American Journal of Educational Research, 2018, Vol. 6, No. 1, 76-82
Available online at http://pubs.sciepub.com/education/6/1/12

DOI:10.12691/education-6-1-12

Effectiveness of 3E, 5E and Conventional Approaches of Teaching on Students' Achievement in High School Biology

Comfort Korkor Sam[1], Kofi Acheaw Owusu[2,*], Christian Anthony-Krueger[2]

[1]Tamale Girls' Senior High School, Tamale, Ghana
[2]Department of Science Education, University of Cape Coast
*Corresponding author: acheaw.owusu@ucc.edu.gh

Abstract The study sought to identify the effectiveness of 3E, 5E learning cycle and the conventional approaches in teaching a Biology lesson. The mixed method approach was used for this study. Three science classes in three Senior High Schools were randomly selected. For the quantitative aspect, a pre-test-post-test non-equivalent quasi-experimental design with two experimental groups was used. The qualitative part constituted an interview to find out students' views with regards to the 3E and 5E teaching approaches. The students in the experimental groups were instructed through 3E and 5E learning cycle whilst those in the control group were instructed on the same concept through conventional approach. ANCOVA and independent t-test were used to analyse the data. The results of the study showed that the experimental groups performed better on the post-test as compared to the control group. The results also revealed that the learning cycle approach was more effective in teaching the biology concepts than the conventional approach. The 3E learning cycle was found to be more effective for improving the performance of low achievers. The students exposed to the 3E and 5E approaches showed positive attitudes towards learning cycle when they were interviewed. Teachers should be encouraged to learn and use the learning cycle approach in the teaching and learning process of Biology concepts.

Keywords: *learning cycle, conventional approach, 3E approach, 5E approach, cell division*

Cite This Article: Comfort Korkor Sam, Kofi Acheaw Owusu, and Christian Anthony-Krueger, "Effectiveness of 3E, 5E and Conventional Approaches of Teaching on Students' Achievement in High School Biology." *American Journal of Educational Research*, vol. 6, no. 1 (2018): 76-82. doi: 10.12691/education-6-1-12.

1. Introduction

Education seeks to bring essential change in the life of learners. This is achieved through the provision of appropriate and desirable learning experiences to the learner. These appropriate learning experiences are provided through teaching [1]. The duty of the teacher therefore is to select appropriate teaching approaches and techniques that can facilitate the delivering of the subject matter to the understanding of the learner. It is not farfetched to indicate that desirable changes in learners can best be achieved through the use of appropriate teaching methods. Reference [2] therefore noted that what teachers do affect their students' learning. Reference [3] asserted that teaching methods work efficiently mostly if they are aligned with the needs of learners since every learner interprets and responds to issues and experiences in an exceptional way.

Due to its importance in the educational set up, several teaching methods and strategies have been developed to bring about effective delivering of content by teachers and easy and meaningful understanding of concepts by students [4,5,6]. These teaching approaches are developed through theories of learning which serve as their philosophical underpinnings. In its broadest sense, two distinct categorizations can be ascribed to the various teaching approaches- teacher-centred and student-centred approaches. The teacher-centred approaches are built on behavioural learning theory which focusses on the provision of appropriate stimuli that would generate the expected and desired outcome in learners [2,7]. Students are passive and become reactive to the teacher's instruction instead of taking active role in the teaching and learning process. Student-centred approaches on the other hand are built on constructivist theories which emphasize the active involvement of students in the construction of their knowledge through interactions with their peers and shaped by their experiences in the environment [8,9].

Constructivist theories have been one of the biggest influence on education in general and science education in particular since the early 1980s [2]. These theories have had impact on educational policies and classroom practices and have become the yardstick for effective teaching [10]. Countries and institutions are therefore emphasizing the use of various constructivists' approaches as the required instructional strategy.

