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Effects of 7E Instructional Model with Metacognitive Scaffolding on Students' Conceptual Understanding in Biology

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Abstract

The main aim of this study was to explore the effect of 7E instructional model with metacognitive scaffolding and gender on 9th grade students' conceptual understanding of human biology concepts and misconceptions. The research method was a quantitative research method and the research design was quasi-experimental research design with pre-test – treatment – post-test. The study was conducted on four purposely selected schools and four classes and teachers (one from each school) and assigned as treatment group 1, treatment group 2, treatment 3 and comparison group randomly. These groups were instructed with 7E instructional model alone, 7E instructional model with metacognitive scaffolding, conventional approach with metacognitive scaffolding and conventional approach respectively to teach human biology for 10 weeks. Human biology conceptual understanding test was administered for all groups as pre-test and post- test. The ANOVA results showed that 7E instructional model supported with metacognitive strategies had a significantly superior effect over the other instructional methods for enhancing students' conceptual understanding and minimizing misconceptions. However, no significant difference was found between males and females in students' conceptual understanding. Hence, metacognitive scaffolding with 7E instructional model could help students to understand biology concepts and minimize misconceptions better than the other instructional methods.

Introduction

One of the factors that affect the social, political and economic development of any nation is Education. However, there should be meaningful learning so as to education play its role. In teaching learning process for meaningful learning, the method of instruction (the pedagogical approach in teaching-learning process) is one of the important factors that affect students' learning (Hosseini, 2012; Munck, 2007). According to Kennedy (1998), students' learning with a conceptual understanding of science is dependent on how their teachers teach science. Therefore, the use of inappropriate instructional approaches by the teachers in a classroom is one of the reasons for students' ineffective science learning (Ganyaupfu, 2013; Munck, 2007; Orji & Ebele, 2006; Oloyede, 2010; Umar, 2011).

Until now, two types of instructional approaches in teaching-learning process which were emerged from behaviorism and constructivism learning theories dominated world education system. These are teacher-centered, (traditional approach) and learner-centered instructional approaches (active learning approach) respectively. Literature indicated that the traditional (teacher-centered) approach often promotes passive and superficial learning (Bransford et al., 2000). These weaknesses of the traditional approach resulted in the emergence of an alternative approach which is termed as learner-centered approach (Baeten et al., 2012). Different from the traditional one, learner-centered approach resulted in the students' active involvement in classroom teaching and change in the role of the teacher from transmitter of information to facilitator of the classroom practices and promoter of learners' involvement in the teaching and learning process (Meece, 2003, McCombs & Whisler, 1997; Schiller, 2009).

For effective implementation of learner – centered approaches, the learner needs to be self-directed, self-regulated and independent learners so as not to depend completely on teachers in knowledge acquisition as in the traditional teacher-centered approach. For this purpose, teaching them how to learn on their own is important (Saavedra & Opfer, 2012). Hence, metacognitive awareness of students is important. Metacognition is one's knowledge concerning cognitive processes and products, and one's actively monitoring and regulating that

cognitive process (Flavell, 1979). In another word, metacognition has been defined as the ability to monitor, evaluate /asses, and make plans for one's learning understanding (Okoro & Chukwudi, 2011).

The students' abilities to control their own learning are vital for effective learning (Boekaerts et al., 2000). Unlike passive learners who do not control their own learning, active learners control their own learning because they know and use useful and best learning strategies and are effective in their schools. Metacognition helps the student to understand what they understand and adjust their learning strategies to improve their learning when they feel their understanding is incomplete (Samson, 2011). As indicated in literature, students who have well metacognitive awareness able to plan, monitor, and modify their cognition at different levels in their learning than those who have low metacognitive awareness (Zimmerman & Martinez-Pons, 1986).

In addition to methods of instruction and metacognitive awareness, prior knowledge of students is an important factor that influences students' effective learning (Grayson et al., 2001; von Glasersfeld, 1992). Before they come to the formal classroom instruction, students have some knowledge about the natural world and phenomena which may be constructed from their daily life experience that affects their learning (Teichert & Stacy, 2002). These students prior knowledge have given different names by scholars at a different time such as misconceptions (Lawson & Thompson, 1988; Nakhleh, 1992; Treagust, 1988), and alternative conceptions (Taber, 2001) to mention some. There are different sources of misconceptions from which students develop. According to Duit & Treagust (1995) and Harrison & Treagust (1996), some of the possible sources of misconceptions include textbooks; teachers; culture and language; mass media; daily usage of concepts; personal real-life experiences; lack of understandings from previous school courses. Moreover, innate structures of the brain (Duit, 1991) and traditional instruction (Kindfield, 1991) were also reported as a source of misconceptions.

These previously perceived concepts about the natural world and phenomena in the mind of students affect the understanding of the new concepts (Schmidt et al., 2003). This is because misconceptions are an obstacle for meaningful learning and resistant to change especially through traditional instructional strategies and remain even after formal science instruction (Guzzetti, 2000; Stavy, 1991; Wandersee et al., 1994). When students come to the classroom and encountered a new knowledge, learning occurs as a result of assimilation and accommodation (Duit & Treagust, 2003; Posner et al., 1982). When students face new information, the prior knowledge serves as a background information on which the new information either fit with it through the process of assimilation or reorganized changing their schema through the process of accommodation as described by Piaget (1953). This type of learning process helps students to have a deep understanding of science concepts (Jonassen et al., 2005). Hence, in teaching toward understanding, an explicit confrontation between pre-knowledge and new knowledge is the critical element, as stated in the theory of conceptual change (Posner et al. 1982; Tanner & Allen, 2005). For meaningful learning to occur, students need to link new knowledge to previously perceived relevant concepts; otherwise, rote learning occurs (Ausubel, 1968).

Consequently, using appropriate strategies that actively involve and help students to become self-directed independent learners that are capable of monitoring their own learning and using their prior knowledge is crucial for learning science with understanding. Among different learner-centered methods and metacognitive strategies, 7E instructional models are useful to extract students' prior knowledge and misconceptions and to teach for conceptual understandings (Bybee et al., 2006; Eisenkraft, 2003) and planning, monitoring and evaluation metacognitive strategies are important for students to know how to learn and monitor their learning progress independently. Hence, in the current study, 7E instructional model with metacognitive scaffolding using metacognitive strategies of planning, monitoring and evaluation were used.

The 7E instructional model was extended from 5E instructional model by Eisenkraft (Eisenkraft, 2003) to make it more suitable than the previous one. It has 7 phases: Elicitation, Engagement, Exploration, Explanation, Elaboration, and Evaluation and Extension. In this newly developed learning cycle model, two more phases were added. These are the elicitation phase to examine prior knowledge of learners and extension phase for application of knowledge gained in daily life or to transfer learning in a new situation (Eisenkraft, 2003).

