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RADICAL CONCEPTUAL CHANGE THROUGH TEACHING METHOD BASED ON CONSTRUCTIVISM THEORY FOR EIGHT GRADE JORDANIAN STUDENTS

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Abstract

The purpose of this study is to investigate the effect of a constructivist-based teaching method to bring about radical conceptual change regarding light misconceptions held by primary eighth graders in Jordan. The randomly selected sample (N=79) consisted of students in Irbid city-Jordan, were assigned to constructivist (N=42) and conventional (N=37) teaching methods. Two instruments, which were a multiple-choice conceptual test covering only light misconceptions commonly held by eighth grade primary students and an inventory classifying participants based on student's levels of learning process were developed. Data was statistically treated based on SPSS software package. The results showed that the constructivist teaching method surpassed the conventional method in bringing about radical conceptual change regarding light misconceptions held by students. However, results also showed that meaningful learners outperformed in-between and rote learners on the radical conceptual change for the same misconceptions, with rote learners being the lowest rank. In earlier results, the study recommended curriculum developers take student's perceptions and misconceptions into account. Teachers are called to make plans for science lessons based on the constructivist approach, and are encouraged to attend workshops on continual basis that provide training on employing teaching methods that have to do with conceptual change from the perspective of the social and cognitive constructivism.

Key Words: Conceptual Change, Radical Conceptual Change, Teaching Method, Constructivism Theory.

Introduction

It is emphasized by Okebokola (1995) that the major concern of science education is to help students acquire accurate and meaningful science concepts, in a way to allow learners identify commonalities, major and minor characteristics of a concept. Parallel to this, Nuffield Foundation stressed on acquiring science concepts whether with direct or indirect experiences (Abdussalam, 2001). Whereas, Rutherford (1990) noted that clarity is necessary for understanding scientific concepts and terms that creates mutual understanding and scientific communication.

There are many reasons why teaching scientific concepts are vital for science learners. Most importantly are those scientific concepts underlying the larger scientific knowledge, and helps to conceptualize the structure of science and its' development (Qatami, 1989; Zaitoun, 1999). Furthermore, concepts are recognized as the basic building units in creating principles, generalizations and scientific theory that integrate voluminous facts (Aani, 1996; Khalili et al, 1996). Whereas many educators describe scientific concepts as the hub of science teaching-learning processes (Wandersee, Mintezes and Novak, 1994).

To summarize, Bruner (1966) highlighted the importance of learning scientific concepts arguing:

- Lessen environment complexity in that they summarize and classify objects and situations in the environment.

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- Harness means to identify objects in the environment.
- Reduce the need for relearning every time a new situation encountered.
- Help guide, predict, and plan for an activity.
- Allow organizing and linking groups of objects and events.

Misconceptions

Scientific conceptions are paramount in one's cognitive construct. Many studies demonstrated that students come to school with their own preconceptions. Bruner (1966), for example argues that every one even a child has his own view and explanation of the world around him. Jarvis and Pell (2005) confirmed that such conceptions and ideas in many cases have caused conflict to the common scientific knowledge as held by scientists to explain the observed phenomena. The worst is when such problem gets complicated and digs very deep in one's cognitive construct and becomes change resistant hinders learning, and frustrates acquisition of a proper scientific concept.

Misconceptions are well-known and intensively studied by educators, particularly researchers in science education field. As an educational phenomenon, misconceptions have been described by guru educators and psychologist such as Bruner, Ausabel, Novak, Tyler and others. This phenomenon had been seriously studied as early as 1930 (Ennenbach, 1983). The proposition that misconceptions predominantly held by students of different ages has become taken for granted (Gill – pers & carrascosa, 1990 ; Zoller, 1991).

Misunderstood basic concepts embedded in scholastic textbooks would be due to various factors. Pfundt and Duit (1991) argue that in basic sciences such as physics, for instance, typically learners would have in mind preliminary mental image of the phenomena to be studied from a physics perspective. This preliminary mental image, normally designated as a misconception, in a way will impact on the learner's complete understanding of physics concepts.

Reviewing such physical concepts, one would find that many concepts were developed as a result of an accumulation of a number of learner's observations experienced in his daily life. Consequently, a learner would compose personal mental image to explain a phenomena. To be exact, many learners who watch a movie in which a person that is shot by a gun would fall back and even destroy things behind. This preconception (observation), of course, contradicts with reality and physics laws. If the bullet had a mass of (0.04 kg), and velocity (300 m/s), then the body mass that fallen back when shot by the bullet shall be less than (1kg). In fact, an average person's mass will surely be heavier, so the movie scene introduces a perception that conflicts with the proper physical knowledge which helps viewer (learner) compose inaccurate mental images.

Hammer (2000) reported unanimous agreement among researchers in physics education that new knowledge created by learner is primarily built on their prior knowledge. Along such lines, Minstrell (1989), for example, described misconception of Newton's passive force because learners would find it difficult to imagine impacting a book on table by a force equaling its' impact on the table. Sometimes, such misconception may develop and taken for granted by learner and imagining that the action and reaction will make an object under two counterbalanced forces, meaning that the book will move by effect of even a blow of air.

