion of all students' replies that corresponded with the opinions of experts on the same survey statements. Students received 1 if they concurred with the expert. Students who disagreed and marked neutral obtained a score of 0 while using SPSS.

To measure the overall changes in epistemological beliefs, a paired t test was performed to evaluate the overall and the seven categories pre- and post-percent favorable scores and shifts of beliefs. A rise in the percentage of favourable responses over time suggests a constructive change, while a fall in the percentage of favourable responses denotes a decline in expert-like beliefs. The scores of the three groups of students were compared using one way ANOVA to determine whether those groups were distinct from one another in all categories of their pre and post results.

**Table 3.** Percent agreement with experts, pre/post means, shift in beliefs, and nature of significance among three groups

| CLASS-Bio category | Treatment group 1 | | | | Treatment group 2 | | | | Comparison group | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % agree with experts | | | | % agree with experts | | | | % agree with experts | | | |
| | Pre | Post | Belief shift | p-value | Pre | Post | Belief shift | p-value | Pre | Post | Belief shift | p-value |
| Overall | 58.29 | 70.66 | 12.37 | 0.000 | 55.51 | 64.58 | 9.07 | 0.024 | 59.62 | 56.09 | -3.53 | 0.187 |
| CC | 42.76 | 60.16 | 17.4 | 0.000 | 47.97 | 60.88 | 12.91 | 0.014 | 43.50 | 46.70 | 3.20 | 0.401 |
| ENJ | 66.32 | 81.5 | 15.18 | 0.009 | 72.25 | 69.25 | -3.00 | 0.592 | 70.47 | 63.74 | -6.73 | 0.103 |
| PSR | 73.16 | 66.84 | -6.32 | 0.389 | 65.12 | 57.21 | -7.91 | 0.208 | 68.20 | 61.60 | -6.60 | 0.135 |
| PSE | 61.29 | 64.29 | 3.00 | 0.570 | 65.05 | 60.47 | -4.58 | 0.412 | 66.20 | 60.34 | -5.86 | 0.144 |
| PSS | 65.92 | 69.74 | 3.82 | 0.492 | 65.35 | 61.05 | -4.30 | 0.527 | 65.40 | 58.80 | -6.60 | 0.246 |
| PSSA | 43.99 | 60.05 | 16.06 | 0.001 | 47.28 | 55.91 | 8.63 | 0.026 | 44.86 | 40.56 | -4.30 | 0.221 |
| RWC | 66.17 | 77.68 | 11.51 | 0.023 | 55.31 | 70.80 | 15.49 | 0.004 | 64.94 | 57.12 | -7.82 | 0.055 |

Note. CC: Conceptual connection; ENJ: Enjoyment; PSR: Problem-solving reasoning; PSE: Problem-solving effort; PSS: Problem-solving strategy; PSSA: Problem-solving synthesis and application; & RWC: Real-world connection

**Table 4.** ANOVA result comparing groups in terms of post-EBQ scores

| | | SS | df | MS | F | Sig. |
|---|---|---|---|---|---|---|
| Overall TG1 post | BG | .472 | 2 | .236 | 8.489 | .000 |
| | WG | 3.558 | 128 | .028 | | |
| | T | 4.030 | 130 | | | |
| CC TG1 post | BG | .594 | 2 | .297 | 6.064 | .003 |
| | WG | 6.264 | 128 | .049 | | |
| | T | 6.858 | 130 | | | |
| ENJ TG1 post | BG | .695 | 2 | .347 | 4.817 | .010 |
| | WG | 9.228 | 128 | .072 | | |
| | T | 9.923 | 130 | | | |
| PSR TG1 post | BG | .187 | 2 | .094 | 1.021 | .363 |
| | WG | 11.736 | 128 | .092 | | |
| | T | 11.923 | 130 | | | |
| PSE TG1 post | BG | .041 | 2 | .020 | .354 | .702 |
| | WG | 7.367 | 128 | .058 | | |
| | T | 7.408 | 130 | | | |
| PSS TG1 post | BG | .276 | 2 | .138 | 1.391 | .253 |
| | WG | 12.695 | 128 | .099 | | |
| | T | 12.971 | 130 | | | |
| PSSA TG1 post | BG | .959 | 2 | .480 | 9.203 | .000 |
| | WG | 6.670 | 128 | .052 | | |
| | T | 7.629 | 130 | | | |
| RWC TG1 post | BG | .979 | 2 | .490 | 9.757 | .000 |
| | WG | 6.422 | 128 | .050 | | |
| | T | 7.401 | 130 | | | |

Note. BG: Between groups; WG: Within groups; SS: Sum of squares; & MS: Mean sqaures

# RESULTS

Before inferential statistics was done, ANOVA and paired t-test assumptions were checked for both pre-test skewness (-.412), kurtosis (-.60), and Levene's test with p=.492); and post-test skewness (-.342), kurtosis (-.544), and Levene's test with p=.751). The result showed that there were no violations of normality and homogeneity of variance assumptions. Before intervention, the ANOVA result showed that there was no discernible difference between groups F(2, 128)=.826, p=.44. Therefore, initially, there was no epistemological belief difference among groups.