The first phase, Elicit, helps to reveal students prior knowledge with the concepts about to be studied, and pique their interest to know more (Tanner, 2010). Identifying students' prior knowledge to construct new scientific knowledge starts here in learning science (Eisenkraft, 2003). The second phase, Engagement, helps to focus students' attention on the phenomenon and stimulate curiosity. The third phase, Exploration, helps students to conduct exploration and formulate and test predictions, make observations, record data, and collaborate with peers to develop and test alternative solutions. The fourth phase, Explanation, helps students to review, analyze, and interpret their observations and data to make concepts, processes, or skills clear. The fifth phase,

Elaboration, helps students to further experience or elaborates the concepts to deepen their conceptual understanding and broaden their understanding of science. The sixth phase, Evaluation, helps students to evaluate their understanding. The seventh phase, Extend, helps students to transfer their learning into new situations in their day to day life. This phase explicitly remind teachers the importance for students to practice the transfer of learning in a new context than simple elaboration (Eisenkraft, 2003 p. 59).

Metacognitive strategies include planning, monitoring and evaluation of thinking and learning processes (Chauhan & Singh, 2014; Schraw & Moshman, 1995; Schraw, 1998). Research suggests that those students that are aware of metacognitive strategies are more successful than the others in their learning (Caraway et al., 2003; Imani et al., 2011). According to Bransford, et al., (2000), metacognitive strategies assist students to manage their own learning through defining learning goals and monitoring their progress in order to achieve the stated goals. This, in turn, enables learners to ensure that their goals and tasks are properly understood and then successfully completed and enhanced their learning (Gourgey, 1998).

There are different strategies that can help learners to plan, monitor and evaluate to improve regulation of cognition. Some of them are self-questioning, concept map, journaling, modeling, think aloud, metacognitive prompts, **Know – Want to Know – Learned** (KWL) chart, regulatory checklists, etc (Blakey & Spence, 1990; King, 1991; Schraw, 1998). As described by Kumari and Jinto (2014) using these strategies in teaching-learning process by the teachers can help students to follow appropriate procedures in the process of learning.

Students can be equipped with these strategies through scaffolding. According to Hartman (2001) scaffolding is providing assistance to students on activities that they need guidance from others to make students independent, self-regulating thinkers, self-sufficient learners, and less teacher-dependent. Metacognitive scaffolding according to, Hannafin et al. (1999) enhances metacognitive thinking and metacognitive strategies of planning, monitoring, and evaluating.

After the development of the 7E instructional model, many studies have been conducted to see its effectiveness in learning science in different fields. The results of these studies revealed that 7E instructional model significantly improved students' critical thinking skills, conceptual understanding, retaining acquired knowledge, and promoting self-regulation, achievement (Gök, 2014; Polyiem et al., 2011).

Though, 7E learning cycle was proofed to be effective, few researches were conducted by combining 7E learning cycle with other strategies. For instance, a research conducted by Warliani et al. (2016) on effects of 7E learning cycle model using technology-based constructivist teaching shows that students in the experimental group performed better in understanding than the control group instructed with 7E learning cycle model alone. Similarly, research conducted by Bulbul (2010) shows the effectiveness of 7E learning cycle with computer animation on students' understanding. Students in this group performed better in the understanding of concepts in osmosis and diffusion. Moreover, a research conducted by Yerdelen-Damar and Eryilmaz (2016) on the effectiveness of metacognitive 7E learning cycle on the students' epistemological understandings revealed that students with in experimental group performed better. According to this study, metacognitive activities like the prompted small and whole group discussions, journal writings as homework, error analyses, and concept mapping were used with 7E learning cycle. They found that the group assigned with the metacognitive 7E learning cycle performed better than those taught with teacher-centered instruction. Similarly, a study conducted by Sornsakda et al. (2009) on the effect of using 7E instructional model with three metacognitive techniques of intelligibility, plausibility and wide – applicability found that the experimental groups performed better in learning achievement, integrated science process skills and critical thinking than control group. In the current study, however, metacognitive strategies of planning, monitoring and evaluation were used with 7E instructional model.

The current study focused on metacognitive scaffolding in which students were given supports to use metacognitive strategies of planning, monitoring and evaluation with training while learning through 7E instructional model. My study builds on what is reported in the literature by including metacognitive strategies planning, monitoring and evaluation in to the 7E instructional model. Using metacognitive strategies with 7E instructional model, however, makes this study somewhat different from the studies conducted so far and it will have its own knowledge contribution to the literature.

The other important issue in science education in the last decades was a gender issue. In most studies, it has been reported that there was a significant difference between males and females in science learning favoring males (Lee &Burkam, 1996). A research conducted by Amedu (2015) on the topic of microorganisms using the jigsaw method shows that males performed significantly better than females. However, other studies point out

female students performed better than male students (Britner, 2008; Britner & Pajares, 2006). A research conducted by Filgona and Sababa (2017) on learning with mastery learning strategy revealed that female students performed better than their male counterparts. On the other hand, studies revealed that there was no significant difference between males and females. For instance, Sungur and Tekkaya (2003) reported that there was no difference between males and females in learning and attitude toward biology. According to Shaheen and Kayani (2015), there is no significant difference in the mean scores of boys and girls with respect to students' learning science. Therefore, the effectiveness of 7E instructional model supported with metacognitive strategies on Ethiopians 9th-grade students' conceptual understanding of biology concepts was investigated. Moreover, the effect of gender on conceptual understanding also examined.

Statement of the Problem

Though learners are expected to achieve the expected outcomes, results from national learning assessment in Ethiopia indicated that most students after completing each grade cycle are unable to fulfill the minimum learning competencies stated by the Ministry of Education. The Ethiopian baseline national learning assessments of Grades 10 and 12 students conducted in April 2009 indicated that students are unable to attain the required minimum competencies (NAE, 2010), less than the 50% achievement level set by the Education and Training Policy of Ethiopia (TGE, 1994, p.18). For instance, the national mean score of biology for Grade 10 was 40.3. The recent national learning assessment of Ethiopia also indicated that grade 10 students scored 46.96 (NEA and EA, 2014). According to Omolade (2008), in order for students to have high academic achievement, they must have deep understanding of basic concepts of the subject. The students' conceptual understanding of science, in turn, depends on how their teachers teach science (Kennedy, 1998).