The knowledge that is inaccurately acquired will make subsequent learning also inaccurate, and the sequence of mistakes will continue and distort one's thinking, that his conclusions and judgmental opinions regarding various other phenomena, will also be inaccurate. Knowing that we will be able to realize how risky is to have misconceptions entrenched in students along their school years without being rectified, as the problem will not only limit to their future studies but also might remain intergenerational problem (Ennenbach, 1983). In this context, Lawrence (1986) stressed that misconceptions are not only made by students, they are also made by others including science teachers.

Clerk & Rutherford (2000) believe that misconceptions develop when one's mental system differs from the realistic state of such system. However, Ivowi & Oludotun (1987) investigated the reasons why physics misconceptions develop. The last two researchers concluded three major reasons underlie physics misconceptions: textbook, student's environment that lacks device, instruments, and educational games that have much to do with developing accurate scientific concepts, and finally teachers who let the students carried their own misconceptions and as classroom teachers, they are not putting any effort to adjust the students' mindset.

The educational literature is replete with many and varied designations that describe the same phenomenon in which one conceptualizes something contrary to the prevalent knowledge among the scientific community. In addition to commonly used designations as misconceptions, there are many designations that differ by philosophical approach of theorists who used them including preconceptions, naïve conceptions, alternative concepts, mistakes, or misleading ideas (Baz and Bawaneh, 2008).

How to Identify and Recognize Scientific Misconceptions?

Studies indicate that there are many methods and strategies to detect misconceptions including concept maps (Novak, 1991), questioning and interpretation (Stover & Saunders, 2000), student writings and noticing changes that have taken place to their cognitive structures within a time span (Fellws, 1994), face-to-face open-ended interviewing (Straver & Saunders, 2000), multiple-choice questions followed by asking students whether they were sure of their answers by ticking a scale or encircling a number on scale to indicate a certainty degree (Hasan et al, 1999).

Conventional Teaching Method versus Conceptual Change Methods

Results from many studies confirmed the observation for entry-level students come to college with their physics misconceptions that could not be removed by conventional teaching methods (Bunge et al, 1995). Knowing how difficult it is to change misconceptions by conventional teaching methods; new teaching methods that enhance higher mental skills in students become important (Zoller, 1991). As a result of growing interest in learner-centered approach, and learning-teaching process itself, many related theories have emerged that can be categorized into two groups; *first* includes approaches that were focused on learner's superficial behavior know as the *behavioral theory*. *Secondly*, the *constructivist/cognitive theory* those investigates the mental processes taking place in learner such as idea generation, structure, and develop. Such notions are well-documented by many of educational studies. Writings by Ausuble recognized as the corner stone in the constructivism (Hany and McArthur, 2002). Ritchie and Cook (1994) described constructivism as an epistemology that is focused on a learner's role in building his own knowledge viewing learning as a process of adaptation whereby learner would tune finely in existed knowledge with newly learned experiences as a result of individual's vigor interaction with others. Mustafa (2004) argued that a constructivist classroom is characterized by being a learning environment in which learner is encouraged to take responsibility on his own learning by assuming the role of discoverer in an attempt to give meaning to experiences to which he is exposed and link them with previous knowledge.

The cope with the paramount problem of how to modify misconceptions held by students throughout their education years from school through college (Lewis and Linn, 2003; Physics Education Group, 2000), various models and strategies have been suggest. Examples including Novak & Nussbaum's strategy that is based on cognitive conflict; Champagne, Gunstone, and Klopfer's strategy that is based on pictorial confrontation. There are many other strategies that depend on dialogue, discussion, and illustrations (Zaitoun, 2004). The most significant strategy is proposed by Posner & Colleagues (1982) which summarizes conceptual change conditions in the following:

1. **Dissatisfaction**: refers to student dissatisfaction as to his own "concept system" (misconceptions) that failed to explain a phenomenon faced.
2. **Intelligibility**: Develop new concept that is principally apprehensible and credible.
3. **Plausibility**: describes how plausible is the new concept to fit into the previously existing knowledge network and instrumentality to overcome dilemmas failed by the older concept.
4. **Fruitfulness:** Fertility of the new concept and ability to open new horizons of inquiry.

A study of Posner & Colleague's (1982) four conditions shows that they are sufficiently elastic to make the targeted conceptual change, because they did not specify certain roles for teacher or learner, or stress on certain teaching method. Having this in mind, researchers were motivated to use Posner & Colleague's

(1982) model to develop constructivist teaching methods to facilitate knowledge restructuring, bringing about conceptual change, and assigning specific roles for teachers and learners (Baz and Bawaneh, 2008). Along the same line, Abdussalam (2005) suggested a conceptual change model that takes into account the conditions proposed in Posner's model (Posner et al (1982)). Abdussalam (2005) described his model as a set of learning-teaching procedures and systematically and sequentially steps were performed by teacher and students in which students hold an active role in building their own knowledge about concepts, events and natural phenomena.

