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ENHANCING NINTH GRADE STUDENTS' UNDERSTANDING OF HUMAN CIRCULATORY SYSTEM CONCEPTS THROUGH CONCEPTUAL CHANGE APPROACH

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Abstract

The present study investigated the effectiveness of combining conceptual change text and discussion web strategies on students' understanding of human circulatory system concepts. The data were obtained from 38 students in the experimental group taught with conceptual change text accompanied with discussion web, and 36 students in the control group taught with traditional instruction. After instruction, data were analyzed with analysis of covariance (ANCOVA) using the Test of Logical Thinking and pretest scores as covariate. The conceptual change instruction, which explicitly dealt with students' misconceptions, produced significantly greater achievement in understanding of human circulatory system concepts. Results also revealed that the students' logical thinking and previous understanding of human circulatory system concepts accounted for significant portion of variation in understanding of human circulatory system concepts.

Keywords: Misconceptions, conceptual change text, discussion web, reasoning ability, human circulatory system

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1. Introduction

Over the past three decades, the interest of researchers has turned to the topic of students' misconceptions in the area of science. This was prompted by evidence that expository text has no power to eliminate misconceptions. To overcome this problem, researchers have developed different text structures such as, refutational text (Alvermann & Hauge, 1989; Diakodoy et al., 2003; Hynd, 2001; Hynd et al., 1997; Palmer, 2003), conceptual change texts (Alkhawaldeh, 2007; Alparslan et al., 2003; Cakir et al., 2002; Chambers & Andre, 1997; Hynd et al., 1997; Mikkila, 2001; Wang & Andre, 1991), and learning cycle text (Musheno & Lawson 1999). Among them conceptual change text has stimulated considerable amount of interest in the area of science education. These studies have reported the effectiveness of conceptual change texts on creating conceptual change and promoting meaningful learning in students regarding many science concepts (Alkhawaldeh, 2010; Cakir et al., 2002; Chambers & Andre, 1997; Hynd et al., 1994; Karaman, 2011; Mikkila, 2001; Sungur et al., 2001; Tekkaya, 2003; Wang & Andre, 1991; Yenilmez & Tekkaya, 2006).

Theoretical models describing learning as an active process in which learners become aware of and reason about conceptual relations, or as a process of conceptual refinement, has been called conceptual change. Starting from their own common sense ideas, learners go through a process of conceptual change by refining their own intuitions about the physical world through organizing, recognizing, or replacing existing conceptual relations. Conceptual change theory, based on Piagets' notions of assimilation, accommodation, and disequilibrium, focuses on the conditions where students' existing conceptions are modified by new conceptions. The conceptual change approach proposes two type: assimilation that describe the process where students use existing concepts to deal with new phenomena and accommodation, which describes when students must replace their existing concepts. The conceptual change approach proposes that if students are to change their ideas they must first become dissatisfied with their existing knowledge (dissatisfaction); new concepts must provide a better explanation and be understandable (intelligible); these concepts must appear to propose solutions to problems and must be in accordance with knowledge in other ideas and believable (plausible); and they must lead to new insights and have potential for new discoveries (fruitful) (Posner et al., 1982). One of the conceptual change instructional strategies is the use of conceptual change texts. In these texts, the identified misconceptions of the students are given first and then students are informed of the scientific explanation supported by examples to create dissatisfaction.

It is also reported that the more pronounced effects have been obtained when text was combined with some types of supportive activity such as small group discussions after reading the texts (Guzzeetti, 2000). A discussion web is found to be an appropriate way to structure discussion and an effective way of altering students' misconceptions (Alvermann, 1991; Guzzeetti, 2000; Yenilmez & Tekkaya, 2006). It uses a graphic aid in which a central question or statement is put in the center; students are asked to choose apposition, agree or disagree, and list their reasons for their positions on lines present on either side of the question. Students should support their ideas by evidence, such as statements from different kind of documents. Students are directed to reach consensus on their positions by discussing in small groups. At the end, whole class is involved in the discussion to reach consensus. By this way misunderstanding or misreading of conceptual change text is prevented. It also provided opportunities for students to consider evidence that contradict their personal theories and thus lead to conceptual change (Alvermann, 1991; Yenilmez & Tekkaya, 2006). Alvermann (1991) stated that the discussion web gives all students the opportunity to involve in discussion and voice their opinion. In discussion web, students think individually about the ideas they want to contribute to the discussion and then discuss these ideas with others.

