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Relative Effects of Three Instructional Approaches on Reasoning Skills and Retention of Students in Evolution Concepts

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Abstract

Evolution, a major unifying biological theme that deals with the origin of life on earth, is the concept that most Ghanaian Senior High School (SHS) students hold misconceptions about. This makes its meaningful understanding challenging, especially on problems that require them to think in abstract forms. The author of this study, therefore, investigated the relative effects of three instructional approaches (*demonstrative lecture, problem-based approach, and classroom discussion*) on reasoning skills and retention of Ghanaian Biology students in evolution concepts. A quasi-experimental design was employed for the study. The population comprised all Science Two students in Berekum Municipality and Berekum West District. Multistage sampling techniques were employed to select thirty-nine (39) students for the study. Biology Reasoning Skills Test-Evolution (BRST-E) of a coefficient value of 0.76 was the instrument designed to gather data. Results from the ANCOVA reveal that students exposed to a problem-based approach had a significant gain in their reasoning [$p<0.05$, $\eta^2p=0.193$] and retention [$p<0.05$, $\eta^2p=0.281$], whereas the t-test results revealed that male students made advancements in their reasoning skills than females [$df=24, t=5.08, F=4.36, p<0.05$]. Therefore, Biology instructors in Berekum Municipality and Berekum West District should embrace the use of a problem-based approach in delivering evolution lessons to shape students' levels of reasoning and memory retention.

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Introduction

Biology is a natural Science that deals with the living world, how it is structured, its functions, what these functions are, how it develops, how living things came into existence, and how they react to one another and their environment (Umar, 2011). It is an essential subject for many fields of learning because it contributes enormously to the technological growth of nations (Ahmed, 2008). These fields include Medicine, Pharmacy, Nursing, Agriculture, Forestry, Biotechnology, Nanotechnology, and many other areas (Ahmed & Abimbola, 2011). Biology as a discipline in Ghanaian Senior High School (SHS) curriculum aim is to enable learners to appreciate living things around them. Because of its reputation, more students enrolled for Biology in the West African Senior Secondary Certificate Examination (WASSCE) than for Physics and Chemistry (WAEC, 2017, 2018, & 2019). Studies conducted about the situation of Biology in Ghana indicated that students have challenges in obtaining a sound understanding of numerous concepts underlying it or have misconceptions about them (Adarkwah & Yawson, 2019; Ameyaw, 2016; Ameyaw & Kyere, 2018; Anamuah-Mensah, 1999; Yeboah, 2010). Empirical studies in the field of Biology point out that there are difficulties in teaching Biology concepts such as respiration (Akpinar, 2007), photosynthesis (Akcay, 2017), osmosis and diffusion (Odom & Barrow, 1995), protein synthesis, and cell (Urey & Calik, 2008), inheritance (Lewis & Kattman, 2004), ecology (Cordero, 2001), mitosis and meiosis (Atilboz, 2004) and that students are tugged into misconceptions during instruction.

A topic that is imperative in terms of Biology teaching, which is challenging to cover and haul learners into misconceptions at any moment, is the concept of evolution. Scott (2004) defined evolution as “a cumulative change through time,” which depicts that there are various meanings of evolution, including astronomical, geological, chemical, and biological evolution (p. 23). Wiles (2010) defined evolution as “the diversity of life on Earth [which] has arisen via descent with modification from a common ancestry” (p. 18). The researcher, however, in this paper restricted the term evolution to the aspect of biological evolution only. Also, the term Biology means Elective Biology; thus, the use of Biology teachers and students means Elective Biology teachers and students. In order for Biology teachers to help students develop a scientific understanding of evolution concepts, it is imperative for them to identify which ideas about the concept constitute their misconceptions (Committee on Undergraduate Science Education National Research Council, 1997).