The developers of the SHS Biology syllabus in Ghana have therefore advocated for constructivists approaches that emphasize student-centred and activity-oriented approaches to be used to teach Biology lessons [11]. This

was recommended because it is believed that these approaches promote understanding and development of skills needed by the student to meet the demands of the 21st century. The Biology teachers unfortunately find themselves in a dilemma as the syllabus does not spell out the specific student-centred and activity oriented methods to be employed since there are a lot of activities and approaches one can use which fall under student-centeredness.

It will be appropriate if teachers can be made aware of the effectiveness of the various student-centred approaches so that they can make informed decisions as to which one they should use. It is in the face of this lack of clarity that this paper seeks to explore the effectiveness of such student-centred approaches in a Biology lesson. The study therefore sought to:

1. determine if there is significant difference in achievement among students instructed through 3E, 5E and the conventional approach.
2. determine if there is significant difference between the post-test scores or performance of low achievers and high achievers when instructed using the conventional approach.
3. determine if there is significant difference between the post-test score or performance of low achievers and high achievers when instructed using 3E learning cycle.
4. determine if there is significant difference between the post-test score or performance of low achievers and high achievers when instructed using 5E learning cycle.
5. identify students and teacher's perception of the learning cycle as instructional strategy.

Thus, the following hypotheses and research question guided the study:

1. there is no statistically significant difference in achievement among students instructed by 3E, 5E and the conventional approach.
2. there is no statistically significant difference between the post-test of low achievers and high achievers when instructed with 3E
3. there is no statistically significant difference between the post-test of low achievers and high achievers when instructed with 5E
4. there is no statistically significant difference between the post-test of low achievers and high achievers when instructed with conventional approach.
5. what are students and teacher's perceptions of the learning cycle as an instructional approach?

2. Theoretical Framework

Teaching approaches or methods are learning scaffold activities consisting of a sequence of teaching strategies, techniques, and routines designed to represent the content to the understanding of the learner [2]. The teaching approach a teacher will employ will determine the classroom interactions and discourse between the teacher and the students [12]. This makes the teacher's teaching approach very pertinent to his practice as well as his students' learning. There are plethora of teaching approaches and these are mostly based on the various teaching and learning theories [12].

The constructivist teaching approaches have been found to be very student-centred and foster student collaboration and increase achievement. Although there are various constructivist teaching approaches [2], the learning cycle has been found to be one of the predominant constructivist teaching approaches. Learning cycle is an inquiry base teaching strategy and therefore seeks to promote learning through investigation and hands on activities. Reference [12] notes that the proponents of this approach of teaching advocates that instruction should be sequenced into phases.

The learning cycle comes in different phases and lengths. The first version included 3 phases from which different versions of the model generated as four [13], five [14] and even seven [15] have evolved. Of the different learning cycles, the 5E learning cycle has been found to be the most popular in the teaching and learning process [16]. Nonetheless, this study sought to investigate the effectiveness of both 3E and 5E.

The 3E learning cycle consists of exploration, concept development (explanation), and expansion [17]. The exploration phase seeks to allow students to investigate into a scientific concept that has been initiated by the teacher. The students collect appropriate data that will help them solve the problem at stake. At this phase, the teacher makes all the necessary tools, equipment and materials learners will need available so that the exploration will go on smoothly. The concept development (explanation) phase is the next phase. Here, teachers facilitate discussion on students' findings. Students are expected to explain the underlying principles of scientific concepts. The third phase of the 3E learning cycle is the expansion phase. This is where students are allowed to extend and extrapolate the concepts to different contexts and situations. Students may engage in further investigation during this phase. Teachers should be cautious so as not to introduce new ideas unknown to students at this phase [17]. Aside the 3E, another popular learning cycle approach is the 5E.