Studies in Ethiopia shows that the practice of applying suitable learner centered methodology in biology classes were limited and traditional lecture methods are dominant in classrooms (Areaya, 2008; Bekele & Melesse, 2010; Berhe, 2006; Beyessa, 2014; Dufera, 2006; Teshome, 2012; Endawoke, 2004). This might be one of the reasons for low learning assessment result of students in biology. As we know, biology is one core component of the education system in Ethiopian. As part of scientific inquiry, it has special relevance to students as individuals, to the society and to the growth and development of Ethiopia at large. Biology education equips learners with the basic knowledge and skills that are essential in the study of fields such as medicines, pharmacy, nursing, agriculture, forestry and biotechnology. Moreover, many of the contemporary issues and problems such as nutrition, health, drug abuse, agriculture, pollution, rapid population growth, environmental degradation, global warming and conservation in the society are essentially biological in nature. In order to effectively deal with the relevance of biology and contemporary issues, an understanding of biological knowledge is required. Therefore, my study was mainly to investigate how the 7E instructional model with metacognitive strategies helps learners in conceptual understanding of biology concepts and minimizing of misconceptions in Ethiopian secondary school context.

Research Questions

1. Is there a significant mean score difference in the conceptual understanding of human biology concepts between groups?
2. Is there a significant mean score difference between males and females in the conceptual understanding of human biology concepts?

To what extent misconceptions in human biology exist among groups?

Research Method and Design

For this study, a quantitative research method was used. The design for this study was the nonequivalent pre-test, treatment, posttest control group quasi-experimental research design. The design has one comparison group and three treatment groups. Accordingly, TG1 was with treatment of 7E instructional model (7EIM) (X_1), TG 2 was with treatment of 7E instructional model with metacognitive strategies (7EIMMS) (X_2), TG 3 was with conventional with metacognitive strategies (CIMS) (X_3) and CG was with conventional instruction (CI). Because of this, the research design for this study can be presented as follows:

Groups	Pre test	Treatment	Post test
Treatment Group1 (TG1)	O ₁	X ₁	O ₂
Treatment Group2 (TG2)	O ₁	X ₂	O ₂
Treatment Group3 (TG3)	O ₁	X ₃	O ₂
Comparison Group (CG)	O ₁		O ₂

Sampling Technique

The study was conducted in Addis Ababa, Ethiopia, on grade nine students. Four schools were selected using purposive sampling based on school facilities, teachers' qualifications and experience and school effectiveness for the intervention. This is because the four schools should have to be in similar conditions. From each of the four schools, one well qualified and experienced biology teacher was purposely selected and one section of grade nine students from those selected teachers are teaching was randomly selected in each school and assigned as treatment and comparison groups randomly. Based on this, the study involved 164 9th grade students (64 boys and 100girls) in public secondary schools.

Data Gathering Instruments

In order to answer the research questions of this study, data were gathered using a human biology conceptual understanding test (HBCUT). HBCUT was a two-tier multiple choice diagnostic test. The two -tiers multiple-choice test contains content response (first tier) with two to four choices and a set of four to five possible multiple-choice reasoning response and one additional blank space (second tiers) that diagnose students' conceptual understanding and help to identify misconceptions held by students in science.

To develop the HBCUT, the procedure described by Haslam and Treagust (1987) and Treagust (1988, 1995) was used. The procedure includes three phases and 10 steps in which the first phase with four steps, the second phase with 3 steps and the third phase with 3 steps. The three phases with each step presented in the table below (Table 1). The final version of the HBCUT for assessing human biology conceptual understanding consisted of 18 items.

Table 1. Shows the three phases and 10 steps.

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

Validity and Reliability

The content and face validity of instruments and the material prepared on 7E instructional model and metacognitive strategies were checked using experts' opinions. Finally, corrections were made by considering the feedbacks and recommendations obtained from the experts. A pilot study was conducted for item analysis of instruments and reliability checking. Based on the analysis of difficulty and discrimination power, some of the items improved and others were discarded. The reliability of HBCUT test was investigated by calculating an internal consistency measure of Kuder-Richardson 20 and it was found to be 0.70.

Intervention Procedure

First training on 7E instructional model was given to the teacher in TG 1 and TG 2. After giving a metacognitive inventory test to all groups, training on metacognitive strategies was given to teachers and

students in TG 2 and TG3. For the training of metacognitive strategies, KWHAL chart and Regulatory checklist were used. KWHAL refers to: **K** = What do I know? **W** = What do I want to know? **H** = How will I know it? **A** = Am I learning well? **L** = What have I Learnt? Self Regulatory checklist was also used which are used to check whether they are on track or not using self questions like what is my goal? Do I have a clear understanding of what I am doing? Have I reached my goal? These two materials were given to all students in the TG 2 and TG3, taped on their desk, wall and exercise book during training and used during implementation of the intervention.

During implementation of the intervention which lasted for 10 weeks, 4 times per week (45 minute each), teachers in TG 1 and 2 used 7E instructional model to teach the topics and design their lesson plan for each lesson indicating activities to be done, the role of the teachers and students under each phases of the 7E instructional model. In addition, teacher in TG 2 included metacognitive strategies of planning, monitoring and evaluation in their lesson plan. Teachers in TG 3 and CG used conventional instruction, most commonly lecture method, to teach and design their lesson plan accordingly. In addition, teacher in TG 3 included metacognitive strategies. The unit taught was human biology which includes food and nutrition, the digestive systems, respiratory systems, cellular respiration and circulatory systems.

Second, pretest about HBCUT was given to the four sections taught by the four teachers. After completing these activities, implementation of intervention was started. Teachers and students were trained very well and several classroom observations were made during the intervention so as to monitor proper implementation of the intervention. After completing the implementation of the intervention, the conceptual understanding test was administered as post-test.

Analysis Methods

For analyzing the data, Statistical Package for Social Sciences (SPSS) software was used. After testing the assumptions parametric test, analysis of variance (ANOVA) was used. Moreover, data obtained from HBCUT were also categorized, analyzed and compared among the four groups in relation to sound understanding, partial understanding and misconceptions. In this regard, there are several studies on how to analyze two tiers multiple-choice items. Based on TarakciHatipoglu et al. (1999) and Ozkan et al. (2015) classification of students' understanding, the table below used to analyze the data obtained from the HBCUT. Misconceptions are considered significant and common if it is held at least 10% of the total sample of students (Chandrasegaran et al., 2007; Haslam & Treagust, 1987).

Table.2 Classification of understanding of students

First-tier	Second-tier	Classification
True	True	Sound understanding
True	False	Misconceptions
False	True	partial understanding
False	False	No understanding

Results

Pretest Scores Analysis

Before the implementation of the intervention begins, HBCUT was administered to all groups as a pretest. The purpose of administering the pretests was to compare whether students in the groups were different from each other in their understanding on human biology or not before the implementation of the intervention. Therefore, ANOVA was executed to investigate whether there was a significant mean difference between them or not in biology conceptual understanding. Before performing the analysis of pre-test scores, assumptions of ANOVA such as normality (skewness and kurtosis) and homogeneity of variance (Levene test) were checked and found were not violated.