Misconceptions are concepts that students have developed as substitutes for scientifically accepted ones (Cordova et al., 2014). Misconceptions about evolution are well documented (Scott, 2005; Smith, 2010; Yasri & Mancy, 2014). For example, many learners think that evolution usually occurs in a focused track starting from lower taxonomical species towards higher ones (Alter & Nelson, 2002, González Galli & Meinardi, 2011). Pongsophon (2006) reported that many students believed that the organisms themselves make changes in individual organisms, and they can pass these characteristics on to their offspring. However, Gregory (2009) explained that physical changes that occur during an organism's lifetime could not be passed on to offspring because the cells that are involved in reproduction (the germ line) are separate from those that make up the rest of the body (the somatic line) thus, only changes that affect the germ line can be passed on (p. 169). Students believed that humans evolved from monkeys (Clores & Limjap, 2006; Yasri & Mancy, 2014). Dagher and BouJaoude (2005) found that College Biology students considered no "solid" evidence to authenticate the theory of evolution by wrongly perceiving the certainty of the theory of evolution by expressing two radical views towards the degree of certainty. Dagher and BouJaoude (2005) further reported that some students viewed the theory of evolution as static, whereas others considered that it remains unclear and will be changed. Scott (2005) argued that, in everyday use, a "theory" means a guess. In science, a theory is not a guess but "a logical construct of facts and hypotheses that attempt to explain a natural phenomenon" (p. 241). Therefore, students' perception that "evolution is just a theory" is a vernacular misconception used to reject evolution on the ground of disbelief rather than logical arguments.

In Ghana, reasoning skills/abilities and retention of concepts among learners are very crucial variables in the Biology curriculum. Holyoak and Morrison (2005) contended that scientific reasoning skills mark the development of cognition that is required for real decision-making and problem-solving. Reasoning skills are central to the process of knowledge attainment and conceptual change (Kuhn (2004), as cited in Zeineddin & Fouad, 2010). According to Kuhn (2004), scientific reasoning is a sentimental, decisive knowledge seeking-process that is social in nature. It is a process that people go through in order to review their ideas and build new understandings and that, the heart of this reasoning process is coordination of theory and proof, which does not only mean reviewing the theory in the light of the proof but distinguishing between and envisioning both (Kuhn, 2004). Students' inability to reason critically results when instructors employ teaching strategies where they act as inert participants by not assigning them direct activities (Irwanto & Prodjosantoso, 2018).

According to Bichi (2002), perpetual and eloquent learning is the aim of every educational endeavor. Ogundokun and Adeyemo (2010) contended that because of these, understanding and retention are the products of meaningful learning when teaching is effective and meaningful to learners. Thus, proper coding of new information provides the index that may be referred to so that retention takes place without intricate search that subsequently empowers learners to reminisce about what they have experienced or what they have in memory. Aggarwal (2008) stated that good memory and retention lead to meaningful learning that results in the production of a series of changes within learners' entire cerebral structure, alters their existing concepts, and enables them to form new connections between them. Learners' reasoning skills and their ability to recall evolution concepts require instructors to employ instructional approaches that result in cognitive disequilibrium among them to aid clear their misconceptions. To help students develop broader conceptions about scientific phenomena, teachers should subject learners to cognitive processes that cause them to face and alter their existing conceptions (Dantonio & Beisenherz, 2001). Anjum and Abida (2013) stated that there are two major approaches to addressing misconceptions in order to enhance conceptual change among students. The former, behaviorism, explains the behavioral pattern of learners, whilst the latter, known as cognitive psychology, provides assistance for learners to understand human thought processes. Thus, instead of teaching and learning sequestered bits of "inert knowledge," recent Science Education opines the need for "quality over quantity, meaning over memorizing, and understanding over awareness" (Mintzes et al., 2001). For this reason, Liras (1994) stated that Science instructors should help students connect theoretical concepts with the practical aspects of the real world via their motivation.