2. Problem Statement

In this study effectiveness of conceptual change text accompanied by discussion web on ninth-grade student' understanding of the human circulatory system concepts was investigated. This topic was chosen due to its curricular significance. It is a core concept in the biology curriculum, and judged to be difficult topic to learn. Less attention, however, has been given to developing strategies to eliminate these difficulties, to remediate misconceptions, and to improve human circulatory system instruction in biology classes. The main question investigated by this study is whether there are significant differences among the effects of conceptual change instruction, and traditional instruction on 9th grade students' understanding of the human circulatory system concepts when human circulatory system concepts pre-test scores and TOLT scores are controlled as covariates.

3. Research Questions

1) What conceptions related to the human circulatory system do ninth-grade students' hold?
2) What is the effect of conceptual change strategy on ninth-grade students' understanding of the human circulatory system concepts?

4. Purpose of the Study:

This study was conducted to investigate the effectiveness of combining conceptual change text and discussion web strategies on ninth-grade students' understanding of the human circulatory system concepts.

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5. Research Methods

5.1. Sample

Participants in this study included 74 ninth-grade students' from two classes of a basic school located in an urban area. Both classes were taught by the same biology teacher and both received identical syllabus- prescribed learning content. One of the classes (n =38) was randomly assigned as the experimental group and the other class (n = 36) as the control group. The students' were typical ninth graders, with a mean age of 14 years. The socioeconomic status (SES) of the students in both groups was similar, with the majority of the students coming from middle-to high- class families.

5.2. Instruments

5.2.1. Human Circulatory System Concepts Test (HCSCT)

Students' understanding of the human circulatory system concepts was measured using a 14-item multiple choice test was developed by Alkhawaldeh (2007). Each item of the test had one correct answer and three distracters which reflected students' misconceptions related to the human circulatory system.

The validity of the test was established through a panel of judges, consisting of five specialist in biology and science education. The classroom teacher also analyzed the relatedness of the test item to the instructional objectives The reliability coefficient computed by Cronbach alpha estimates of internal consistency was found to be 0.76. HCSCT was administered to both experimental and control groups as a pre-test and post-test.

5.2.2. The Test of Logical Thinking (TOLT)

The test was originally developed by Tobin & Capie (1981), to determine the formal operational reasoning modes. The test was translated and adapted into Arabic

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by Abu Ruman (1991). It consists of 8 items designed to measure controlling variables, proportional, probabilistic, correlational, and combinational reasoning. Students select a response from among five possibilities and then they are provided with five justifications among which they choose from. The correct answer is the correct choice plus the correct justification. The reliability coefficient of the test, computed by KR-20, was found to be 0.66.

5.3. Treatment

The study was carried out in the second semester of the school year 2010-2011. It took two sessions a week for 4 weeks. A total of 74 students from two biology classes was assigned as the experimental group and other as the control group. The experimental group was instructed using conceptual change text accompanied by discussion web. The control group received traditional biology instructions. The topics related to the human circulatory system covered as part of the regular classroom curriculum in biology course. Students in both groups were exposed to the same content for the same duration. Duration of the lessons was two 45-min periods per week.

Students in the control group were taught the unit on the human circulatory system by the teacher upon the basis of a lecture/discussion methods. The teacher explained the facts on the blackboard to illustrate the various concepts of the human circulatory system and described their function. The teacher had designed and photocopied worksheets and information sheets. The teacher defined and described each concept in order in which appeared in the passage. Students read each passage and then the major concepts were written on the board. The teacher described and defined the concepts and after teacher explanation, the concepts were discussed (in small groups), prompted by the teacher-directed questions. The majority of instruction was devoted to instruction and engaging in discussions stemming from the teacher's explanation and questions. In the control group teaching strategies relied on teacher explanation, textbooks and worksheet study within a discussion environment with no consideration of the students' misconceptions. But in the experimental group, teaching strategies relied on teacher explanation, questions, and discussion of conceptual change texts with students, taking into account the students' misconceptions.

Students in the experimental group worked with conceptual change texts and discussion web. Conceptual change texts were prepared by the researcher by using information obtained from related literature. Conceptual change texts were written concerning the following topics: blood, heart, blood vessels, and homeostasis. In each of the texts, students were introduced with questions and their possible answers that my include misconceptions held by the students. Each possible answer was then discussed in the texts. In this way students were expected to be dissatisfied with their current conception. Then scientifically accepted explanations that are more plausible and intelligible were described. Also, example and figures were included in the texts for further helping students understand the scientific concept and realize the limitations of their own ideas.