The 5E model consists of five phases of instruction within the learning cycle: engagement, exploration, explanation, elaboration, and evaluation [18]. At the engagement stage, the teacher is provided with an opportunity to find out what the students already know as well as their misconceptions. Reference [19] indicated that this phase should be used to improve students' motivation in order for them to develop in-depth desire to learn more about the issues to be discussed. The exploration phase provides students with first hand experiences of investigations into scientific concepts. Students engage in activities that will generate investigative ideas. Reference [2] highlighted that this step aims to facilitate students' understanding of the scientific principles underlying concepts.

Reference [20] accentuated that at the explanation phase students are provided with the opportunity to demonstrate their conceptual understanding of the scientific principles they are dealing with. Teachers are expected to guide learners to make meaning out of their discoveries as well as point out inconsistencies in students' arguments to them. The fourth phase which is the elaboration phase seeks to provide students with further opportunity to fine-tune their understanding of the

scientific concepts under discussion. There is the possibility of students undertaking further investigations at this phase. The last phase (evaluation) seeks to provide students with the avenue to evaluate their own learning. The evaluation can be done by the teacher or the whole class can assess each student.

Third teaching approach in this study was the conventional method of teaching. A lot of research studies on conventional approach have established that lecture is still the most popular and widely used teaching method today employed by teachers in teaching and learning [21]. With the conventional approach of teaching, students simply obtain information from the teacher without much engagement with materials. This approach emphasis on lectures, regurgitating of scientific facts with less inquiry-based activities. Reference [22] point out that students being instructed with the conventional approach simply regurgitate information which has been transferred from the teacher that has been imbibed passively.

Most studies conducted on learning cycle indicate that the learning cycles enable the learner to develop positive attitudes and curiosity toward science as well as increase their level of self-concept [23,24,25,26]. There has been evidence of improved conceptual understanding of concepts when students are instructed through the learning cycles [24,27,28,29,30]. In terms of student achievement, [31,32,33] all highlighted that learning cycle increased students' achievement in science. Aside student achievement, [34] accentuated that learning cycle is capable of encouraging students to more critical in their thinking. There is overall mastery of concepts when students are taught with learning cycle [20] as well as improvements in teachers' attitude towards teaching [35].

The learning cycle does come with its issues however. Reference [26] and [35] found out that the learning cycle is time consuming. In addition [36] believed that standardized tests restrict curriculum leaving no time for inquiry because teachers are expected to teach everything stated in the curriculum. Since the learning cycle is typically an inquiry process, it falls victim to this problem. Again, it has also been found that low ability students who most often are dependent on teachers for all information and directives may experience some difficulties using learning cycle approach for learning [37].

The Conventional method on the other hand has been found to have the advantage of covering a wider area within a short time. Studies conducted by [38] suggested that college students like it and have a great value for the traditional approach when he studied college students' perceptions of the traditional lecture method. Reference [39] indicated that the traditional approach tend to be more effective in terms of performance for high achievers than low achievers. Aside these seemingly positives, research has found out that little student activity and involvement occur when the conventional approach is used [40].

Several key studies have compared the learning cycle approach with conventional approaches. The outcome of these researches shows that the learning cycle is effective in improving student achievement than the conventional approaches. Reference [41] reported that students instructed with the 5E learning cycle demonstrated greater understanding of the information covered especially on questions that required interpretation as compared to students instructed through the conventional approach. Reference [31] also found out that pre-service teachers instructed with learning cycle out performed their colleagues who were taught with the conventional approach. This indicates that the learning cycle is also effective at the tertiary level. At the lower levels of educational ladder, [42] found out that students' critical thinking improves steadily when they are instructed with the learning cycle as compared to the conventional approach. Reference [24] also reported that the learning cycle was superior in eliminating students' misconceptions than traditional instruction when he studied 66 grade 9 students. Reference [27] explored the effectiveness of the learning cycle method when teaching direct current (DC) circuits to university students. The findings revealed that the learning cycle method is likely to be successful for both females and males, and led to the better understanding of the DC circuit concepts than did traditional method.