After checking the assumption for ANOVA, descriptive statistics of the pre test scores were analyzed. The descriptive statistics result (table 3) revealed that the mean score of pre-HBCUT for TG 1, TG 2, TG 3 and CG were 12.47, 13.16, 10.34, and 10.72 respectively. The descriptive statistics of pre-HBCUT test scores of the groups were summarized below (Table 3).

Table 3. The descriptive statistics of pre-HBCUT scores of the groups

Variables	Groups											
	Treatment Group 1			Treatment group 2			Treatment group 3			Comparison group		
Pre-HBCUT	N	M	SD	N	M	SD	N	M	SD	N	M	SD
	41	12.47	7.74	38	13.16	5.39	43	10.34	5.63	42	10.72	6.18

From the results of descriptive statistics, the mean score of each of the groups looks somewhat different. Therefore, ANOVA was conducted to check whether there is a statistically significant difference between treatment and comparison groups on their pre-HBCUT test or not. The result from ANOVA analysis (Table 4) revealed that there was no statistically significant mean difference between the groups in pre-HBCUTF (3, 163) = 1.88, $p = .14$) for the groups. In summary, there was no statistically significant mean difference among groups. So, the change observed after intervention could not be attributed to treatment groups' difference before the implementation of the intervention. The ANOVA result is shown in the table below (Table 4).

Table 4. ANOVA result comparing groups in terms of pre-HBCUT

		Sum of Squares	df	Mean Square	F	p
Pre-HBCUT	Between Groups	224.51	3	74.84	1.88	.14
	Within Groups	6367.71	160	39.80		
	Total	6592.22	163			

Posttest Scores Analysis

After the implementation of the intervention, HBCUT was administered to all groups as a post test. After assumptions of ANOVA such as normality, homogeneity of variance and outliers were checked and found no serious violation of the assumptions, ANOVA was executed to investigate whether there was a significant mean difference between groups and between gender or not in biology conceptual understanding.

As it can be seen from Table 5, the mean scores of the TG 1, TG 2, TG 3 and CG on post-HBCUT test were different. The mean score of post-HBCUT for TG 1, TG 2, TG 3 and CG were 37.94, 44.44, 31.91, and 30.69 respectively. The mean score for TG 2 is higher than the other groups in post HBCUT followed by TG 1, TG 3 and CG consecutively.

Table 5. Descriptive statistics for post-HBCUT scores across groups

Variables	Groups											
	Treatment Group 1			Treatment group 2			Treatment group 3			Comparison group		
Post-HBCUT	N	M	SD	N	M	SD	N	M	SD	N	M	SD
	41	37.94	10.16	38	44.44	8.57	43	31.91	8.14	42	30.69	8.52

In addition to groups, the descriptive statistic of post test scores across gender also computed. As it can be seen from the table 6, the mean post-HBCUT score of females (40.67) was higher than males in TG 1 (33.68) and males in TG 3 (33.68) were higher than females (30.86) whereas score of males was almost similar with females in TG 2(44.79 and 44.19) and CG (30.90 and 30.56).

Table 6. Descriptive statistics for post-HBCUT scores across gender

Variables	Groups											
	Treatment Group 1			Treatment group 2			Treatment group 3			Comparison group		
Post-HBCUT	M	N	SD	N	M	SD	N	M	SD	N	M	SD
	F	16	33.68	10.03	16	44.79	7.72	16	33.68	10.44	16	30.90
	25	40.67	9.45	22	44.19	9.31	27	30.86	6.41	26	30.56	8.50

In order to check whether these differences across groups and gender statistically significant or not, inferential statistics were run and the results were presented below. As described above, the result of the descriptive statistics revealed that there was a mean score difference between groups and males and females in relation to post test scores of post-HBCUT test. To assess if there were statistically significant post- tests mean score differences between the four groups and males and females ANOVA was conducted. The ANOVA results revealed that there was a statistically significant difference between the four groups on posttest mean scores: post-HBCUTF (3, 163) = 20.17, $p = 0.00$).

Table 7. ANOVA result comparing groups in terms of post-HBCUT

		Sum of Squares	df	Mean Square	F	p
Post-HBCUT	Between Groups	4767.81	3	1589.27	20.17	.00
	Within Groups	12605.80	160	78.79		
	Total	17373.61	163			

However, there was no statistically significant difference between males and females on post test mean scores: post-HBCUTF (1,163) = .06, p = .81). The following table is the ANOVA result.

Table 8. ANOVA result comparing gender in terms of post-HBCUT

		Sum of Squares	df	Mean Square	F	p
Post-HBCUT	Between Groups	6.33	1	6.33	.06	.81
	Within Groups	17367.27	162	107.21		
	Total	17373.61	163			

Even though ANOVA result revealed that there was a significant difference between groups in post test mean scores, it did not show a significant difference among groups on the dependent variable. Therefore, post hoc analysis was conducted. The post hoc analysis result revealed that there was statistically significant mean difference between TG 1(M = 37.94) and TG 2 (M= 44.44), $p = .01$; between TG 1(M = 37.94) and TG 3 (M=31.91) $p = .01$; between TG 1(M = 37.94) and CG (M = 30.69), $p = .00$ in post-HBCUT. There was also statistically significant mean difference between TG 2(M =44.44) and TG 3 (M=31.91), $p =.00$; between TG 2(M =44.44) and CG (M = 30.69), $p = .00$ in post-HBCUT. Although there was a mean difference, the difference between TG 3 (M =31.91) and CG (M =30.69), $p =.92$ in post-HBCUT was no statistically significant. The table below shows post hoc multiple comparison result.

Table 9. Post hoc multiple comparison test result

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	p
Post-HBUT	TG 1	TG 2	-6.50*	1.99	.01
		TG 3	6.03*	1.94	.01
	TG 2	CG	7.25*	1.95	.00
		TG 3	12.53*	1.97	.00
	TG 3	CG	13.76*	1.98	.00
		CG	1.22	1.93	.92

Analysis of HBCUT Items and Misconceptions

In addition to significant result of ANOVA, percentages of students’ responses to post HBCUT and misconceptions identified provided evidence of the difference between the groups after the treatment supporting the effectiveness of the intervention. At first, the percentages of students’ responses and then the percentage of students’ misconceptions for each item were calculated and analyzed.