For example, in the conceptual change text related to blood vessels, students were informed of the fact that the middle and outer layer in the arteries have thick walls with large quantities of elastic fibers and were asked to explain what might be the function of arteries related to elasticity. Then, the misconception that thick and elastic walls of arteries help maintain high blood pressure was presented in the conceptual change text as a belief that some students have. Next, the text explained why this belief is incorrect by making an analogy with a balloon filled water (Vander et al., 1994). It was reminded in the text that pressure inside a balloon depends on the

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volume of water filling it and the stretch ability of the balloon. If the wall of the balloon is stretchable, then large quantities of water can be added with only small increase in pressure. So, if the arterial wall were not stretchable, the arterial pressure would be higher, which is the case in atherosclerosis ("hardening" of the arteries). Accordingly, arteries do not maintain high blood pressure. Finally, it was explained that elasticity helps blood pressure not to fall to zero during ventricular relaxation: blood remaining in the arteries stretches the elastic walls of arteries, which recoil. In this way, elasticity helps blood flow through tissue. Figures of stretching and recoiling of artery walls during ventricular contraction and relaxation were included in the text to help students visualize the event.

Discussion webs were used to support conceptual change texts. A sample discussion web concerning human circulatory system is given in Figure 1.

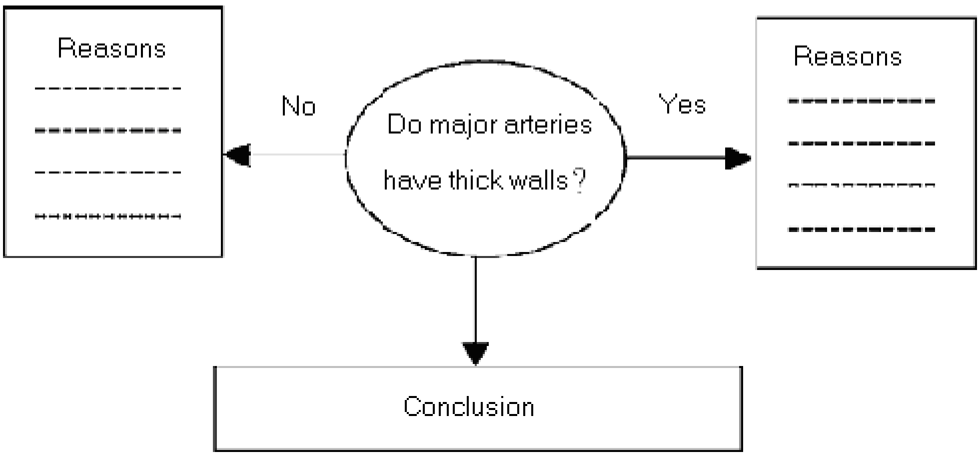

Figure 1. A sample discussion web concerning human circulatory system

For this activity, a graphic aid was constructed which included a central statement placed in the center. This statement reflected the students' misconceptions, which have identified before. Students were required to choose a position, agree or disagree, and their reasons for their positions supported by evidence from the text. Firstly, students worked in groups of two and shared their opinions to reach a consensus. Then, one set of partners was paired with another set of partners. The four students of the new group were asked to compare their reasons for the statement given. When each group of six has reached its conclusion, a speaker for each group was selected by the group members. Each group was given 4 min to discuss which of all the reasons gave best supports the group's conclusion. The speaker then reported their conclusions that they have reached after group discussion. In this way, the whole class was involved in the discussion while reaching a consensus. In addition, the teacher emphasized common misconceptions held by students by asking questions and mentioning the scientifically correct explanations of the concepts.

In order to facilitate the proper use of conceptual change texts and discussion web in the experimental section, the teacher involved in the study was given two 45-minute training sessions prior to beginning the study. Meetings with the teacher were held during the study to ensure that he was conducting the treatments in both groups appropriately. The teacher was contacted several times a week to enable the researcher to answer any questions or to address problem to review the treatment procedures. At least three random visits by the researcher were conducted to each group during the classroom instructional phase, and the researcher confirmed that the lessons were delivered competently.