Steps of Constructivist Teaching Model proposed for radical conceptual change (Large-scale conceptual change)

Abdussalam (2005) developed his model in light of constructivist theorization of a radical or revolutionary conceptual change (large-scale conceptual change). The six key stages include minor teaching-learning steps as follows:

First phase: *Student awareness of their preconceptions based on their personal experience, including:*

1. Identify misconceptions were held by students regarding each concept, event or scientific phenomenon by analyzing results from the pre-test.
2. Formulating questions and problems associated with concepts and scientific phenomena for each class (questions could be closed, open-ended, or selected out of pre-test questions).
3. Allowing students the opportunity for closed or open discussion in small cooperative groups in order to raise their pre-understanding, express preconceptions, ideas, and beliefs, thus identify their explanations about scientific phenomena or concepts, and to draw out their misconceptions during discussion, and having them to focus, thereby students become aware of their own preconceptions.

Second phase: *Imbalance and Conflicts****:*** The teacher demonstrates and explains concepts, events, and scientific phenomenon, and clarifies interrelationships thereby students will feel dissatisfied about their preconceptions Dissatisfaction (D).

Third phase*: Experimentation and Activity****:*** The new concept will be clear and intelligible when students use devices and materials and make practical experiments that encourage observing, verifying varied scientific phenomena, clarifying acceptable scientific understanding in addition to questioning, discussions, activities and experimentation so that the new concept becomes clear and intelligible (I).

Fourth phase: *Resolving conflicts and accommodating the new concept:* Students work towards resolving conflicts between concepts they hold (preconceptions held and classroom discussion) and observations, ask questions, discuss results from activities and practical experiments that help building their new scientific concept, leading their discussions and guiding them to make comparisons between their preconceptions or misconceptions with the new scientific concept in order to create accommodation with the new concept which enhances the acceptable scientific perception as credible and plausible (P).

Fifth phase: *Extend new learning concept:* The teacher would ask students to give examples about different phenomena and problems from their own environment that help them apply the new scientific concepts, make generalizations, and link the concept to be learned in classroom with other life situations, transfer their learning to other situations, and explain natural events and phenomena as such extend fruitfulness of the acceptable new concepts Fruitful (F).

Sixth phase: *Metaconcept or metacognition*: Raising new questions about the concept to encourage students to go beyond the concept and immediate experience by questioning and presenting extra problems that associate with other new scientific phenomena and concepts, day-to-day life, problems solving, and self-questioning so that they become aware to the proper scientific concepts, the knowledge they learned, and become able to evaluate such learning, and build concepts, relations, inferences and generalizations.

Meaningful & Rote Learning

Meaningful learning confirms the individual's ability to draw out new learning, and apply it in other situations; otherwise rote learning will result as when facts are forcibly crammed into one's cognitive construct, although, new facts are retrievable, they could not be applied to solve new problems (Okebakola, 1990).

Ausubel (1978) argued that an individual's conceptual constructs are the prime factor governing whether or not new facts to be learned are meaningful to learner, will be acquired or retained. In consequence, conceptual constructs already held by students that have to do with the new facts shall be well-established and intelligible. In this context, Ausuble states "should I summarize educational psychology in one principle it should be: the significant factor influencing learning is individual's preconceptions, so check it and teach accordingly". However, meaningful learning is best described as "process by which new facts are linked with cognitions already held by individual i.e. one's conceptual construct".

Meaningful learning is more effective and lasts longer because of the links, connections, and integration in the learning process in comparison with rote learning (Novak & Gowin, 1984; Novak, 1991; She, 2005). The meaningful learning facts are stored in the long-term memory and thus linked and integrated with the previous knowledge (Novak, 1991).

On the other hand, many research studies (Van Rossum & Schenk, 1984 ; Watkins, 1983) explicitly demonstrate that students who are shallow in their knowledge unexpectedly to produce quality learning outcomes. Similarly, Watkins, Reghi & Astilla (1991) emphasize those students who profoundly acquire textbook content link new knowledge with their previous knowledge structure and tend to be more academically successful.

Prior Studies

Proponents of conceptual change theory have been the first to identifying the effect of their conditions on the conceptual change and correct concept acquisition by the learners. Posner et al (1982), for example, analyzed a number of clinical interviews conducted with students on relativism in physics. Analysis results showed that students who followed conceptual change procedures were those who could correct their concepts and give up misconceptions.

However, Omleh (1996) conducted a study aimed in identifying the effect of using the conceptual change model in replacing naïve concepts among eighth grade students, and to identify which of the two groups of students (high achievers versus low achievers) is the most effective in conceptual change. Results showed statistically significant differences between experimental and control groups in favor of the experimental group; and that the conceptual change strategy was more effective with high achievers.

She (2004) investigated effect of the Dual-Situated Learning Model (DSLM) on the accelerated radical conceptual change of alternative concepts in students. The model sought to identify students' beliefs and forethoughts about the nature of scientific concepts. The researcher addressed heat convection, heat conduction, processes and gradual changes. Results showed that DSLM model was very effective in the radical conceptual change process for learning heat transfer.