Based on the categories of students response in to sound understanding (SU)- answering both two tiers; partial understanding (PU)-answering only the second tier; misconception (MC)-answering only first tiers, and no understanding (NU)-answering any other than correct first and correct second tier, each items were analyzed. In view of that, when we look at the percentage of students’ responses the mean percentage of students’ response in the table below (Table 10) showed that 37.21, 44.06, 31.26 and 30.47of the students for TG 1, TG 2, TG 3, and CG respectively have sound understanding on the concepts inhuman biology. On the other hand, 11.70, 11.62, 12.14 and 15.07 mean percentage of students’ response showed that they have partially understood the concepts whereas 27.42, 25.02, 31.52 and 30.87% for TG 1, TG 2, TG 3, and CG have misconceptions about concepts in human biology. Moreover, 23.54, 19.30, 25.08 and 23.47 mean percentage of students’ responses showed that they have no understanding of the concepts. Relatively higher mean percentage of misconceptions found from TG 3 and CG (31.52 and 30.87) respectively. The misconception held by students relatively lower in TG 2 (25.13) ensuring the effectiveness of 7E instructional model with metacognitive strategies than the others in minimizing misconceptions followed by TG 1 (27.65) with 7E instructional model alone. In relation to no understanding of concepts, TG 2 has a lower percentage of students followed by TG 1.

Furthermore, when each item was analyzed, students in TG 2 performed better in an understanding of the concept than students in TG 1, TG 3 and CG in 12 of the items (67%), in 14 of the items (78%) and in 16 of the items (89%) respectively. In relation to misconception, students in TG 2 hold less percentage of misconceptions in 11 of the items (61%) than the TG1 and in 12 of items (67%) than TG3 and in 13 items (72%) than CG. Similarly, students TG 1 better performed in understanding in 11 of the items (61%) than CG. Students in TG 1 hold less percentage of misconceptions in 12 of the items (67%) than TG 3 and in 11of the items (61%) than CG.

The percentage of students response in TG 2 was higher than the others followed by students in TG 1 in relation to sound understanding and lower in relation to misconceptions and no understanding indicating that 7Einstructional model with metacognitive strategies was superior to the other instructional methods followed by 7E instruction model alone in helping students understand the concept. This can be taken as an evidence that supports the ANOVA result.

Table 10. Percentages of the responses of students on post-HBCUT tests scores per categories

Item	Treatment Group 1				Treatment Group 2				Treatment Group 3				Comparison Group			
	SU	PU	MC	NU	SU	PU	MC	NU	SU	PU	MC	NU	SU	PU	MC	NU
1	28.86	29.27	21.96	19.91	26.85	26.32	23.68	23.15	18.99	23.26	23.26	34.49	30.86	33.33	14.28	21.53
2	26.42	14.64	7.32	51.62	40.01	10.52	5.26	44.21	18.99	9.31	25.58	46.12	26.1	21.42	19.04	33.44
3	21.54	12.2	36.59	29.67	29.49	7.89	7.89	54.73	28.29	6.98	18.6	46.13	23.72	4.76	19.04	52.48
4	33.73	19.51	7.32	39.44	40.01	13.16	7.89	38.94	28.29	11.63	25.59	34.49	26.1	16.67	16.66	40.57
5	28.86	9.76	39.03	22.35	40.01	13.16	36.84	9.99	35.26	18.6	41.88	4.26	26.1	9.53	29.56	34.81
6	50.81	12.2	29.27	7.72	42.64	15.59	23.68	18.09	46.89	6.98	23.17	22.96	42.77	11.9	38.1	7.23
7	21.54	14.63	19.51	44.32	26.1	13.16	36.64	24.1	21.31	11.63	32.53	34.53	18.96	14.29	26.18	40.57
8	28.86	12.2	36.58	22.36	66.33	5.26	23.68	4.73	28.29	11.63	32.56	27.52	30.86	9.3	26.18	33.66
9	57.58	2.44	39.00	0.98	55.8	7.89	34.22	2.09	25.96	20.93	48.84	4.27	40.39	14.29	50.01	-4.69
10	50.81	0	50.22	1.02	40.01	7.89	42.11	9.99	35.26	9.3	41.86	13.58	28.48	9.52	45.24	16.76
11	70.32	4.88	9.76	15.04	74.22	5.26	7.89	12.63	35.26	9.31	18.61	36.82	59.44	7.14	28.57	4.85
12	31.29	4.88	17.08	46.75	50.54	15.78	18.42	15.26	30.61	16.28	25.58	27.53	23.72	26.19	33.33	16.76
13	31.29	2.44	41.47	24.8	55.8	0	42.1	2.1	25.96	2.33	58.13	13.58	33.25	4.76	54.76	7.23
14	54.76	9.76	24.4	11.08	42.64	13.16	28.95	15.25	30.61	11.63	44.18	13.58	30.86	7.14	28.56	33.44
15	36.17	9.76	31.72	22.35	53.17	23.68	7.89	15.26	39.92	9.13	39.54	11.41	26.1	19.05	21.42	33.43
16	28.86	12.2	26.84	32.1	32.12	5.26	50	12.62	39.92	9.31	30.23	20.54	23.72	16.66	26.18	33.44
17	45.93	13.07	40.9	0.01	45.28	14.68	40.11	.07	46.89	16.28	27.91	8.92	28.48	14.29	54.76	2.47
18	19.1	26.83	14.64	39.43	32.12	10.53	13.15	44.2	25.96	13.96	9.31	50.77	28.48	30.95	26.18	14.39
Mean	37.21	11.70	27.42	23.54	44.06	11.62	25.02	19.30	31.26	12.14	31.52	25.08	30.47	15.07	30.87	23.47

The analysis for the identification of misconception using the percentage of students' on each item was presented as follows with examples of items. The analysis was based on the categories of concepts in human biology such as food and nutrition; the digestive system; the respiratory system, cellular respiration and the circulatory system. Thirty misconceptions were identified from all items and groups most of them from comparison groups. For identification of misconceptions, responses of students to all items were analyzed but two examples (items 2 and 15) were presented below to show the process of the analysis and identification of misconceptions.