The percentage of agreement with experts increased after intervention. To confirm whether the shift observed was significant or not, paired t- test was used (**Table 3**). The paired t-test confirmed that in their overall results, there is a large distinction between post and pre-test results in TG 1 (p=.000) and TG 2 (p=.024); however, there is no appreciable distinction in CG (p=.187). There is also a significant difference among TG 1 students in the category of CC (p=.000), ENJ (p=.009), PSSA (p=.001), and RWC (p=.023), and TG 2 students in CC (p=.014), PSSA (p=.026), and RWC (p=.004). On the other hand, there is no significant difference in PSR, PSE, and PSS categories in both TG students and in all categories among CG students' pre-post-tests (**Table 3**).

The TG 1 students (n=38) made substantial changes in favour of expert-like ideas in overall score and in four CLASS-Bio categories: "conceptual connection, enjoyment, problem-solving synthesis and application, and real-world connection". On the other hand, in three problem-solving categories: "problem-solving reasoning, problem-solving effort, and problem-solving strategy", TG 1 students had novice beliefs. Students in TG 2 (n=43) produced statistically significant changes in the direction of the experts in the overall score and in three categories like that of TG 1: conceptual connections, problem-solving synthesis and application, and real-world connection except enjoyment category. Thus, students in both REACT (TG 1) and combined methods (TG 2) shifted dramatically in several CLASS-Bio categories toward more expert-like attitudes with no changes in the three CLASS-Bio categories. In CG students' overall and all categories mean post-test results did not differ significantly from mean pre-test results.

The ANOVA results show that there was a substantial mean disparity among groups in overall and four CLASS-Bio categories (**Table 4**).

To identify between, which groups the difference was found, post-hoc analysis was made (**Table 5**), and there was a significant difference among treatment and CGs in the overall beliefs, and in four categories. However, there was no significant difference between TGs and CGs in relation to problem-solving reasoning, effort, and strategy categories. There was no discernible difference between TGs 1 and 2 in any categories.

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:

**Table 5.** Post-hoc multiple comparison test result

| Dependent variable | (I) Groups | (J) Groups | Mean difference (I-J) | Standard error | p-value |
|---|---|---|---|---|---|
| Overall TG1 post | Treatment group 1 | Treatment group 2 | .0607650 | .0371187 | .234 |
| | | Comparison group | .1456385* | .0358791 | .000 |
| | Treatment group 2 | Treatment group 1 | -.0607650 | .0371187 | .234 |
| | | Comparison group | .0848735* | .0346736 | .041 |
| | Comparison group | Treatment group 1 | -.1456385* | .0358791 | .000 |
| | | Treatment group 2 | -.0848735* | .0346736 | .041 |
| CC TG1 post | Treatment group 1 | Treatment group 2 | -.0072583 | .0492547 | .988 |
| | | Comparison group | .1345789* | .0476097 | .015 |
| | Treatment group 2 | Treatment group 1 | .0072583 | .0492547 | .988 |
| | | Comparison group | .1418372* | .0460101 | .007 |
| | Comparison group | Treatment group 1 | -.1345789* | .0476097 | .015 |
| | | Treatment group 2 | -.1418372* | .0460101 | .007 |
| ENJ TG1 post | Treatment group 1 | Treatment group 2 | .1225194 | .0597814 | .105 |
| | | Comparison group | .1776000* | .0577848 | .007 |
| | Treatment group 2 | Treatment group 1 | -.1225194 | .0597814 | .105 |
| | | Comparison group | .0550806 | .0558434 | .587 |
| | Comparison group | Treatment group 1 | -.1776000* | .0577848 | .007 |
| | | Treatment group 2 | -.0550806 | .0558434 | .587 |
| PSSA TG1 post | Treatment group 1 | Treatment group 2 | .0414565 | .0508236 | .694 |
| | | Comparison group | .1949263* | .0491262 | .000 |
| | Treatment group 2 | Treatment group 1 | -.0414565 | .0508236 | .694 |
| | | Comparison group | .1534698* | .0474756 | .004 |
| | Comparison group | Treatment group 1 | -.1949263* | .0491262 | .000 |
| | | Treatment group 2 | -.1534698* | .0474756 | .004 |
| RWC TG1 post | Treatment group 1 | Treatment group 2 | .0689351 | .0498703 | .353 |
| | | Comparison group | .2056135* | .0482048 | .000 |
| | Treatment group 2 | Treatment group 1 | -.0689351 | .0498703 | .353 |
| | | Comparison group | .1366784* | .0465852 | .011 |
| | Comparison group | Treatment group 1 | -.2056135* | .0482048 | .000 |
| | | Treatment group 2 | -.1366784* | .0465852 | .011 |

> 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.