According to WAEC Chief Examiner Report (2017, 2018, & 2019), despite the popularity of Biology, results of research studies always reveal declines in the performance of students in the subject compared to Physics and Chemistry owing to the fact that the discipline include lots of abstract concepts which cause numerous students to have challenges in constructing its meaningful understanding. Senior High School Biology students in Berekum Municipality and Berekum West District are victims of this situation. Evidence gathered by the researcher from the Berekum Municipality and Berekum West District Educational Directorate shows that the problem prevails within the setting. In 2018, out of the 572 candidates who sat for May/June WASSCE, 263 (45.98%) obtained grades A1-C6, whilst 309 (54.02%) obtained grades D7-F9. In 2019, for instance, out of the 603 candidates who sat for the same examination, 297 (49.25%) obtained grades A1-C6, while 306 (50.75%) obtained grades D7-F9. In 2020, 679 candidates sat for the examination, and out of these, 337 (49.63%) obtained grades A1-C6, whereas 345 (50.37%) obtained grades D7-F9. It can be deduced from the WASSCE results that the percentage of candidates that obtained lower grades in 2018, 2019, and 2020 is 54.02%, 50.75%, and 50.37%, respectively. Though the percentage of students that obtain grades D7-F9 is declining uniformly in these respective years, it can be inferred from the data that Biology students performed abysmally poor during WASSCE in the past three years because the percentage of candidates who obtained grades A1-C6 in these subsequent years did not exceed 50.0%. There are different teaching methods that can be employed by instructors to improve upon students' educational variables such as performance, reasoning, memory retention, interest, motivation, and attitudes toward Biology concepts rather than a formal lecture approach. Some of these include; interactive lectures, concept maps, jigsaw, demonstrative lectures, inquiry, classroom discussion, problem-based approaches, and project-based approaches. Empirical studies have revealed that demonstrative lectures in which teachers deliver lessons verbally and act when the need arises at intervals for students to watch and exhibit those actions later are influential in enhancing learners' reasoning skills (Duruji et al., 2014; Sweeder & Jeffery, 2013) and their retention abilities (Auwal, 2013; Hemanthakumar et al., 2013; Ogologo & Wagbara, 2013; Price & Brooks, 2012). Problem-based approach, which involves instructors posing "ill-structured" problems to learners for they to find solutions to those problems themselves, is also potent in improving learners' reasoning skills (Arifin et al., 2019; Karaçalli & Korur, 2014; Michel et al., 2012; Rakhshanda, 2013) and knowledge retention (Arifin et al., 2019; Leuchter et al., 2014; Strobel & van Barneveld, 2019). Classroom discussion encompassing the exchange of ideas between instructors and students and or between the learners themselves is also effective in enhancing students' reasoning skills (Cazden & Beck, 2003; Sun et al., 2015; Webb et al., 2015) and knowledge retention (Christianson & Fisher, 1999; de Grave et al., 2001; Falode et al., 2015). Despite the potentials associated with these instructional approaches in improving learners reasoning abilities and their long-term knowledge retention across various disciplines, it is unknown, particularly in Ghana, that a study has been carried out to investigate the relative effects of demonstrative lecture, problem-based approach, and classroom discussion on the reasoning skills and retention abilities of Biology students in evolution concepts at the Senior High School level. This study, therefore, seeks to seal this knowledge gap. The purpose of the study, therefore, is to investigate the relative effects of the three instructional approaches on reasoning skills and retention of Ghanaian Biology students in evolution concepts.

Related Hypotheses

Ho1- There is no statistically significant difference in the mean prior knowledge scores of students to be taught evolution using demonstrative lecture, problem-based approach, and classroom discussion.

Ho2- There is no statistically significant difference in the mean Biology reasoning skills scores of students taught evolution concepts using demonstrative lecture, problem-based approach, and classroom discussion.

Ho3- There is no statistically significant difference in the mean retention scores of students taught evolution concepts using demonstrative lectures, problem-based approach, and classroom discussion.

Ho4- There is no statistically significant difference in the mean reasoning skills scores of male and female students in the experimental group.

Method

Research Design

The non-equivalent pretest posttests quasi-experimental design was employed for the study.