According to the percentage of correct first-tier and incorrect reason choice, it was found that a considerable percentage of students had misconceptions from item 2 about the purpose of converting food in to lipid and result of glucose test with Benedict solution. For this study, those correct first tier and incorrect second-tier reason responses above 10% were taken as major misconceptions (Haslam & Treagust, 1987). When we look at item 2, the result showed that only 26.42%, 40.01%, 18.99 % and 26.1% from TG1, TG2, TG3 and CG respectively have understood the reason for colour change in glucose test using Benedicts solution while considerable percentage of students in TG3 (25%) and CG (19%) have misconceptions compared to students in TG1(7%) and TG2 (5%). The relatively higher percentage of the students understood the concept from TG 2 (40.01%) followed by TG 1(26.42%). Considering correct first tier and incorrect second tier, students' responses with percentage of 14 from TG3 and 11.93 from CG were taken as two misconceptions from item 2. Students in TG 3 and CG considered the change in colour during testing the presence of glucose with Benedict's solution is due to reduction of monosaccharide to disaccharides in the reaction and because when water boils it changes its colour. No misconceptions were identified from TG1 and TG2. This implies that 7EIM alone and 7EIMMS were effective in reducing misconceptions. However, 7EINMS was more effective than 7EIM because only 5.26% of

students in TG 2 have misconceptions compared to 7.32% in TG 1. Responses of students for item 2 were analyzed as shown in the table below (Table 11).

Table 11. Percentage of students' responses to item no. 2

Item	TG1	TG2	TG3	CG
2				
A grade 9 student conducted an experiment in the biology laboratory. First she put a sample of glucose powder and water in to a test tube. Then she added a few drops of Benedict's solution in to the test tube and placed it in boiling water. What was the most probable colour she observed within the test tube?				
A Blue	29.27	26.56	42.14	29.66
B Purple	30.73	23.84	11.62	27.28
C Black	7.32	5.26	2.33	7.14
D Orangey-red*	33.74	45.27	44.47	47.5
The reason for my answer is				
1 Copper(II) in the Benedict's solution is reduced to copper(I)*	26.42	40.01	18.99	26.1
2 Copper(I) in the Benedict's solution is oxidized to copper(II)	2.44	5.26	2.33	7.14
3 A monosaccharide is reduced in the reaction to disaccharides	0	0	9.3	11.93
4 When water boils it changes its colour	4.88	0	13.95	2.38
5 Other reason:	0	0	0	0

NB. Percentages under reasons are those only with correct first choice

* indicates correct combination of response

Similarly, result from item 15 showed that 36.17%, 50.87%, 39.92 and 23.8% from TG 1, TG 2, TG 3 and CG respectively have understood the concept of blood transfusion while others have misconceptions. The relatively higher percentage of students in the TG 2(50.87%) understood the concept. Responses with percentage of 12.2 (TG1), 11.63 and 13.95 (TG3) and 11.9 (CG) were taken as major misconceptions. No misconception was identified from TG 2. But three misconceptions were identified from this item in other groups. The first one is that students considered transfusion of blood from O type to A type is because O type has no antibody that reacts with antigen of the red blood cells of the person with blood type A. The second misconception is that O type has antigen AB that does not react with antibody in the red blood cells of the person with blood type A. The third misconception was O type has no antigen and antibody that reacts with the red blood of the person with blood type A. 7EIMMS was effective in minimizing misconceptions compared to the other groups. Responses of students for item 15 were analyzed as shown in the table below (Table 12).

Table 12. Percentage of students' responses to item no. 15

Item	TG1	TG2	TG3	CG
15				
If someone with blood group "A" has got a car accident and lost a lot of blood. Therefore, he needs blood transfusion. Which of the following blood group is used during the transfusion?				
A B	9.76	5.26	13.95	14.28
B AB	22.03	34.62	6.98	40.14
C O*	67.73	60.71	79.36	47.52
The reason for my answer is				
1 It has no antibody that reacts with antigen of the red blood cells of the person.	9.76	7.89	11.63	4.76
2 It has antigen AB that does not react with antibody in the red blood cells of the person.	9.76	2.63	13.95	11.9
3 It has no antigen that reacts with antibody of the red blood cells of the person*	36.17	50.87	39.92	23.8
4 It has no antigen and antibody that reacts with the red blood of the person.	12.2	0	11.63	4.76
5 Other reason:			2.33	2.38

Discussion and Conclusion

In this section, the findings from the data analysis results on conceptual understanding were discussed in relation to findings from different related literature. As it is already mentioned, the aim of this study was mainly to investigate the effect of 7E instructional model with metacognitive strategies and gender on 9th grade

students' conceptual understanding of concepts in human biology. The topics covered in this study include food and nutrition, the digestive systems, respiratory systems, cellular respiration and circulatory systems.

Accordingly, the first research question of the study was to investigate students' conceptual understanding of human biology concepts between groups. The findings showed that students in TG 2 who received 7EIMS outperformed than TG 1, TG3, and CG who received 7EIM alone, CIMS and CI alone in conceptual understanding. Similarly, students in TG 1 who received 7EIM alone outperformed than TG3 and CG who received CIMS and CI alone. In other words, 7EIMMS has more significant effect on students' conceptual understanding than the other three types of instructional methods. Moreover, 7EIM alone also has more significant effect on students' conceptual understanding than the other two instructional methods. Therefore, since the groups were found similar in their pretest score, this difference between groups was due to the intervention.

However, the result revealed that, though the mean score was different, there was no statistically significant conceptual understanding means scores difference among TG 3 and CG. This means the effect of CIMS on students' conceptual understanding is not statistically different from conventional instruction. Students who received CIMS did not perform well than who instructed with CI in terms of the dependent variable.

In addition, to mean score analysis, each item of the HBCUT was analyzed in terms of percentages. The results of the analysis of each of the HBCUT item results also supported the findings of HBCUT mean score analysis result. Most students in TG 2 have sound understanding of the concept of human biology followed by students in TG 1 than students in TG 3 and CG. TG 2 students have a low percentage of students that did not understand the concept.

Analysis of each item indicated that, students in TG 2 performed better in the understanding of the concept in 12 of the items than TG 1, in 14 of the items than TG3 and in 16 of the items than CG. This means TG2 students have a better understanding in concepts of food and nutrition, digestive system, respiratory system, cellular respiration and cellular respiration. The difference can be explained by the method the teachers used which actively engages students in their learning. This indicates that 7EIMMA was relatively superior to the other instructional methods and 7EIM alone is also relatively superior to the two instructional methods in helping students understand the concept.

As indicated in literature, for learners to conceptually understand concepts, an explicit confrontation between pre-knowledge and new knowledge (Posner, et al., 1982; Tanner & Allen; 2005) and active participation of students in discovery, reflection and critical thinking is the critical element in learning process (Santrock, 2001). In other words, for conceptual understanding to occur, there should be shifting and restructuring of pre-existing knowledge in to new knowledge through active involvement of students (Tanner & Allen, 2005). This type of learning, according to Posner et al. (1982), occurs through assimilation in which knowledge is incorporated into existing schemas and accommodation in which new knowledge conflicts with existing schemas. Moreover, according to Piaget (1953), children's mental structures (schema) which are basic for learning, are constructed through the process of assimilation and accommodation leading towards equilibrium. In other words, assimilation is using pre-existing knowledge to deal with new knowledge and accommodation is replacing and reorganizing preexisting knowledge to develop new new knowledge. Moreover, for learning through assimilation and accommodation, there must be dissatisfaction with existing conceptions and the new conception must be intelligible, plausible and fruitful. It is this type of learning process helps students to have deep understanding of science concepts in their learning (Jonassen et al., 2005).