3. Research Methodology

The research followed a mixed methods paradigm combing both quantitative and qualitative approaches in the data collection and analysis [43]. The quantitative part of the research was a non-equivalent control group pre-test- post-test quasi-experimental design. The design was used to find out whether there was any significant difference between the academic achievement of student taught by learning cycle and those instructed with the conventional method. Three schools were randomly sampled from the total number of Senior High Schools in Cape Coast Metropolis. Within the three selected schools, simple random sampling method was used to select the two experimental groups and one control group. The school that was selected first was called the control group and the second (3E learning cycle) and third (5E learning cycle) constituted the experimental groups. From each of the selected schools, one science class was selected randomly from Form 2 science classes since each school had more than one Form 2 science class. The teaching strategies (Learning Cycle and Conventional approach) were independence variable while the academic achievement of the students were the dependent variable. The study employed three treatments, the experimental groups were treated with 3E and 5E learning cycle and the control group was taught with the conventional method of teaching. The content to be learnt was the same for all the groups but the mode of teaching varied from one group to the other. Lesson plans were develop for all the groups based on the same content and enacted by the same teacher in all the groups. This was done to ensure that teacher effect will be minimized. The teacher was a regular Biology teacher in one of the selected schools and was trained on how to use the learning cycle to teach. The teacher used two weeks to teach the topic in the various schools using the assigned teaching approach.

Before the start of the treatment, a pre-test was conducted in all the three groups. The pre-test was used to categorize students within each as high or low achievers. Students whose scores in the pre-test were above the

group mean was identified as high achievers and those whose performance was below the mean were categorized as low achievers. After teaching in all the groups ended, post-test was conducted. In the experimental groups some of the students were randomly selected and interviewed. The teacher was also interviewed to share his experiences when using the learning cycle.

The subject for the study comprised of 145 senior high school year two science students from three randomly selected schools in the Cape Coast Metropolis in the Central Region of Ghana. These students were automatic members of the study when their classes were selected for the study. Thus, the study used intact classes of students. There were 50, 48 and 47 students in 3E, 5E and conventional groups respectively. The Form 2 students were chosen for the study because by the time the study was undertaken they had not yet been taught the topic (content) that was used in this study.

The instruments for this study were two teacher made tests (pre-test and post-test) and semi structured interview. The pre-test was developed from the topic 'cell' which was taught in Form 1 while the post-test was based on what was taught during the experiment. The pre-test was conducted to find out if the three groups were performing at the same level before the study and also to categorise student into achievements that is low and high achievers. On the other hand, the post test was developed based on the cell division topic, which was taught during the experiment. Both the pre and post- tests consisted of 30 multiple choice items. To ensure content validity of the test, table of specifications for the lesson plan was used to develop the test items. The instruments were reviewed by two Biology teachers. The reliability of the test was established by the use of Kuder Richardson (K- R 20) because the test was scored dichotomously. The reliability of the test was found to be 0.78.

In addition, semi-structured interview was conducted on the experimental groups to gain in-depth view of students' perceptions of the learning cycle as an instructional strategy. Eight students each from the 3E group and the 5E group (total 16) were randomly selected for the semi-structured interview.

4. Results

The Analysis of Covariance (ANCOVA) was used to test the first hypothesis because there were differences among the groups when they were pretested before the experiment. Thus, the pre-test scores were used as covariates in the analysis of the post-test. The ANCOVA showed statistically significant difference at $p < 0.01$ between the means of the post-tests of the students in the 3E, 5E learning cycle and conventional approach. From Table 1, it could be seen that there was significant difference among the post-test scores of the students in the 3E, 5E learning cycle and conventional approach. Therefore, the first null hypothesis was rejected. A post Hoc analysis was therefore conducted to identify where the differences lie.

The Post Hoc analysis revealed that students in both 5E and 3E groups out performed their counterparts in the conventional group. However, there was no statistical difference between the performances of students in the 5E and those in 3E.