Population, Sample and Sampling Techniques

The population comprised all public SHS 3 students in Berekum Municipality and Berekum West District, Bono Region. The target population consisted of all Biology students within the two selected schools in Berekum Municipality and one school in Berekum West District, with the accessible population comprising all

Science Two (SC2) students within each school. Multistage sampling techniques were employed. Convenience sampling was used to select students on the researchers' first visit to each school. Afterward, a systematic approach was employed by the researcher to select every third member from each of the classes. Thirty-nine (39) students were selected for the study. The detail of the sample is distributed in Table 1.

Table 1. Distribution of Students to the Instructional Methods and their Sample Sizes

School	Students Sampled	Conveniently	Sample Size
SHS X (Demonstrative Lecture Group)	41		13
SHS Y (Problem-Based Group)	34		11
SHS Z (Classroom Discussion Group)	47		15
Total	**122**		**39**

Instrument

Biology Reasoning Skills Test-Evolution (BRST-E) was the instrument designed to gather data. The items were constructed to cater to the application of knowledge and analysis dimension consisting of twenty (20) multiple-choice items and ten (10) one-word answers/phrases items.

Validity, Pilot-Testing, and Reliability of Instrument

The instrument was handed over to three Biology instructors teaching in Colleges of Education to analyze it vividly to ascertain its content and construct validity. After the validation exercise, the items that were not measuring reasoning skills and those that contradicted the requirements of the syllabus were reconstructed. This was to ensure the credibility of the difficulty and discrimination indexes of the instrument. Afterward, accidental sampling was employed to select twelve biology (12) students from Drobo SHS, an institution that shares similar characteristics with that of the study area, and the instrument was pilot tested on them. The reliability of the instrument was computed using Kudder-Richardson (KR-20) formula, and the coefficient was found to be 0.76. Therefore, the instrument was considered reliable for data collection since its coefficient value obtained lies within the acceptable benchmarks of all reliable instruments (Ary et al., 2002).

Procedures for Data Collection

The researcher sought permission from the authorities in the various institutions where the study was conducted. A pre-BRST-E was administered to the selected students in each school on the second visit to solicit their prior knowledge about the topic before subjecting them to a teaching approach. Each of the teaching groups was assigned randomly to one of the three instructional strategies by means of the researcher's own judgment. Students at SHS X were assigned as the Control Group (CG) and were exposed to demonstrative lecture; SHS Y students were assigned as Experimental Group One (EG1) and were subjected to a problem-based approach, whereas SHS Z was assigned as Experimental Group Two (EG 2) and was subjected to classroom discussion. Each respective group was subjected to their teaching methodology for four (4) weeks. Immediately after the fourth week, a post-BRST-E was administered to them to ascertain the effect of each strategy on their reasoning skills. The post-post-BRST-E was administered to the students three weeks after the post-BRST-E to determine the memory retention abilities of students from the post-BRST-E to the post-post-BRST-E. After each BRST-E, the scores of each instructional group are recorded separately, likewise those of males and females.

Procedures for Data Analysis

Data were analyzed using various statistical tools by using Version 22 of Statistical Package for Social Sciences (SPSS) by employing descriptive statistics and inferential statistics, with each inferential tool tested at 0.05 alpha level of significance. Mean, standard deviation, and Single-factor Analysis of Variance (ANOVA) was used in analyzing the pre-BRST-E scores. Means, standard deviations, minimum scores, maximum scores, Analysis of Covariance (ANCOVA), Gabriel Post Hoc Test, and partial eta squared (η^2p) were used to analyze the post-BRST-E (reasoning skills) scores. The post-post-BRST-E (retention) scores were analyzed using means, standard deviations, mean decline scores, paired sample t-test, ANCOVA, Gabriel Post Hoc Test, η^2, and η^2p. Finally, the reasoning skills scores of males and females were analyzed using means, standard deviation, and independent t-tests.