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5.4. Variables of the study

In this study data were analyzed by using analysis of covariance (ANCOVA). The independent variable was methods of instruction (conceptual change and traditional). Posttest scores served as dependent variable. The scores on pretest and TOLT were used as covariates.

5.5. Design of the study

Quasi-experimental design using a non equivalent control-group was used in this research. Such a design is characterized by the random assignment of classes to groups and the administration of pretest and posttest to each group.

6. Findings

Table 1 presents the results of analysis of covariance (ANCOVA). The scores on pretest and TOLT were used as covariates. The independent variables were treatment, the dependent variable was students understanding measured by posttest scores. The analysis indicated significant effects for the covariates pretest score, $F(1, 73) = 11.277$; $P < 0.05$, and TOLT score, $F(1, 73) = 15.152$, $P < 0.05$. The results also revealed a statistically significant treatment effect $F(1, 73) = 13.71$, $P < 0.05$. The students in the experimental group who were engaged in conceptual-change-text oriented instruction demonstrated better performance over the control group.

Table 1. Summary of ANCOVA Comparing the Mean Posttest Scores of Students in Experimental and Control Groups

Source	df	F	p	η2
Method of instruction	1	13. 71	0.000∗	0.16
TOLT	1	15 152	0.000∗	0.18
Pretest	1	11.277	0.001∗	0.14
Error	70			

∗P < 0.05.

Strength of the relationship between the treatment and the post-test score was strong (η2 = 0.16). The students in the experimental group who were engaged in discussion web and conceptual change text oriented instruction demonstrated better performance (adjusted mean = 7.49) over the control group students who were engaged in traditional instruction (adjusted mean = 6.54).

Many students before treatment failed to develop a scientifically acceptable understanding of the human circulatory system concepts. Average percentages of students in both experimental and control groups selecting the correct responses were evaluated for both pre-post human circulatory system concepts test. The results indicated that while the average percentage of students in the experimental group holding scientifically correct views had risen from 18.78% to 54.86%, again of 36.08%, the percentage of correct responses of the students in the control group had increased from 16.43% to 45.21%, again 28.78% after treatment.

The greatest difference in the performance between the two groups after treatment was observed on the following items. For example, in one item related to the material exchange through capillaries, students were asked to identify what would happen if the blood pressure in capillaries increased above the normal level. Before the treatment, 10.52% of the students in the experimental group and 13.89% of the

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students in control group selected the correct responses, which was "less intercellular fluid would be absorbed into the blood". After the treatment, approximately 55.26% of the students in the experimental group and 25% of the students in the control group selected the correct response. The most prevalent misconception among students 52.78% in the control group was that " if blood pressure in capillaries increased above normal level carbon dioxide would accumulate in cells". The misconception reflected from this item indicated that most of the students, especially in the control group, failed to realize the central role of diffusion as the mechanism of the nutrient, gas, and metabolic end product exchange.

Another item reflecting the striking difference among students in the experimental and control groups was related to the velocity of the blood in the capillaries. In this item students were asked to determined why blood velocity is the lowest in capillaries. Before the treatment, only 7.89% of the students in the experimental group and 5.56% of the students in the control group selected the correct reason that velocity of the blood is lowest in capillaries due to the high cross-sectional area of the capillaries. After the treatment, while the percentage of the students who selected the correct reason in the experimental group increased to 86.84%, the percent of the correct reason in the control group increased to 13.89%. the most prevalent misconception held by 58.33% of the students in the control group was that velocity of the blood is the lowest in capillaries due to the material exchange through capillaries.

Likewise, in an item dealing with students understanding of the heart contraction. In each alternative of this item, students were provided with one statement related to the heart contraction and required to select the correct one. Before the treatment, only 13.16% of the students in the experimental group and 16.67% of the students in the control selected the desired response, which was "oxygen-rich and oxygen-poor blood leaves the heart during the same beat". After treatment, approximately 73.68% of the student in the experimental group and 30.56% of the students in the control group selected the correct response. The most prevalent misconception held by 66.67% of the student in the control group was that "the brain send stimulus to the sinoatrial node (SA) to initiate heart contraction.