The second hypothesis sought to indicate that there was no significant difference between high achievers and low achievers on the post-test when they were taught with Conventional approach. The independent sample t-test was used and the results have been presented in Table 3. The test was significant ($p<0.01$) on the pre-test scores with means 17.47 and 12.65 for high achievers and low achievers respectively. The scores suggest that the low achievers were more spread out than the high achievers. In the post-test scores, the performance between the High and low achievers in the Conventional approach was still statistically significant. Therefore, the null hypothesis was rejected.

Table 1. Results of ANCOVA for Post -test for CA, 5E and 3E

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	881.726[a]	3	293.909	29.233	.000
Intercept	1120.405	1	1120.405	111.439	.000
Pre-test	23.027	1	23.027	2.290	.132
Group	555.080	2	277.540	27.605	.000
Error	1417.612	141	10.054		
Total	51501.000	145			
Corrected Total	2299.338	144			

a. R Squared = .383 (Adjusted R Squared = .370)

Table 2. Post Hoc Analysis of the groups using Bonferroni

(I) Groups for CA,5E, and 3E	(J) Groups for CA,5E, and 3E	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
CA	5E	-4.449*	.740	.000	-6.241	-2.657
	3E	-4.970*	.700	.000	-6.666	-3.273
5E	CA	4.449*	.740	.000	2.657	6.241
	3E	-.521	.645	1.000	-2.085	1.043
3E	CA	4.970*	.700	.000	3.273	6.666
	5E	.521	.645	1.000	-1.043	2.085

Table 3. Results of Independent Samples t-test on Pre-test and Post-test scores of high and low achievers in the Conventional approach

	Achievement levels	N	Mean	SD	t	df	p
Pre-test Scores	High achievers in CA	30	17.47	1.50	-9.29	45	0.00*
	Low achievers in CA	17	12.65	2.03			
Post-test Scores	High achievers in CA	30	15.47	3.60	-1.72	45	0.00*
	Low achievers in CA	17	13.94	0.66			

*Significant, since p < 0.05

Table 4. Results of Independent Samples t-test on Pre -test and post-test scores of high and low achievers in the 3E group

	Achievement levels	N	Mean	SD	t	df	p
Pre test Scores	High achievers in 3E	20	22.55	1.76	-10.33	48	0.00*
	Low achievers in 3E	30	16.73	2.07			
Post test Scores	High achievers in 3E	20	21.20	1.06	-1.87	45	0.07
	Low achievers in 3E	30	19.70	3.47			

*Significant, since p < 0.05

Table 5. Results of Independent Samples t-test on Pre- test and Post-test scores of high and low achievers in the 5E group

	Achievement levels	N	Mean	SD	t	df	p
Pre test Scores	High achievers in 5E	26	22.38	1.39	-8.84	46	0.00*
	Low achievers in 5E	22	17.18	2.61			
Post test Scores	High achievers in 5E	26	21.85	3.97	--4.86	46	0.00*
	Low achievers in 5E	22	17.59	1.14			

*Significant, since p < 0.05

The third hypothesis sought to indicate that there was no significant difference between high achievers and low achievers on the post-test when they were taught with 3E approach. From Table 4, high achievers performed better than low achievers in the pre-test conducted before the experiment. However, in the post-test after the experiment, the performance of the low achievers significantly improved to a level whereby there was no difference them and the high achievers. The null hypothesis was therefore not rejected.

The fourth hypothesis sought to indicate that there was no significant difference between high achievers and low achievers on the post-test when they were taught with 5E approach. The independent sample t-test was used to analyse the scores with the results presented in Table 5. The results show that the pre-test conducted before the experiment was significant between high achievers and low achievers. The high achievers performed significantly better than the low achievers. On the post-test scores also the high achievers significantly performed better than the low achievers. Therefore, the null hypothesis that there was no significant difference between the Post-test of low and high achievers when instructed with 5E was rejected.