Results and Discussion

Ho1-There is no Statistically Significant Difference in the Mean Prior Knowledge Scores of Students to be taught evolution using Demonstrative Lecture, Problem-Based Approach, and Classroom Discussion

In determining whether the students selected from the schools are equal in terms of their prior knowledge of evolution concepts, their pre-BRST-E scores were analyzed using descriptive and inferential statistics. The result of the descriptive analysis is presented in Table 2.

Table 2. Descriptive Analysis of Equality of Students' Prior Knowledge Scores

Instructional Group	N	Mean	Std. Deviation	Minimum	Maximum
Demonstrative Lecture	13	20.3077	3.66025	15.00	27.00
Problem-Based	11	21.3636	4.36515	14.00	28.00
Classroom Discussion	15	19.8667	3.46135	14.00	29.00
Total	**39**	**20.4359**	**3.74724**	**14.00**	**29.00**

It can be inferred from the data in Table 2 that the pre-BRST-E mean scores of students were 20.31, 21.36, and 19.87, with standard deviations of 3.66, 4.36, and 3.46, respectively, for students assigned to demonstrative lecture, problem-based approach, and classroom discussion respectively. This spells out clearly that students that were assigned to the problem-based approach attained a high mean and standard deviation pretest score, followed by those assigned to demonstrative lecture and, finally, those that were assigned to classroom discussion. In order to ascertain whether there is any statistically significant difference among these mean scores, ANOVA was carried out to claim the fact, as indicated in Table 3.

Table 3. ANOVA Analysis of Homogeneity of Students' Prior Knowledge

Sources of Variation	Sum of Squares	df	Mean Square	F	p
Instructional Groups	14.542	2	7.271	.504	.61
Pre-BRST-E Scores	519.048	36	14.418		
Total	**533.590**	**38**			

Data in Table 3 spells out clearly that [$F(2,38)=0.504$, $p=0.608 > 0.05$] suggests no statistically significant difference, so the null hypothesis is maintained. This clarifies that before the study, students from the three schools held similar views in terms of their intellectual ability levels in evolution concepts depicting that they were suitable for the study because neither group's previous knowledge prevailed over the other.

Ho2-There is no Statistically Significant Difference in the Mean Reasoning Skills Scores of Students Taught Evolution Concepts using Demonstrative Lecture, Problem-Based Approach, and Classroom Discussion

In determining which of the instructional methodology was more powerful in enhancing students' reasoning skills, the mean performance scores, standard deviations, maximum score, and minimum score of each respective teaching strategy generated during the post-BRST-E is illustrated in Table 4 to boost the assertion.

Table 4. Descriptive Analysis of Students' Reasoning Skills Scores

Instructional Group	N	Mean	Std. Deviation	Minimum	Maximum
Demonstrative Lecture	13	26.0769	3.83974	19.00	31.00
Problem-Based	11	32.9091	5.08831	20.00	37.00
Classroom Discussion	15	31.2667	3.91821	20.00	35.00
Total	**39**	**30.0000**	**5.04715**	**19.00**	**37.00**

It can be deduced from the data in Table 4 that the post-BRST-E mean score of students is 26.08, 32.90, and 31.27, and standard deviations of 3.83, 5.09, and 3.92, respectively, for the students that were taught using demonstrative lecture, problem-based approach, and classroom discussion respectively. This reveals clearly that students subjected to a problem-based approach obtained a higher posttest mean mark, followed by those exposed to classroom discussion and, finally, demonstrative lecture. The Table further pointed out that students that were exposed to problem-based approach and classroom discussion had the highest minimum score of 20. In addition, the data clarified that the problem-based group had the higher maximum score of 37, followed by the classroom discussion group with a score of 35. Finally, the Table established that demonstrative lecture group students obtained the lowest minimum and maximum scores of 19 and 31, respectively.

In ascertaining whether there is any statistically significant difference between these mean scores, ANCOVA analysis was carried out in order to establish the fact as indicated in Table 5.