Jaber (2004) aimed in identifying the effects of computer-based instruction in comparison with traditional method. Both teaching methods were designed based on the conceptual change model and focused on eighth grade light subject in Jordan. Results found improvements in both groups' performance in the conceptual change though no statistically significant differences were found in mean conceptual change attributed to teaching method.

Baz and Bawaneh (2008) supported the positive effects of conflict maps as a teaching methods based on the constructivist approach to bring about conceptual change in electric energy and mechanic waves among eighth grade students in Jordan.

Bawaneh, Ahmad Nurulazam, & Munirah (2010) stressed the effectiveness of such teaching methods as V-Shape and Conflict Maps that are based on the constructivist approach on electric energy conceptual change among Jordanian eighth grade students, though results were not conclusive regarding which of the two methods were superior for the conceptual change.

Despite perceived success of the conceptual change theory, some studies might be partially inconsistent with the general context of prior studies (Hsieh, 1996). It is indicated that conceptual change strategies are not completely effective in helping student's acquisition of accurate scientific concepts. Parallel to this, no statistical significant differences were found in Perals & Nievas (1995) study conducted in Spain favoring conceptual change strategy. This study included two groups: control taught optics concepts traditionally and experimental taught same concepts with the constructivist method based on the conceptual change strategy. The findings showed statistically significant improvement for the four groups' performance on the post-test; whereas no statistical significant improvement for the experimental over control groups in conceptual change rate attributed to teaching method. Chin and Malhotra (2002) demonstrated that teaching methods that are based on oriented observation and explanation were effective in bringing about conceptual change more than the conceptual change strategy.

Statement of the Problem

Research studies that take teaching-learning theories into focus seek to cast light on best methods for learner to acquire knowledge. Despite the pivotal role of scientific concepts in science teaching (Rutherford, 1990; Wandersee, Mintez, and Novak, 1994; Zaitoun, 2002), many studies (Bawaneh, Ahmad Nurulazam, & Munirah, 2010; Baz and Bawaneh, 2008 ; Afra, Osta and Zoubeir, 2007; Cepni, and Keles, 2006 ; Demirci and Cirkinoglu, 2004 ; Masad et al, 2002) reported a significant problem caused by the fact of entry-level students come to school with many misconception in mind. The findings that received also supported the American Association for the Advancement of Science (AAAS, 1989), and the National Research Council (NRC, 1996). Jordan is not an exception as publications by Jordan Ministry of Education explicitly report prevalence of misconceptions among Jordanian students (Al-Masad et al, 2002) and results from many studies reached a similar conclusion (Bawaneh, Ahmad Nurulazam, & Munirah, 2010 ; Baz & bawaneh, 2008 ; Jaber, 2004 ; Shorman, 2002).

Results from the Third International Study on Mathematics and Science that was conducted several years (1994/1995; 1998/1999; and 2002/2003) on primary eighth grade students in many world countries including Jordan revealed widespread of science misconceptions, basically physics concepts among students.

In comparison with developed countries in which science education, primarily physics education, receives tremendous attention, developing countries shall pay greater attention to science education in order to create learners to be able to understand physics properly and accurately.

On that ground, the problems encounter by this study, rest on the widespread of misconceptions, particularly the minor ones, among the students.

Significance of the Study

The main purpose of the present study is to investigate the effect of a proposed instructional model based on the constructivist approach in conceptual change among primary eighth grade students as to "light". The significance of studying this issue is multifaceted as results from this study would assist conceptual change in students and acquisition of accurate scientific concepts which is a basic goal of science education (Rutherford, 1990 ; Lewis and Linn, 2003), alerting teachers to pay greater attention to misconceptions held by primary eighth graders when teaching Light Unit so that to rectify such mistakes using the proposed constructivist instructional model. The study further intends to assist curriculum developers take advantage from the proposed constructivist instructional model when design their curricula, textbooks, and teacher manuals to improve the teaching learning process in various schools levels. Specifically, this study seeks to answer the following questions:

Question One: Would students taught via constructivism teaching method perform better than students taught via conventional teaching method in radical conceptual change in some concepts of "light"?

Question Two: Does the radical conceptual change in some concepts of "light" for eighth grade students differ among students' level of learning process?

Study Objectives

This study mainly seeks to investigate effect of a proposed constructivist instructional model on light conceptual change among primary eighth grade students in comparison with conventional teaching method. Specifically, this study amid to:

1. Identify the steps of the proposed constructivist instructional model to bring about light conceptual change among primary eighth grade students in science subject.
2. Test the proposed constructivist instructional model and identify its rectifying effect of light misconceptions among primary eighth grade students in comparison with the conventional teaching method.
3. Investigate the effects of students' level learning process (meaningful learners, in-between learners, and rote learners) on light conceptual change among primary eighth grade students.