The interview data conducted to help answer the research question revealed that students enjoyed the learning with the learning cycle approach. The students accentuated that the approach made learning fun and understandable. They also noted that the approach made them active participants in the teaching and learning process which helped to increase their curiosity. Students highlighted how the approach made them "motivated to learn since it is involving". Some students asserted that the learning cycle "was more exciting, because it was full of activities". The students further argued that they believed they really learnt because they "did the searching and presented the information". Student found the cooperative nature of the learning cycle very useful. Students agreed that the learning cycle was a very effective approach "since our group share (sic) a lot of ideas together to be able to have a good presentation".

The teacher also noted how useful the learning cycle was to the teaching and learning process. He highlighted the cooperative nature of the approach and argued that it "made students to learn from their peers". He was of the view that the approach facilitated "active engagement and participation of students in the lesson". The learning cycle made "students to own the knowledge they produced since they searched and presented the information themselves" as argued by the teacher. The teacher however alerted that the learning cycle approach 'was too time consuming". According to him, he could have used less time to complete the same amount of content if he had used the conventional approach.

5. Discussion

The results of this study have revealed that those students who were taught with 3E and 5E learning cycle (experimental groups) performed better than those taught in the conventional approach (control group). This significant difference of the post-test of the experimental groups clearly demonstrated the effectiveness of the models in enhancing learning outcome of cell division at the SHS level. This is in agreement with earlier research by [31] which indicated that the learning cycle prove superior to those who used Conventional Instruction in improving achievement in biology concepts.

The result of the study also shows that when 3E learning cycle is used to instruct students the performance of the low achievers in the group would be enhanced and at the end both the low and high achievers will perform better. This therefore seems to disagree with [37] that learning cycle does not support low achievers. However, when 5E learning cycle was used to instruct students, the performance of the high achievers outperformed that of the low achievers. This finding agrees with [37] who indicates that learning cycle does not support low achievers.

In addition, when conventional approach was used to instruct students, the performance of the high achievers becomes better than that of the low achievers. This agrees with the study of [39] when they also found out that high achievers out performed low achievers in the conventional group when they compared conventional instruction with computer -assisted instruction. The outcome of this study and others reported seem to suggest that when CA was used to teach, it creates an achievement gap between high and low achievers.

The views of the students who were interviewed seem to correlate with their performance in the post test since they outperformed their colleagues who were instructed through the conventional approach. From the responses of the students interviewed, it can be seen that the students showed interest in the learning cycle although it was the first time they were being taught with the learning cycle approach. This agrees with [24] who asserted that the learning cycle enables learners to develop more positive attitudes towards learning.

The teacher's views on learning cycle was consistent with [35] argument that teachers' attitude towards teaching improves when they use learning cycle as the teaching approach. Again, just as [26] and [35] found that teachers' argue that learning cycle is time consuming, this study also encountered similar opinion from the teacher who used the learning cycle approach.

6. Conclusions

Based on the findings of the study, it can be concluded that the learning cycle approach has a better chance of improving students' academic achievement than the conventional approach. It can also be concluded that when it comes to bridging the gap between high and low achievers within a class, the 3E instructional approach does a better job than the 5E and the conventional approach. Moreover, the study has brought to the fore that students have positive attitude towards the learning cycle approach and they find it engaging as a teaching and learning strategy.

Due to the effectiveness derived from the use of the learning cycle approaches, it is being recommended that teachers should be encouraged to learn and use the learning cycle approaches in the teaching and learning of Biology concepts. The advocacy for the use of the learning cycle approaches stems from the fact that they enable students to search for information, discuss, test their previous ideas and also develop and sustain their interest throughout the lesson with little teacher-assistance. In addition, in order to bridge achievement gap between high and low achievers, teachers should endeavour to use the 3E learning approach in their teaching process. Although the outcome of this study looks promising, it is appropriate that other researchers also replicate this study with different biology concepts and to a large extent in other science related subjects.