Table 5. ANCOVA Analysis of Students' Reasoning Skills

Source of Variation	Sum of Squares	df	Mean Square	F	p	η^2p
Corrected Model	347.045	3	115.682	6.520	.001	.359
Intercept	446.589	1	446.589	25.172	.000	.418
Covariate (Pre BRST-E Scores)	29.811	1	29.811	1.680	.203	.046
Instructional Groups	148.211	2	74.106	4.177	.024	.193
Error	620.955	35	17.742			
Total	**36068.000**	**39**				

Data from Table 5 points that [$F(2,39)=4.18$, $p=0.024 < 0.05$] reveals a statistically significant difference, so the null hypothesis is rejected because the reasoning skills scores of students in the various instructional groups were different. Since significant difference exists among the teaching groups, Multiple Comparison Analysis (Gabriel Post Hoc Test) was carried out to discover which of the instructional groups' mean reasoning skills scores was statistically significantly dissimilar from each other and is presented in Table 6.

Table 6. Gabriel Post Hoc Analysis of Students' Reasoning Skills Across the Teaching Groups

(I) Instructional Group	(J) Methodology	Mean Difference (I-J)	Std. Error	p
Demonstrative Lecture Group	Problem-Based	-6.83217*	1.74180	.001
	Classroom Discussion	-5.18974*	1.61110	.008
Problem-Based Group	Demonstrative Lecture	6.83217*	1.74180	.001
	Classroom Discussion	1.64242	1.68774	.700
Classroom Discussion Group	Demonstrative Lecture	5.18974*	1.61110	.008
	Problem-Based	-1.64242	1.68774	.700

*. The mean difference is significant at the 0.05 level.

It can be deduced from the data in Table 6 that a pairwise comparison between the demonstrative lecture group and the problem-based group resulted in [$p=0.001< 0.05$], suggesting a significant difference, so the null hypothesis is not maintained. The efficiency of the instructional approaches in increasing the reasoning skills of students differs. Furthermore, the Table revealed that the comparison between the demonstrative lecture group and classroom discussion group produced [$p=0.008< 0.05$] reveals a statistically significant difference, so the null hypothesis is not maintained because the effectiveness of the two instructional approaches in increasing students' reasoning abilities was different from each other. Moreover, the analysis reveals that pairwise comparison between the problem-based group and classroom discussion group yielded [$p=0.70 > 0.05$] portrays no statistically significant difference, so the null hypothesis is maintained owing to the fact that the potential of the two instructional strategies in enhancing students' reasoning skills was similar.

From the above assertions, it elucidates that out of the three instructional groups, students that were taught evolution concepts by problem-based approach had an increase in their levels of reasoning better than their counterparts who were taught the same concept using classroom discussion and demonstrative lecture approach based on the data illustrated in Table 5 and the p values demonstrative lecture group established with it during the Post Hoc Analysis. The value of η^2p in Table 5=0.193 suggests that the problem-based approach was influential in contributing 19.3% of the variance of students' reasoning skills scores. This finding corroborates Arifin et al. (2019) and Karaçalli and Korur (2014), who reported that a problem-based approach increased students' reasoning abilities more than other teaching methodologies in their study.

Ho3-There is no Statistically Significant Difference in the Mean Retention Scores of Students Taught Evolution Concepts using Demonstrative Lecture, Problem-Based Approach, and Classroom Discussion

In order to establish the degree of mean decline in the mean scores of students that were subjected to the respective instructional methodologies, paired samples t-Test was carried out to determine its extent from the post-BRST-E to the post-post-BRST-E. The results are illustrated in Table 7.