Moreover, there was an item examining the students' understanding of the homeostasis in relation to the human circulatory system. In this item students were required to identify why skin takes on a red appearance when environment temperature increased. Before the treatment 18.42% of the students in the experimental group and 16.67% of the students in the control group selected the desired response- that "when environment temperature increase, skin takes on a red appearance because blood flow to capillaries increases. After the treatment approximately 73.68% of the students in the experimental group and 22.22% of the students in the control group selected the desired response. The most common misconception among students in the control group 38.89% on this item was that "when environmental temperature increases skin takes red appearance because blood pressure increases. Another misconception detected in the control group 30.56% was that "when environmental temperature increases, skin takes a red appearance because the diameter of capillaries increases. These results showed that students in the experimental group who were taught with conceptual change text had better acquisition of scientific conception than those in the control group taught by traditional instruction. A list of common misconceptions identified in the study is given in Table 2. many of these misconceptions are typical misconceptions identified by other studies (Alkhawaldeh, 2007; Sunnger et al., 2003; Yip, 1998).

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Table 2. Students' Misconceptions Concerning the Human Circulatory System

1	Fat is not found in plasma.
2	Vitamins are not found in plasma.
3	Uric is not found in plasma.
4	All plasma proteins are used to meet cells' amino acid needs.
5	All plasma proteins help material transport across capillaries.
6	All plasma proteins catalyze reactions in blood.
7	The shape of red blood cells allows them to hold more hemoglobin.
8	The shape of red blood cells allows them to be in close contact with body cells.
9	The shape of red blood cells allows them to pass through capillary walls more easily.
10	The thick and elastic wall of arteries helps maintain high blood pressure.
11	The thick and elastic wall of arteries helps prevent heat loss.
12	The thick and elastic wall of arteries pumps blood under high pressure.
13	When blood pressure in the capillaries increases above normal level, tissues gets fewer nutrients.
14	When blood pressure in the capillaries increases above normal level, carbon dioxide accumulates in cells.
15	When blood pressure in the capillaries increases above normal level, the amount of oxygen diffusing out of capillaries increases.
16	Heart beat is reflex.
17	The brain sends stimulus to the senatorial node to initiate heart contraction.
18	Heart beat occurs when we breathe.
19	Ventricular filling occurs mostly during atrial contraction.
20	Ventricular filling occurs mostly during ventricular ejection.
21	Ventricular filling occurs mostly during contraction of atrioventricular valves.
22	Veins have the lowest blood pressure compared to other blood vessels because veins have the thinnest walls.
23	Veins have the lowest blood pressure compared to other blood vessels because gravity interferes with blood flow.
24	Veins have the lowest blood pressure compared to other blood vessels because blood velocity is the lowest in the veins.

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25	Low blood velocity in capillary is due to their small diameter.
26	Low blood velocity in capillary is due to material exchange through capillaries.
27	Low blood velocity in capillary is due to their long distance from the heart.
28	In the systemic circulation, percent of blood volume in the arteries, and capillaries, and veins is equal.
29	In the systemic circulation, percent of blood volume in the arteries and capillaries is equal, which is greater than that of veins.
30	In systemic circulation, the percent of blood volume in the arteries is the highest, while the blood volume in the veins is the lowest.
31	Contraction of heart is one of the factors that help blood return to the heart.
32	Pressure created by the valves in the veins is one of the factors that help blood return to the heart.
33	Cohesion between blood and blood vessels is one of factors that help blood return to the heart.
34	Blood from the left and right halves of the heart goes to all parts of the body.
35	Blood from one side of the heart goes to the right side of the body. Blood from the other side goes to the left side of the body.
36	Blood goes into the heart on one side. Blood leaves the other side and goes to all pans of the body.
37	When blood reaches the cells, it stays inside blood tubes that go to and from the cells.
38	When blood reaches the cells, it leaves the tubes and bathes the cells.
39	When blood reaches the cells, some of it stays inside blood tubes and some leaves the blood tubes and bathes the cells.
40	When environmental temperature increases, skin tacks a red appearance because the velocity of the blood increases.
41	When environmental temperature increases, skin tacks a red appearance because the diameter of the capillaries increases.
42	When environmental temperature increases, skin tacks a red appearance because blood pressure increases.

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7. Discussion and Conclusions

The present study examined the effectiveness of combining conceptual change text with discussion web on students' understanding of human circulatory system concepts. Before the treatment no significant difference between groups regarding their understanding of the concepts was found. Moreover, administration of the TOLT showed that two groups were similar with respect to reasoning ability. Therefore, pretest and TOLT scores used as covariates in this study served mainly to reduce error variance. In fact, it was found that both covariates had significant effects on understanding of human circulatory system concepts. This result are consistent with previous researchers finding in which reasoning ability and prior knowledge have great influence on students' understanding of science concepts (BouJaude et al., 2004; Doru-Atay & Tekkaya, 2008; Kang et al., 2004; Johnson & Lawson, 1998). For example, BouJaude et al. (2004) reported that formal operational reasoning was the main predictor of performance on conceptual chemistry problems, accounting 18% of the variance.