Operational Definitions

1. *Misconceptions*: Conceptions commonly held by students regarding light that are inaccurate, mistaken, confused, and conflict whether partially or wholly with the acceptable scientific knowledge by science educators regarding 'light"
2. *Proposed Teaching Model based on constructivist conceptual change*: A set of teaching-learning procedures and steps systematically and sequentially performed by teacher and students in which student takes an active and effective role in building their own knowledge on light that considers conceptual change conditions as suggested by Posner et al. (1982) (Abdussalalm, 2005).
3. *Conceptual Change*: A process within which learner gives up misconceptions that are inconsistent with the acceptable knowledge within the scientific community, adopting concepts that are more scientifically. This conceptual change is measured in this study by the difference between student achievements on conceptual pre-test and post-test scientifically designed to meet study objectives.
4. *Students' level of learning process*: Refers to cognitive skills level employed by student on learning measured by Inventory of Learning Process scale developed by She (2005). It is originally designed based on Bloom's cognitive taxonomy (1956). In this study, the same cut-offs as used by She (2005) will be used to classify students based on their level of learning process.

Method and Procedures

Population & Sample*:* The population consisted of the entire boy schools that include primary eighth grade level within Irbid First Directorate of Education during the first semester of the academic year 2009/2010. Four school buildings were randomly selected to serve as the study sample. The sample schools were randomly assigned teaching methods (proposed constructivist teaching model, conventional method) one teaching method for two schools. The next Table (1) shows some sample of school names, student numbers, and teaching method in each school.

Table 1: Participants by sample schools and respective teaching method

Teaching Method	School name	Students number
Proposed constructivist model	Koferjayez Comprehensive Boys' Secondary School	22
	Ala'al Comprehensive Boys' Secondary School	20
Conventional Method	Maro Boys' Basically School	17
	Byat Rass Comprehensive Boys' Secondary School	20

Teachers with approximately the same educational level and teaching experience in the same primary eighth grade level were chosen to teaching one classroom in their respective schools. Teachers received training on how to teach with the constructivist teaching model within two sessions, one hour long for each session. Teachers in the randomly selected schools served as the experimental group.

Study Design: This quasi-experimental factorial 2 x 3 (Complete Random Design: CRD) study included two groups; the experimental group is taught using the proposed constructivist teaching model, and the control group taught via conventional teaching method. Both groups were assigned a pre-test and later assigned a post-test.

Variables: This study addresses the following variables:

1. *Independent variable*: represented by the teaching method with two levels:

   a. Proposed teaching model based on constructivist approach.

   b. Conventional method

2. *Moderator variable*: represented by students' level of learning process (meaningful learners, in-between learners, and rote learners)

3. *Dependent variable*: represented by conceptual change taking place in primary 8^{th} grade students regarding light concepts.

Instrumentation

1. Conceptual Test: Prior building the conceptual test, the researcher conducted face-to-face interviews with a randomly selected sample from the study population in order to inquire light misconceptions commonly held by students within limitation of concepts presented in the Eighth Science Textbook during the academic year 2009/2010. Major misconceptions identified in the sample students were:

1. Lack understanding of real and unreal images.
2. Properties of an image remain unchanged so long as an object's distance from lens (mirror) was constant irrespective to the focal length of lens (mirror).
3. The image constitute on surface of a convex or plane mirror (because have unreal images) not behind.
4. The function of a wall is forming an image, meaning no image will be found without a wall.
5. If there was an image on wall and wanted a bigger image, we should place the wall farther behind.
6. Properties of images in convex lenses are much like those in concave lenses, because reflection and refraction of light are similar.
7. When there is an enlarged image, the lens or mirror does is to increase light quantity.
8. Lack of understanding on reflection or refraction of light takes place at the incidence point on lens or mirror (light reflection or refraction happens at optional points).
9. Lack of understanding on real images form when reflection or refraction rays meet together, whereas unreal images form when reflection or refraction extension rays meet together.

- Based on the common surveyed misconceptions, the conceptual text was developed for purpose of exploring the conceptual change taking place in students. The final version of the test was a multiple-choice nine-item scale measuring misconception commonly held by students with four alternatives among which only one is the correct answer. Test development process can be summarized in the following:

- Misconceptions were surveyed through interviews conducted by one researcher on light in Jaber (2004) study. The selection criterion adopted was that only misconceptions related to concepts found in Primary Eighth Science Textbooks in Jordan during the academic year 2009/2010 will be included. The items of the conceptual change measuring alternative light concepts commonly held by Jordanian eighth grade students were developed.
- Validation was secured by having the conceptual test reviewed by a panel of five experts including a teacher, educational supervisor and faculty members in some Jordanian Universities, and they suggested feedback comments and some test items were modified accordingly.
- To verify reliability, the conceptual text was administered to a pilot sample comprising of 43-students from the ninth grade level that previously exposed to light subjects one year earlier. Reliability coefficient (0.84) was tested using Chronbach alpha formula and found suitable for study purposes (Audeh, 1993). Students response on the conceptual change pre-test and post-test were scored by giving one mark for each item, and then scores were aggregated, tabulated and inputted to computer for statistical treatment using the Statistical Package for Social Sciences (SPSS).