Research findings point out that the traditional instructional approach encourages memorization and recalling of facts which is gaining knowledge than conceptual understanding (Zakaria & Iksan, 2007). In this approach, students are passive listeners than active participants in learning. Similarly, Dhaaka (2012) also reported that this approach encourages students to memorize the content and reproduce the same to pass the examination without understanding the concept of the subject. Researchers indicated that students' learning cannot be determined by acquiring knowledge to pass the examination but rather by acquiring deep meaningful understanding of the materials presented to the students (Sakiyo & Waziri, 2015).

However, the modern constructivist approaches are found to be effective in helping students to learn science with conceptual understanding. The 7EIM, one of the constructivist approaches, found to be useful to actively engage students, extract students' prior knowledge and misconceptions, discover new knowledge leading to conceptual understandings (Byee et al., 2006; Eisenkraft, 2003). This study used 7E instructional model and metacognitive strategies to teach students. The 7E instructional model has 7 phases. These phases are elicit,

engage, explore, explain, elaborate, evaluate and extend. The first phase enables students to brainstorm prior knowledge so as to know what students know and identify misconceptions. According to Piaget (1953), the prior knowledge serves as background information on which the new information either fit with it through the process of assimilation or reorganized changing their schema through the process of accommodation. The second phase actively engages students mentally in their learning through activities that focus their attention and curiosity (Bybee, et al., 2006). This creates a cognitive conflict and they try to either assimilate the new information with an existing mental structure or reorganize to develop new knowledge, accommodation. The third phase allows students to observe, explore, formulate hypotheses, test and record results and discuss with others. This leads to the process of equilibration between existing mental structures and new information either through assimilation or accommodation. The fourth phase allows students to present concepts, processes and skills briefly to the teacher and their classmates. In this phase, equilibration continues and misconceptions can be corrected. The fifth let students to further discuss the concepts. This helps them to understand concepts and minimize misconceptions. The six-phase give opportunity for students to assess their understanding and skills acquired with feedback from the teacher. The seventh phase provides students a chance to apply what they have learned in their day to day life. Hence, 7E instructional model is very useful to facilitate meaningful learning. The result obtained from this study provides evidence for its effectiveness.

Furthermore, in addition to instructional methods, literature reported that metacognition has an effect on students learning and performance because the learners' awareness about their learning and control of the way they are learning is important in meaningful learning (Azevedo, 2005; Efklides, 2006; Lin, 2001). This is because, according to Schraw et al. (2006), scientific inquiry requires metacognitive skills such as planning, monitoring, reflection, and self-evaluation of learning. Hence, the metacognitive strategies that students used in this study enabled learners to develop metacognitive skills of planning, monitoring and evaluation which are important skills in scientific inquiries. Therefore, students in this study benefited from the combined advantages of both 7E instructional model and metacognitive strategies so as to enhance their conceptual understanding. As a result, students taught by 7EIMMS outperformed in the understanding of concepts than students taught with 7EIM alone. Moreover, students instructed with 7EIM alone also performed better than those instructed with CI alone and CIMS.

Therefore, the use of the metacognitive strategies with the 7EIM contributed to the superiority of the 7EIMMS over 7EIM alone in improving students' conceptual understanding of concepts in biology. This is because in addition to providing opportunities for students to think and reflect what is in their mind (elicit), actively engage in investigations, explain and relate what they have learned with their day to day life, the method used in this study gave opportunities for students to plan ahead what they want to learn, monitor their learning progress while learning and to evaluate what they have learned before the actual assessment by the classroom teacher.

The use of MS with CI, however, was not effective in enhancing students learning. The reason might be in the CI most of the teachers use lecture method which didn't give an opportunity for students to actively engage in their learning because they are expected to listen to the teacher and take note at the same time. This, in turn, did not give an opportunity for students to use metacognitive strategies because they are busy so as not to miss what the teacher is writing and talking about.

Similarly, different studies conducted to compare the effectiveness of 7EIM with CI on students' conceptual understanding of concepts and reported significant results in favor of 7EIM (Gök, 2014; Polyiem et al., 2011; Shaheen & Kayani, 2015). The results of these studies revealed that 7EIM significantly improved students' conceptual understanding of concepts than CI.

Even though, 7EIM was found to be effective in enhancing students' learning, few researches have been conducted by combining 7E learning cycle with other strategies. For instance, a research conducted by Bulbul (2010) shows the effectiveness of 7E learning cycle with computer animation on students' conceptual understanding. Students in this group performed better in understanding of concepts in osmosis and diffusion. Another research conducted by Warliani, Muslim and Setiawan (2016) on effects of 7EIM using technology-based constructivist teaching shows that students in experimental group performed better in understanding than control group instructed with 7EIM alone in physics.

Nevertheless, few studies have been conducted on the effect of 7EIM with metacognitive strategies on students' conceptual understanding reported significant results in favor of the 7EIM with MS. For instance, a research conducted by Sornsakda et al. (2009) on the effect of using 7EIM with three metacognitive techniques of intelligibility, plausibility and wide – applicability in environmental education found that the experimental groups performed better in learning achievement, integrated science process skills and critical thinking than

control group. The other research conducted by Yerdelen-Damar & Eryilmaz (2016) on the effectiveness of metacognitive 7EIM using metacognitive activities on the students' epistemological understandings in physics revealed that students with an experimental group performed better. They found that the group assigned with metacognitive 7EIM performed better than those taught with teacher-centered instruction. However, this study used metacognitive strategies differently than they used. Unlike these studies, metacognitive strategies of planning, monitoring and evaluation were used in this study.

Generally, the findings of this study supported the previous research findings that revealed 7EIM with technology and metacognitive strategies is more effective than the other approaches to enhance students' biology conceptual understanding of concepts and extended the previous findings because this study used different approaches. Moreover, the results provide further empirical support for the studies reported significant results about the effectiveness of 7EIM alone over CI on students' understandings of biology concepts. The finding ensures that using 7EIM alone is important in enhancing students learning but supporting the 7EIM with MS is even better to increase students learning than using 7EIM alone.