Table 7. Mean Decline and Paired Sample T-Test Analysis of Students' Scores from the Post-BRST-E to the Post-Post-BRST-E

Instructional Group	M_P	M_{PP}	Mean Decline (M_P-M_{PP})	Std. Deviation	df	t	p	η^2
Demonstrative Lecture	26.0769	23.3846	2.6923	4.23054	12	-2.295	0.041	0.334
Problem- Based	32.9091	29.1818	3.7273	5.63915	10	-2.353	0.045	0.980
Classroom Discussion	31.2667	27.6667	3.6000	5.46155	14	-2.553	0.023	0.642

M_P = Mean of post-BRST-E Scores M_{PP} = Mean of post-post-BRST-E Scores

The data in Table 7 clearly point out that the mean decline of students from the post-BRST-E to the post-post-BRST-E in each of the respective teaching groups was statistically significant. Students that were exposed to demonstrative lectures had the lowest mean decline and SD of 2.96 and 4.23, respectively. Students in the classroom discussion group whose mean declined and SD was 3.60 and 5.46, respectively, followed it. Students in the problem-based group had the highest mean decline of 3.72 and a high SD=5.63. These points show that retention favors students in the demonstrative lecture group, followed by the classroom discussion group, and finally, students in the problem-based group. The Table further reveals that the p-value of students in the demonstrative lecture group, classroom discussion group, and problem-based group is 0.041, 0.045, and 0.023, respectively. This suggests that retention favors students in problem-based groups followed by demonstrative lecture groups and, finally, classroom discussion groups. The data finally revealed that η^2p of the demonstrative lecture group, classroom discussion group, and problem-based group is 0.33, 0.98, and 0.64, respectively. This implies that retention favors students in problem-based groups followed by classroom discussion groups and, finally, demonstrative lecture groups. However, in establishing whether differences exist in the mean decline scores among the respective instructional groups, their post-post-BRST-E (retention scores) were subjected to ANCOVA and are presented in Table 8.

Table 8. ANCOVA Analysis of Students' Retention across the Teaching Groups

Source of Variation	Sum of Squares	df	Mean Squares	F	p	η^2p
Corrected Model	225.475	3	75.158	4.638	.008	.284
Intercept	802.451	1	802.451	49.517	.000	.586
Covariate (Students Sex)	.855	1	.855	.053	.820	.002
Instructional Groups	221.902	2	110.951	6.847	.003	.281
Error	567.192	35	16.205			
Total	**28526.000**	**39**				

It can be deduced from the data in Table 8 that [$F(2,39)=6.85$, $p=0.003 < 0.05$] reveals a significant difference, so the null hypothesis is rejected. The memory retention abilities of students in the teaching groups were different. Since a statistically significant difference exists, Gabriel Post Hoc analysis was carried out to establish where the difference exists. The result is presented in Table 9.

Table 9. Gabriel Post Hoc Analysis of Students' Retention across the Teaching Groups

(I) Instructional Groups	(J) Methodology	Mean Difference (I-J)	Std. Error	p
Demonstrative Lecture Group	Problem-Based	-5.79720*	1.62734	.003
	Classroom Discussion	-4.28205*	1.50523	.021
Problem-Based Group	Demonstrative Lecture	5.79720*	1.62734	.003
	Classroom Discussion	1.51515	1.57683	.708
Classroom Discussion Group	Demonstrative Lecture	4.28205*	1.50523	.021
	Problem-Based Group	-1.51515	1.57683	.708

*. The mean difference is significant at the 0.05 level.

Gabriel Post Hoc Analysis in Table 9 reveals that pairwise comparison between the demonstrative lecture group and problem-based group resulted in [$p=0.003< 0.05$], suggesting a significant difference, so the null hypothesis is rejected. The potentials of the instructional approaches in increasing the recollection abilities of students differ. Furthermore, the Table revealed that the comparison between the demonstrative lecture group and classroom discussion group produced [$p=0.021< 0.05$] reveals a statistically significant difference, so the null hypothesis is not maintained because the effectiveness of the two instructional approaches in increasing students' remembering abilities was different from each other. Moreover, the analysis reveals that pairwise comparison between the problem-based group and classroom discussion group yielded [$p=0.71> 0.05$] portrays no statistically significant difference, so the null hypothesis is maintained. The potential of the two instructional strategies in enhancing students' retention abilities was similar.