References

[1] Tebabal, A., & Kahssay, G, "The Effects of Student-Centered Approach in Improving Students' Graphical Interpretation Skills and Conceptual Understanding of Kinematical Motion", Latin-American Journal of Physics Education, 5(2), 2011.

[2] Abell, S. K., Appleton, K., & Hanuscin, D. L, Designing and teaching the elementary science methods course, Taylor & Francis, New York, 2010.

[3] Bhardwaj, B. K., & Pal, S, "Data Mining: A prediction for performance improvement using classification", arXiv preprint arXiv:1201. 3418, 2012.

[4] Ajewole, G. A, "Effects of discovery and expository instructional methods on the attitude of students to biology", Journal of Research in Science Teaching, 28(5), 401-409, 1991.

[5] Rogus, J. F, "Promoting self-discipline: A comprehensive approach", Theory into Practice, 24(4): 70, 1985.

[6] Webb, N. M, "Peer interaction and learning in cooperative small groups", Review of Educational Research, 52(3): 70-72, 1982.

[7] Ertmer, P., & Newby, T. J, "Behaviorism, cognitivism, constructivism: comparing critical features from an instructional design perspective", Performance Improvement Quarterly, 6(4), 50-72, 1993.

[8] Dhindsa, H.S., Makarimi-Kasim & Anderson, O.R, "Constructivist-visual mind map teaching approach and the quality of students' cognitive structures", Journal of Science Education and Technology, 20, 186-200, 2011.

[9] Simpson, G, "Learner characteristics, learning environments, and constructivist epistemologies", Australian Science Teachers Journal, 47(2), 22-24, 2001.

[10] Moreno, R, Educational Psychology, John Wiley & Sons, Danvers, 2010.

[11] Curriculum Research and Development Division (CRDD), Teaching Syllabus for Biology, Ministry of Education, Accra, 2010.

[12] Hassard, J, The art of teaching science: inquiry and innovation in middle school and high school, Oxford university press, New York, 2005.

[13] Barman, C, The learning cycle revisited: A modification of an effective teaching model. Monograph 6, Council for Elementary Science International, Washington, DC, 1997.

[14] Bybee, R.W., and Landes, N.M, "Science for life & living: An elementary school science program from the Biological Sciences Curriculum Study", The American Biology Teacher, 52 (2), 92-98, 1990.

[15] Eisenkraft, A, "Expanding the 5E model", The Science Teacher, 70, 56- 59, 2003.

[16] Ergin, İ., Kanlı, U. & Ünsal, Y, "An Example for the Effect of 5E Model on the Academic Success and Attitude Levels of Students: Inclined Projectile Motion", Turkish Science Education-TUSED, 5(3), 47-59, 2008.

[17] Marek. E. A, "Why the learning cycle?", Journal of Elementary Science education, 20(3), 63-69, 2008.

[18] Bybee, R. W, "The BSCS 5E instructional model and 21st century Skills", A commissioned paper prepared for a workshop on exploring the intersection of science education and the development of 21st century skills, 2009.Available www.bscs.org. [Accessed May 9th, 2017].

[19] Duran, L. B., & Duran, E, "The 5E instructional model: A learning cycle approach for inquiry-based science teaching", The Science Education Review, 3(2), 49-58, 2004.

[20] Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. The BSCS 5E instructional model: Origins, effectiveness, and applications, BSCS, 2006. [E-Document] Available: www.bscs.org [Accessed May 9th, 2017].

[21] Berrett, D, "Harvard conference seeks to jolt university teaching", The Chronicle of Higher Education, 58, 24, 2012.

[22] Roblyer, M. D., Edwards, J., & Havriluk, M. A, Integrating educational technology into teaching, Upper Saddle River, Prentice-Hall, New Jersey, 1997.

[23] Bybee, R. W., & Van Scotter, P, "Reinventing the Science Curriculum", Educational Leadership, 64(4), 43-47, 2007.