## DISCUSSION

Our study result revealed that both novice and expert beliefs were observed among different groups. TG students' epistemological beliefs have changed to more expert-like views, in overall and in sort of enjoyment, real-world connection, problem-solving synthesis and application, and conceptual connection. This result is supported by other findings (Connell et al., 2016; Hoskins & Gottesman, 2018; Jeffery et al., 2016; Westerlund & Chapman, 2017). In contrast, our result contradicted with the studies of Adams et al. (2006), Barbera et al. (2008), and Semsar et al. (2011). This might be due to the difference in contexts (Gilbert et al., 2011). The context of Ethiopian schools and classrooms might not be the same with the contexts of other countries.

The change observed in epistemological belief in TGs may be due to the experience-based activities that facilitated students' discussion on core concepts based on real life experiences and natural phenomena instead of focusing on specific details and accumulated facts (Gilbert, 2006). Activities which were frequently introduced and closely related to students' experiences might have impact of students' beliefs. Consequently, the pupils might perceive the subject domain from a more positive and holistic perspective. In the current study, the activities involved were important to make the concept concrete instead of congesting the material with abstract concepts, which lead students to develop memorization of facts and theories to score pass mark on exams.

The other possible reason might be the amendment made on the curriculum material. As Ding and Mollohan (2015) argue, the applicability of the curriculum materials for students may have effect on their shift toward more expert-like epistemological beliefs. Similarly, in TG 2 supplementing curriculum with context-based activities related to fundamental concepts could be helpful to students to develop expert like epistemological beliefs. This study filled two literature gaps. These are a positive consequence of real-life based education on the development of epistemological beliefs plus shed light on implementing context-based learning in Ethiopia.

Nevertheless, there was no change in the beliefs of both TG 1 and TG 2 students related to problem-solving strategy, reasoning, and effort. This result is in line with other findings from different countries (Adams et al., 2006; Beumer, 2019; Ding & Mollohan, 2015; Floro, 2014; Semsar et al., 2011). Lack of sophisticated shifts documented in CLASS-Bio might be because of the development of more mature epistemological beliefs with short term intervention do not occur automatically. Besides, teachers' beliefs may have effects on students' beliefs. If the teachers' epistemological belief is not in line with experts' belief, they may have a chance of expressing it to the students directly or indirectly which may in turn affect students' epistemological beliefs (Schommer-Akins, 2004). Another reason might be time constraints. A one-time intervention in a specific topic might not be sufficient to change pupils away from persistent non-expert beliefs and viewpoints (Hofer & Pintrich, 1997).

Students in the CG showed no significant differences in their epistemological beliefs after instruction. Likewise, other studies found that science majors' express novice epistemological beliefs after conventional instruction (Ding & Mollohan, 2015; Hansen & Birol, 2014). The CG students used an overloaded curriculum and might feel overwhelmed with accumulated facts, and that's why they were stuck on recalling passing the exam (Ding & Mollohan, 2015). The textbook contains theoretical details and focuses less on the real-world relevance of the subject. This could be the reason for unchanged novice beliefs of the CG students that they view biological knowledge is not related with their daily life. The interview result confirmed the result obtained from the statistical analysis.

# CONCLUSION

This study generally concluded that daily thinking and experience-based activities and lessons aid students in developing scientific thinking and an understanding of how scientific information is constructed. All of the students initially held the same epistemological views, but following the intervention, post-test results showed a substantial difference between the groups. This implies emphasizing the relevance of biology to students' lives is essential to them to develop expert like beliefs. The current study provides evidence that context-based approaches are vital to create the greatest possible learning environment and a more effective facilitation of instruction. Similar to other active learning techniques that produce expert-like epistemological views, implementing context-based learning results in expert-like changes across several CLASS-Bio categories. As a result, participation in an experience-based activity appears to benefit all students by fostering the development of more expert-like beliefs on science. This means that if students receive a quality education, their beliefs about biology and how it should be taught will be comparable to or closer to those of experts (Lederman et al., 2014). Therefore, rather than utilizing conventional instruction, teachers should be encouraged to use appropriate pedagogy that will result in the formation of epistemological views toward expertise beliefs.

## Implications

In primary and secondary schools, through university education, there is an on-going effort to develop students' epistemological belief and its applicability into everyday life. The present findings at the secondary school level suggest a promising direction for developing and testing of context-based instructional materials that could raise students' epistemological beliefs. For instance, the results indicate that encouraging students to view biology as a regular practice may help them progress in a positive direction toward mastery of the real-world link category. Since genetic terms and concepts are introduced starting from grade ten, it is hoped that students will continue to deepen their understanding of genetics and retain it with more supportive or expert-like epistemic beliefs. Most significantly, if they continue to learn through context-based methods, students will discuss and make decisions about social issues in society. However, it is possible to say that a one-time intervention in a single subject will not be enough to get students to abandon their ingrained novice beliefs. To accomplish long-term transformations in epistemological beliefs, it may be necessary to expressly reiterate the essence of science, and all disciplines should leverage their own context to build a context-based learning culture.

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