Findings also indicated that the students taught by conceptual change text and discussion web performed significantly better on a posttest and demonstrated more of a change in their understanding of human circulatory system concepts. Throughout the treatment, the experimental group received instruction using conceptual change texts accompanied by discussion web, while students in the control group received traditional instruction. The difference between the two strategies was that the conceptual change approach explicitly dealt with students' misconceptions, while the traditional approach did not. However, the present study revealed that there were still some misconceptions in both groups after treatment. For example, after instructions, students still through the blood pressure is lowest in veins because blood velocity is lowest in veins. It was strongly probable that the concepts of blood pressure, velocity of blood and factors affecting them were not clear in the minds of students. One possible reason these misconceptions were prevalent among students was that all these concepts are interdisciplinary in nature. Understanding of blood pressure, velocity of blood, and material exchange through capillaries requires the understanding and application of knowledge in physics and chemistry apart from biology (Sungur et al., 2001; Yip, 1998). Also, Arnaudin & Mintzes (1985) claimed that understanding of such concepts places demand on students requiring more conceptual restructuring. However, as they mentioned, teachers and textbook authors give less emphasis to interrelationship among concepts and devote less time to challenging students' misconceptions. They mostly focus on topics related to the circulatory system that require less conceptual restructuring.

These results are supported the idea that misconceptions are strongly held ideas, which are not easily remediated through traditional instructions and are resistant to change even with instruction designed to address them (Arnaudin & Mintzes, 1985; Fisher, 1985; Gilbert et al., 1982; Gunstone et al., 1981; Karaman, 2011; Palmer, 2003; Smith et al., 1993; Vosniadou et al., 2001; Wandersee et al., 1994; Yenilmez & Tekkaya, 2006).

Achievement of students in the experimental groups can be explained as follows: Students in the experimental group were involved in activities that helped them revise their prior knowledge and struggle with their misconceptions. For example, in the conceptual change approach, emphasis was given to students' misconceptions. In order to deal with these misconceptions, students became dissatisfied with their existing conceptions, which let them accept better explanations to the problems that were introduced. In this way, students were allowed to think about their prior knowledge and reflect on it. Actually, the important part of the use of the conceptual change approach used in this study was the social interaction provided by teacher guided discussions. These discussions helped students share their ideas and ponder them in depth. The instruction involved intensive teacher–student interaction. The discussions were also characterized by lively debate among students. The students were willing to participate in these activities as learners. Discussion of the concepts in the texts could facilitate students' understanding as well as encourage their conceptual restructuring. As a result, students became convinced that the scientifically acceptable new conception was more meaningful. Teaching for conceptual change, then, requires a teaching strategy in which students has enough time to identify and express their conceptions, examine the soundness and utility of their existing ideas and apply new ideas in a context familiar to them. In short, this study showed that conceptual change texts accompanied by discussion web led to better acquisition of human circulatory system concepts through differentiation, exchange, and integration of new conceptions into existing ones.

In summary, this study suggests that it is possible to produce a significant change in students' understanding of human circulatory system concepts by using conceptual change approach. Conceptual change texts accompanied by discussion web can provide alternatives to traditional and other alternative methods to remediate students' misconceptions. This strategy not only helps teachers analyze the ideas of their students but also help students acquire a better understanding of science concepts. The findings of the study provide further support for the use of conceptual change text and discussion web in both research and teaching. Findings might be useful for informing classroom practices in the teaching of science concepts and the development of suitable materials promoting students' understanding in science. Furthermore, teachers' awareness of students' misconceptions could itself contribute to the improvement of their teaching. The present study provided further evidence to support the findings in a growing body of literature indicating that students hold misconceptions concerning human circulatory system and support the notion that it is not easy to eliminate misconceptions at least by employing traditional instructional methods. What remains unknown in this study is whether the strategy employed produced long-term retention It is hoped that this investigation will serve as a motivating force for further interest and research in the area of effectiveness of conceptual change approach on students' understanding of science concepts.

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