2. Inventory of Learning Process; ILP: Depending on She (2005), a classification instrument was developed to classify students by their level of learning process that fit the Jordanian environment. She's instrument (r = 0.88) classified students into three levels (meaningful learners, in-between learners, and rote learners). The following procedures describe instrument development process:

- Through email message, She's (2005) instrument was requested. She gratefully sent the English version of her 32-item scale.
- Three professors of Science Education Methods and Educational Psychology in Jordan Universities who are graduates from English-speaking countries (USA and Britain) separately translated the questionnaire into Arabic.
- One of the researchers – an Arabic researcher - then compared and contrasted such translation versions and initial items were formulated.
- Questionnaire validity was secured by showing the instrument to five experts from faculty members holding Ph.D. in Psychology and Teaching Methods. Some of the items were reformulated in accordance with their suggestions and opinions.
- Reliability (0.83) was computed using Chronbach alpha by having the questionnaire administered to two classrooms of 41-students of original population in the eighth grade level. Depending on Odeh, (1993), this reliability coefficient was considered as suitable for the questionnaire to be used.

Measuring Students' Learning Level by the Instrument: Though modified and developed items to fit Jordan environment, the questionnaire included 32-items of truth/false question for the students to answer them all. This questionnaire was originally designed based on guidelines of Bloom's Taxonomy (1956) as highlighted by She (2005) and Schmeck et al (1977) (cited in She 2005). In order for students to score high on this questionnaire, higher cognitive skills should be employed in learning. She (2005) classified students based on their scores obtained in responding to all questionnaire items. Based on this scale, students were categorized as meaningful learners (22 or above), in-between learners (11-21), and rote learners (10 or below). In this study, students will be categorized after She (2005) as described earlier, where student score represents the aggregate "T" responses to the developed questionnaire items (ILP).

Instructional Content: The light Chapter, the first of the fourth unit of Primary Eighth Science Textbook during the academic year 2009/2010 is selected in this study. The researchers designed seven Instructional Booklets for all lessons in accordance with the constructivism-based proposed model, whereas no instructions were presented conventional group teachers. Teachers taught the instructional content to both groups for three weeks in four classes a week, thus the total is 12-classes. To follow-up, regular classroom visits were made to groups in their respective schools as well as phone calls.

Statistical Treatment: The Means and The standard deviations were computed in order to test the mean differences. T-test, ANCOVA and post hoc analysis were applied with a significance level of ($\alpha = 0.05$).

Results

First: Testing the two groups' equivalence on the conceptual pre-test: Table (2) shows the means and standard deviations for the student performances on the conceptual pre-test in the groups under study. The comparison between the estimated mean of subjects' performances reveals a computational difference (0.2303) in favour of the constructivist group.

Table 2: Means, standard deviations of the study groups on the conceptual pre-test

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pretest	Constructivism	42	2.0952	1.22593	.18917
	Conventional	37	1.8649	.78748	.12946

To ascertain whether this difference was statistically significant, a T-test was conducted, as shown in Table (3).

Table 3: T-test results of independent data comparing the estimated mean of the study groups on the conceptual pre-test

Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
.331	.23037	.23542	-.23840	-.69915
	.23037	.22922	-.22672	-.68746

Table (3) demonstrates that the mean difference between the study groups was insignificant, implying that both groups were equivalent. The results show a low performance of both groups on the pre-test. The mean of the constructivism group performance was 2.0952 out of nine, and the mean of the conventional group performance was 1.8649 out of nine also. And this confirms the prevalence of misconceptions among students in the study sample.

***Second*:** To answer the first question of the study which related to the independent variable (teaching method including the constructivism method and conventional method), means and standard deviations were calculated for students' scores in the conceptual test on the subject "light" according to the different teaching method (Table (4)).

Table 4:. Means and standard deviations for students' scores based on teaching method.

group	Mean	Std. Deviation	N
Constructivism	6.6905	1.40536	42
conventional	4.5676	1.19118	37
Total	5.6962	1.68214	79

Table (4) shows that there are differences between the means for students' scores according to the different teaching methods. In order to verify that these differences are significant, ANCOVA test has been conducted (Table (5)) due to the equivalence of groups and using the pre-test scores as covariate.

Table 5: ANCOVA test for the differences between means of students' scores on conceptual test based on different teaching methods.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	107.784[a]	2	53.892	36.270	.000
Intercept	369.223	1	369.223	248.493	.000
Pretest	19.133	1	19.133	12.877	.001
group	78.725	1	78.725	52.983	.000
Error	112.924	76	1.486		
Total	2784.000	79			
Corrected Total	220.709	78			

a. R Squared = .488 (Adjusted R Squared = .475).

The results indicate that there is a statistically significant difference at the significance level ($\alpha = 0.05$) between the means for students' scores on the subject of "light" due to the teaching methods in favor of the proposed constructivism method. The mean of the students' scores is (6,690) as opposed to the conventional method which the mean of students scores is (4.567) with a difference between the two means (2.123).