[24] Bulbul, Y, "Effects of learning cycle model accompanied with computer animations on understanding of diffusion and osmosis concepts" (Unpublished doctoral dissertation), Middle East Technical University, Ankara, Turkey, 2010.

[25] Milne, C., & Otieno, T, "Understanding engagement: Science demonstrations and emotional energy", Science Education, 91(4), 523-553, 2007.

[26] Stamp, N., & O'brien, T, "GK-12 partnership: A model to advance change in science education", BioScience, 55(1), 70-77, 2005.

[27] Ates, S, "The effectiveness of the learning-cycle method on teaching DC circuits to prospective female and male science teachers", Research in Science & Technological Education, 23(2), 213-227, 2005.

[28] Balci, S., Cakiroglu, J., & Tekkaya, C, "Engagement, exploration, explanation, extension, and evaluation (5E) learning cycle and conceptual change text as learning tools", Biochemistry and Molecular Biology Education, 34(3), 199-203, 2006.

[29] Gerber, B. L., Cavallo, A. M., & Marek, E. A, "Relationships among informal learning environments, teaching procedures and scientific reasoning ability", International Journal of Science Education, 23(5), 535-549, 2001.

[30] Odom, A.L. and Kelly, P.V, "Integrating concept mapping and the learning cycle to teach diffusion and osmosis concepts to high school biology students", Science Education, 85 (6), 615-635, 2001.

[31] Balci, S, "The effects of 5E learning cycle model based on constructivist theory on the academic success of students in biology education" (Unpublished master's thesis). Gazi University, Ankara, Turkey, 2009.

[32] Cakiroglu, J, "The effect of learning cycle approach on students' achievement in Science", Eurasian Journal of Educational Research, 22, 61-73, 2006.

[33] Saunders, W., & Shepardson, D, "A comparison of concrete and formal science instruction upon science achievement and reasoning ability of sixth grade students", Journal of Research in Science Teaching, 24, 39-51, 1987.

[34] Bryant, R. J., & Marek, E. A, "They Like Lab-Centered Science", Science Teacher, 54(8), 42-45, 1987.

[35] Metin, M., Coskun, K., Birisci, S., & Yilmaz, G. K, "Opinions of prospective teachers about utilizing the 5E instructional model", Energy Educ Sci Technol Part B, 3, 411-422, 2011.

[36] Wilson, C. D., Taylor, J. A., Kowalski, S. M., & Carlson, J, "The relative effects and equity of inquiry-based and commonplace science teaching on students' knowledge, reasoning, and argumentation", Journal of research in science teaching, 47(3), 276-301, 2010.

[37] Ajaja, O.P, "Which strategy best suits biology teaching? Lecturing, concept mapping, cooperative learning or learning cycle?" Electronic Journal of Science Education, 17(1), 1-37, 2013.

[38] Covill, A. E, "College students' perceptions of the traditional lecture method", College Student Journal, 45(1), 92-102, 2011.

[39] Owusu, K. A., Monney, K. A., Appiah, J. Y., & Wilmot, E. M, "Effects of computer-assisted instruction on performance of senior high school biology students in Ghana", Computers & Education, 55(2), 904-910, 2010.

[40] Ajaja, O.P, Teaching methods across disciplines, Bomn Prints, Ibadan, 2009.

[41] Lord, T. R., "A comparison between traditional and constructivist teaching in environmental science", The Journal of Environmental Education, 30 (3), 22-28, 1999.

[42] Mecit, O, The effect of 7E learning cycle model on the improvement of fifth grade students' critical thinking skills. (Unpublished master's thesis). Middle East Technical University, Turkey, 2006.

[43] Creswell, J. W., & Plano Clark, V. L, Designing and conducting mixed methods research (2nd ed.), Sage, Thousand Oaks, CA, 2011.

[44] Liu, W. & Shi, J, "An analysis of language teaching approaches and methods- effectiveness and weakness", US-China Education Review, 4(1), 69-71, 2007.