The second research question of this study was whether there is a significant mean score difference across gender in the conceptual understanding of human biology concepts or not. In this study, therefore, the variable was also investigated in relation to gender. In relation to the dependent variable, after the implementation of the intervention, there was a mean score difference between males and female students. The ANOVA results of this study, however, revealed that there was no significant mean difference between male and female students in conceptual understanding of human biology concepts. Therefore, it can be said that male and female students gained similar benefits from the implementation of the intervention.

The results of this study is consistent with the studies investigated the effectiveness of learning cycle across gender. Several studies indicated no significant difference between males and females with respect to science learning (Cakiroglu, 2006; Uguw & Soyibo, 2004; Thompson & Soyibo, 2002). For example, Uguw and Soyibo (2004) indicated that there is no significant gender difference in performance on nutrition and plant reproduction concepts among 8th-grade students. The third research question was the extent of misconceptions held by students among groups. Therefore, one of the purposes of this study was to identify misconceptions in human biology concepts and compare the effects of the instructional methods with respect to misconceptions in relation to conceptual understanding of concepts. Hence, this study investigated misconceptions held by students' in human biology concepts from HBCUT. So, in this study, all the misconceptions in human biology concepts were identified and a list of misconceptions was developed.

According to the findings of this study, 7EIMMS was effective than other instructional methods in terms of conceptual understanding of human biology concepts and the reduction of misconceptions. The analysis of students' post-HBCUT scores showed that students taught by 7EIMMS understood the concepts well and reduced misconceptions compare to students instructed with 7EIM alone, CI alone and CIMS (Table 10). Relatively higher mean percentage of misconceptions found from TG 3 and CG. Here again, misconception held by students relatively lower in TG 2 ensuring the effectiveness of 7EIMMS than the others in minimizing misconceptions followed by TG 1 with 7EIM alone.

When we examine each item of HBCUT in relation to misconception, students in TG 2 hold less percentage of misconceptions in most of the items than TG 1, TG 3 and CG. This is because students instructed by 7EIMMS elicit their prior knowledge, engaged in exploration of concepts by their own and used metacognitive strategies of planning, monitoring and evaluation. Even if the students assigned with 7EIMMS understood the concepts better and reduced misconceptions than the other instructional methods, still there are misconceptions held by students in the groups. Analysis of post HBCUT result revealed that students' in all treatments and comparison groups hold some misconceptions though the extent of the percentage of the misconceptions held varies between groups. For example, from an analysis of HBCUT, two major misconceptions were identified from TG 3 and CG in concepts of food and nutrition.

One of the misconceptions was when we add Benedict solution to glucose, orange red colour was formed due to when water boils (TG 3) and due to monosaccharide is reduced in the reaction to disaccharides (CG). The correct conception is that the formation of orange red colour is due to the reduction of copper II to copper I compound during the reaction. The reason for the development of the misconception may be due to the reason that this concept was presented in the form of activity in the textbook but most of the time teachers did not give emphasis for activities in the textbook because of lack of materials and they think that it takes time to do the activities which in turn affects their pace to complete the course on time at the end of the academic year.

From the digestive system category, students know that mechanical digestion breaks food in to smaller soluble once but they considered that mechanical digestion releases enzymes from glands and involves enzyme action to break large food substances. These misconceptions were obtained from TG 3 and CG respectively. The correct conception is that mechanical digestion breaks dawn food in to smaller pieces by teeth bite and chewing and muscular tubes so as to increase the surface area for enzymes action. Enzymes are involved in chemical digestion.

From the circulatory system, the misconception identified was about the reason behind the transfer of blood from one person to another person. Although students know that blood type O is universal donor, they have misconceptions in that this is because of the reason that blood type O has no antibody that reacts with antigen of the red blood cells of the person; blood type O has antigen AB that does not react with antibody in the red blood cells of the person and blood type O has no antigen and antibody that reacts with the red blood of the person. The correct conception is that a person with blood type A can receive blood from blood type O because blood type O has no antigen that reacts with antibody of the red blood cells of the person with blood type A. This helps the blood type O not to be recognized by other cells. The reason may be due to the word antigen and antibody which is somewhat difficult to differentiate because of their similarity.

Misconceptions can be barrier for learning since knowledge construction occur based on already existing understandings (Guzzetti, 2000, Stavy, 1991; Wandersee et al., 1994). Therefore, identifying and finding way of minimizing misconceptions is very important for meaningful learning. Being aware of the students' misconceptions is very important for teachers to designing their instruction to remedy these misconceptions and overcome the difficulties of students in learning concepts.

According to Duit & Treagust (1995) and Harrison & Treagust (1996) sources of misconceptions includes the textbooks; the teachers; the culture and language; the mass media; daily usage of concepts; personal real-life experiences and lack of understandings from previous school courses. Moreover, innate structures of the brain (Duit, 1991) and traditional instruction (Kindfiled, 1991) were also reported as a source of misconceptions. So, the misconception identified in this study may be caused by such different sources of misconceptions.

Even though misconceptions can be minimized, there are several evidences as students had misconceptions after instruction (Guzzetti, 2000; Kaynar et al., 2009; Stavy, 1991; Wandersee et al., 1994). However, according to Marek et al. (1994) using learning cycle is useful to minimize misconceptions and to help students understand the concepts. For instance, the results obtained from the research conducted on the effectiveness of 5E learning cycle shows that students' misconceptions reduced after the instruction of 5E instructional model (Ajaja, 2013; Artun & Coştu, 2012; Cakiroglu, 2006; Nuhoglu & Yalcin, 2006; Sadi & Çakiroğlu, 2010). However, it is difficult to completely eliminate misconceptions because there are various misconceptions (Duit & Treagust, 1995; Harrison & Treagust, 1996).

In this study, students assigned with 7EIMMS engaged in the exploration of concepts on their own and they planned monitored and evaluated themselves using metacognitive strategies with the help of the teacher. Therefore, students taught with 7 EIMMS able to minimize misconceptions than students taught with 7EIM alone and CI alone and CIMS. Students taught with 7EIM alone also able to understand human biology better than the two groups taught with CI alone and CIMS and minimized misconceptions.

From the finding of this study, it can be concluded that metacognitive scaffolding while learning with 7EIM helped students to learn biology concepts better than learning with only 7EIM alone. When students are supported with metacognitive strategies of planning, monitoring and evaluation, they benefited much from 7EIM in understanding of concepts and minimizing of misconceptions. Moreover, students benefited more from 7EIM alone than CIMS and CI to learn biology concepts. Since the 7EIMMS helped students to conceptually understood concepts better than the other instructional methods, the percentage of misconceptions held by students also reduced among this group followed by students taught with 7EIM alone. However, students in all groups continued to hold some misconceptions in relation to human biology concepts due to the persistent nature of some misconceptions. Gender has no any significant effect on students learning.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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