To answer the second question of the study which is related to the moderator variable (students' levels of learning process: Meaningful learners, In-between learners and Rote learners), means and standard deviations were calculated for students score in the conceptual test on the subject "light" according to the different students' levels of learning process (Table (6)).

Table 6: Means and standard deviations for students' scores based on students' levels of learning process.

levels	Mean	Std. Deviation	N
Rote	3.5294	.94324	17
In-between	5.3529	.48507	34
Meaningful	7.4286	1.06904	28
Total	5.6962	1.68214	79

Table (6) shows that there are differences between the means for students' scores according to the students' levels of their learning process. In order to verify that these differences are significant, ANCOVA test has been conducted (Table (7)) because of the equivalence of groups and using the pre-test scores as covariate.

Table 7: ANCOVA test for the differences between means of students' scores on conceptual test due to students' levels of learning process.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	172.565[a]	3	57.522	89.609	.000
Intercept	373.657	1	373.657	582.096	.000
Pretest	4.713	1	4.713	7.343	.008
levels	143.505	2	71.753	111.779	.000
Error	48.144	75	.642		
Total	2784.000	79			
Corrected Total	220.709	78			

a. R Squared = .782 (Adjusted R Squared = .773)

The results indicate that there is a statistically significant difference at ($\alpha = 0.05$) between the means of the students scores on the subject of "light" due to the students' levels of learning process in favour of the meaningful learners, compared with in-between learners and rote learners. The mean of the Meaningful learners is (7,428); the mean of in-between learners is (5,352) while the mean for rote learners is (3.529).

The ANCOVA results comparing between the students' levels of learning process across the three levels (Meaningful learners, In-between learners, Rote learners) on radical conceptual change indicated that there are statistically significant differences between students' levels of learning process in groups. Therefore, the researchers further investigated the univariate statistics results (analysis of covariance ANCOVA) by performing a post hoc on the radical conceptual change in order to identify where the significantly differences in the means resided (Table (8)).

Table 8: A post hoc analysis in order to identify where the significantly differences in the means resided based on students' levels of learning process.

(I) levels	(J) levels	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Rote	In-between	-1.853*	.238	.000	-2.327	-1.378-
	Meaningful	-3.749*	.253	.000	-4.252-	-3.246-
In-between	Rote	1.853*	.238	.000	1.378	2.327
	Meaningful	-1.896*	.215	.000	-2.324-	-1.468-
Meaningful	Rote	3.749*	.253	.000	3.246	4.252
	In-between	1.896*	.215	.000	1.468	2.324

Based on estimated marginal means

* The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The results of the (post hoc) analysis indicated that in-between learners (M = 5.3529, SD = 0.48507) improved better than rote learners (M = 3.5294, SD = 0.94324) in radical conceptual change (P = 0.000). At the same time, the meaningful learners (M = 7.4286, SD = 1.06904) improved better than in-between learners (M = 5.3529, SD = 0.48507), (P = 0.000). Finally, the results show that, meaningful learners (M = 7.4286, SD = 1.06904) improved better than rote learners (M = 3.5294, SD = 0.94324) in radical conceptual change (P = 0.000). In summary, students' levels of learning process in radical conceptual change can be arranged as follows: meaningful learners > in-between learners > rote learners.

Discussion

In general, the results demonstrated improvements in the performance of both experimental and control groups following the experiment regarding light concepts. The improvement is measured by mean scores obtained by both groups on the pre-test and post-test. Results emphasized effectiveness of the proposed constructivist model and superiority on the conventional method in rectifying misconceptions held by eighth grade students and acquisition accurate understanding of light concepts. This result is consistent with results from many other studies which investigated effectiveness of the constructivist approach-oriented teaching methods and conceptual change conditions to bring about conceptual change (Omleh, 1996 ; Jaber, 2004; She, 2004; Baz and Bawaneh, 2008; Bawaneh, Ahmad Nurulazam, & Munirah, 2010).

This result supports conceptual change theory that can find explanation in the rationales submitted by conceptual change theorists for their conditions in that they were consistent with Piaget theory of learning, and with science philosophical perceptions of acceptance or decline of a theorization by science community. In addition, the proposed constructivist teaching method employed the conceptual change conditions as represented by (*First phase: Student awareness of their preconceptions based on their personal experience, including*, *Second phase: Imbalance and Conflicts*, *Third phase: Experimentation and Activity, Fourth phase: Resolving Conflicts and accommodating the new concept, Fifth phase: Extend new concept learning and the Sixth phase: Metaconcept or metacognition*) which already have been demonstrated in the theoretical framework of this study and originally stipulated by Posner et al. (1982) for bringing about conceptual change in which scientific concepts will be logically sequenced to allow learner readjust his cognitive construct by stimulating higher thinking skills and achieving more comprehensive understanding (Jaber, 2004). Ritchie & Cook (1994) stated that the major focus of constructivism is learner's role in building his own knowledge viewing learning as an adaptation process wherein learner would already readjust known facts in response to newly learned experiences as a result of active interaction with others. A constructivism-based classroom is characterized as being a learning environment in which one is encouraged to take responsibility on his own learning assuming the role of explorer, and giving meaning to experiences to which he might expose by associating them with his previous learning.