It can be deduced from the statements above demonstrative lecture, and problem-based group resulted in [p=0.003] and yielded [p=0.021] with classroom discussion and no statistically significant difference manifested between the problem-based group and classroom discussion group [p=0.71]. This elucidates that out of the three instructional groups, students that were taught evolution concepts by problem-based approach had an increase in their memory retention magnitudes better than their counterparts who were taught the same concept using classroom discussion and demonstrative lecture based on the respective p values they established among themselves during the Post Hoc Analysis in Table 8. The value of η^2p in Table 5=0.281 suggests that the problem-based approach was influential in contributing to the variance in students' memory retention scores by 28.1%. The finding agrees with Leuchter et al. (2014) and Strobel and van Barneveld (2019), who found positive results in problem-based approaches in enhancing learners' memory retention in their separate studies.

Ho4-There is no Statistically Significant Difference in the Mean Reasoning Skills Scores of Male and Female Students in the Experimental Group

In determining whether the reasoning abilities of males and females in the experimental group are similar or not, their post-BRST-E scores were analyzed using both descriptive and inferential statistics. The result of the descriptive statistics is presented in Table 10.

Table 10. Descriptive Analysis of Reasoning Skills Scores of Males and Females

	Gender	N	Mean	Std. Deviation
Scores	Males	14	34.8571	1.51186
	Females	12	28.5833	4.33712

It can be inferred from data in Table 10 that the post-BRST-E mean scores of male and female students are 34.86 and 28.58, and standard deviations of 1.51 and 4.34, respectively. However, in establishing whether differences exist in their mean reasoning skills, their post-BRST-E scores were subjected to an independent t-Test, which is presented in Table 11.

Table 11. t-Test Analysis of Males and Females Reasoning Skills

Group		**Levene's Test for Equality of Variances**				
		F	**Sig.**	**t**	**df**	**p**
Scores	Equal variances assumed	4.361	.048	5.079	24	.000
	Equal variances not assumed			4.769	13.289	.000

Data in Table 11 point that [df=24, t=5.08, F=4.36, p=0.000< 0.05] suggests a significant difference, so the null hypothesis is rejected. Males' and females' levels of reasoning regarding evolution concepts differ from each other in favor of males. The finding corroborates that of Yenilmez (2006), who found that male students had higher scores than females on proportional, probabilistic, and combinational reasoning. Similarly, Valanides's (1996) study on 12th-grade Cypriot students' reasoning abilities reported that males outperformed females in proportional and probabilistic reasoning.

Conclusions

The results reveal because students exposed to the problem-based approach tried to find solutions to ill-structured problems posed to them, it challenged them to address associated tasks that were beyond their current ability levels, which made it eligible for them to think in abstract terms, which made it eligible for them to solve high-order problems compared to their counterparts taught the same concepts using demonstrative lecture and classroom discussion [$F(2,39)=4.18$, $p<0.05$, $\eta^2p=0.193$]. In addition, the problem-based approach made students experience little confusion and interferences, and this accelerated their memory retention abilities more than the other students exposed to the other strategies [$F(2,39)=6.85$, $p<0.05$, $\eta^2p=0.281$]. Finally, male students were always observed making individual advancements about their freshly learned knowledge and skills in real situations, and this led to an upsurge in their high-order reasoning skills than their female counterparts [df=24, t=5.08, F=4.36, p<0.05].

Recommendations

1. Biology instructors in Berekum Municipality and Berekum West District should embrace the use of a problem-based approach in delivering evolution lessons to shape students' level of reasoning and memory retention.
2. Ministry of Education, in collaboration with Ghana Education Service, should encourage Science instructors in Berekum Municipality and Berekum West District to teach students how to make use of a problem-based learning approach. Their appreciation that students' sex, learning style, learning

motivation, learning skills, reasoning skills, memory retention, and difficulties in learning Biology are all embedded in a problem-based approach which in turn affects their achievement.

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