On the other hand, the proposed constructivist method showed success in stimulating student's interest and since it is similar to a novel, thus there was little or no boredom as novelty creates excitement and interest. Under the proposed constructivist methods, student takes a major role in doing activities, experimentation, data collection, hypothesizing, and explanation. Comparatively, the conventional method is more teacher-focused, and student assumes passive role particularly if concepts were presented superficially which increases boredom among students who are mainly low achievers. Further, the students would be refrained from answering classroom questions fearing to make mistakes (Baz and Bawaneh, 2008).

Researchers see superiority of the constructivist method in that it allows sufficient time for students to discuss their preconceptions and meaningfully link scientific concepts together. This, of course, increases student ability to learn, as one would learn more and better effective when interact with more skilled peers. Parallel to this, Vygotsky (1978) argued that if a more skilled and cognizance student could understand a concept prior to his peer who is less cognizant, then he may explain to his peer ways to understand the concept.

Further, the constructivist method encourages students to raise applied examples from their everyday life that are connected with the concept under study, which of course, enrich and develop the scientifically acceptable new concepts. In addition, the constructivist method encourages students to raise new questions to go beyond immediate experience, and building new concepts, ideas, inferences, and generalizations.

The improved performance of the experimental group would have been assisted by the teacher's attention at the beginning of teaching process to recognize student misconceptions and preconceptions for purpose of modifying them in classroom.

As for the control group, the teaching was much concerned with definitions, examples, and educational situations, while they were required to infer accurate scientific concepts. The objective was achieved at a limited degree as shown by results obtained. The explanation on this matter is that conventional method which concerns with rote learning, memorization and short-term learning disregards preconceptions, misconceptions or ways to modify them. Further, the conventional method typically used in science education shows little or no consideration of long-term or meaningful learning. Balfakih (2003) argued that science teaching strategies that are most widely common is the least effective; so similar to other subjects, science education is dominated by lecturing, and in most cases aided by another other teaching method that the content coverage is the major concern rather than a teaching method or processes.

The above results are partially inconsistent with results reached by (Hsieh, 1996) that found conceptual change theories as less effective in assisting student's acquisition of accurate scientific knowledge. On the other hand, this result stands parallel to Perals and Nievas (1995) that found no statistically significant differences in conceptual change rates in comparison with traditional interpretation and illustration, though both teaching methods could bring about conceptual change. The results related to teaching method suggested by Chinn and Malhorta (2002) was in sharp contrast with results concluded by this study, since it was found that a teaching method which depend on guided observation and interpretation as more ability to bring conceptual change than conceptual change methods.

On the other hand, this study revealed that meaningful students outperformed in-between and rote learners. This study is consistent with She (2003 and 2005). This result is explainable by fact that the constructivist teaching methods as suggested by this study is based on the conceptual change conditions in which scientific concepts are presented in logical sequence. In addition, the constructivist method is much concerned with identifying preconceptions and misconceptions held by students, target them by its teaching, and purporting to adjust and develop such mistaken concepts. Originally, Ausubel's theory is based on meaningful learning (linking new knowledge with one's cognitive structure) which is created when new notion takes a potential meaning, and when learner acquires suitable concepts that assist anchoring such concepts in one's cognitive construct in conscious manner. In consequence, individual's cognitive constructs are the essential factor governing whether or not new knowledge to be learned is meaningful, will be acquired, or retained.

Researches (Watkins, Reghi, and Astilla, 1991) indicate that students who profoundly acquire textbook contents and associate new cognition with their previous cognitive construct tend to be more academically successful. Educators (Alexopoou and Driver, 1996 ; Basconas and Novak, 1985) emphasize that quality and quantity of cognitive construct determines whether facts could be retrievable and helpful. In return, Ausubel (2000) emphasizes on learner's predispositions to learn new facts. On the other hand, it could be that meaningful learning student who outperformed in-between and rote learning students have been affected by misconceptions presented on classroom discussions with their inability to modify such mistakes along the teaching-learning process. Normally, learners who are more susceptible to misconceptions though accurate concepts are more likely to have fragile concepts which mean that they do not have coherent cognitive construct built on proper basics (Jaber, 2004).

Recommendations

1. Student preconceptions need to be further studied and obtainable results as insightful for science textbook and curriculum developers.
2. Training teachers on ways to understand their students and change the way they deliver their teaching based on the constructivist theory inside classroom which is the starting point to introduce proper scientific explanations.
3. Science teachers' preparation requires training before and during service on using teaching methods related to conceptual change from the (social and cognitive) constructivist

perspective, and encourage them to use such methods through practical issues dealt with, at workshops attended by educators and professors of science Education.

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