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Momentum Concept in the Process of Knowledge Construction

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Abstract

Abstraction is one of the methods for learning knowledge with using mental processes that cannot be obtained through experiment and observation. RBC model that is based on abstraction in the process of creating knowledge is directly related to mental processes. In this study, the RBC model is used for the high school students' processes of constructing momentum concept that were examined in an appropriate learning environment. Application was carried out with two volunteer tenth grade high school students. Two problems enabling the students to use their experiences and prior knowledge were designed and respectively used in the instruction. Observation, document review, and interviews were used as qualitative data collection methods. As a result, at the end of the implementation problems, it was observed that the students benefited from their prior knowledge in constructing new knowledge and they could construct momentum concept.

Key Words

Science-physics Teaching, Process of Abstraction, Construction of Knowledge, RBC Model, Momentum.

Although the adaptation of the idea of knowledge construction into education environment is not a new situation, content-rich appropriate methods to achieve knowledge construction (Schwarz, Neuman, Gil, & Ilya, 2003) and determination of how knowledge will be constructed poses a separate difficulty. Moreover, since it is supposed that students also use some mental models in constructing new knowledge in the knowledge construction process (Viiri, 1996), a lot of studies are made to investigate into knowledge construction processes today.

Students' having alternative concepts or misconceptions is one of the important problems preventing them from learning science. Studies on alternative concepts in students have been one of the most intensive areas in the studies on science education in recent years (Şekercioğlu & Kocakülah, 2008; Tanel & Tanel, 2010; Tao & Gunstone, 1999; Thompson & Logue, 2006).

In this study, the knowledge construction process during the implementation was tried to be determined by doing a teaching implementation in accordance with the constructivist approach. In this study, the subject was chosen as the concept of momentum, an abstract concept in physics.

The process of abstraction studied in the study is known, in the simplest term, as "the process of transition from concrete to abstract" and the level of abstraction is affected by the individual's cultural environment, previous experiences, learning environment and the context in which the subject of learning is taught (Altun & Yılmaz, 2008).

Abstraction as a method accounting for learning of information which cannot be acquired through experiment and observation but acquired through mental processes is defined by Hershkowitz, Schwarz, and Dreyfus (2001) as students' reorga-

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nizing their previously acquired information into mental constructs which they newly form and as an knowledge construction process.

Abstraction is, in one sense, the transformation of events or objects in the external world into mental constructs and related to obtaining new information from these constructs. In other words, abstraction amounts to the appearance of new information through arrangement of information vertically (Halverscheid, 2008). Here the arrangement of information vertically means establishing relationships between concepts. However, Noss and Hoyles (1996) addressed abstraction in the dimension of students' relating conceptual information which they have; according to this, when students perform activities successfully and progress, they learn to combine previous activities with new ones (as cited in Yeşildere & Türnüklü, 2008).

According to RBC model, there are three epistemic events, which can be observed and defined, in the knowledge construction process, namely recognizing, building-with and construction (Hershkowitz, Hadas, Dreyfus, & Schwarz, 2007; Hershkowitz et al., 2001). This model makes clear how abstract knowledge is acquired by the learner and is directly related to mental processes. Building-with is related to joining defined pieces of information together, arranging them in the direction of a limited goal, realizing strategies, revealing facts or solving problems. Students need structures with which they are already acquainted and resort to them. Construction means joining defined pieces of knowledge together (Hershkowitz et al., 2001). Or, according to Bikner-Ahsbahs (2004), it is the process of restructuring and rearrangement by making known structures subject to partial changes and building new meanings.

As it is known, many of the concepts encountered in science lessons are abstract concepts. Physical sciences is the sum of many mathematical relationships especially together with physics and chemistry subjects as well. Understanding those mathematical relationships is very important in learning subjects because those relationships, at the same time, underlie natural laws. Mathematical relationships between science concepts make students' learning science a complex process (Ellis & Turner, 2003). In physical sciences, teachers can use problem solving method to help students be able to form their own knowledge (Kang, 2008).

Like in many subjects of physics, students are observed to live difficulty understanding concepts and between-concept relationships in the field of dynamics. That one of the most difficult subjects to learn and to teach in physics education is the concepts of impulse and momentum has been revealed by many studies (Aycan & Yumuşak, 2003; Bryce & MacMillan, 2009; Gaigher, Rogan, & Braun, 2007; George, Broadstock, & Vazquez Abad, 2000; Graham & Berry, 1996; Güneş, İngeç, & Taşar, 2002; Hestenes & Wells, 1992; İngeç, Taşar, & Ünlü, 2005; İngeç, Ünlü, & Taşar, 2006; Kızılcık & Tan, 2011; Lawson & McDermott, 1987; Sarıay & Kavcar, 2009; Şekercioğlu & Kocakülah, 2008; Tanel & Tanel, 2010).

Stating that the most important problem related to knowledge construction in the physics learning process is asking the question of how students should be helped most effectively in the arrangement of knowledge, Ellis and Turner (2003) drew a simple conceptual framework related to implementation of the subjects in dynamics based on student-centered program and combined an approach based on graphical representation and mathematics. For example, students cannot see the mathematical relations yielding the relation between the second law of Newton and impulse-momentum and relations between concepts related to subjects. For this reason, they have great difficulty understanding and using these concepts. When impulse or momentum is the matter of discussion, the only thing that comes to students' minds is collision problems. One of the important concepts in Newton mechanics is the concept of impulse. For an object to be able to move, an impulse or a motive force should be applied (Viiri, 1996).

Purpose

The purpose of the study was to analyze the abstraction process in students' constructing knowledge about the concept of "momentum".

Method

This study designed to investigate into and implement the use of the abstraction process in science education was a qualitative one studying a case. In the direction of purpose, for this study, teaching materials were developed and the teaching was performed in accordance with the constructivist approach. Since the study was a descriptive one, it was limited to the student group to which the implementation was made. To analyze in detail the students' abstraction process and their levels of understanding the pieces of knowledge which they constructed during this process, the methods of observation, document

analysis and interviewing, which are qualitative data collection methods, were used. The study was carried out with 2 volunteer students whose achievement levels were equal. The equality in their achievement levels was determined based on their grades and by consulting their teachers. The students were taken in the science laboratory to be able carry out the tasks and worked under the audio-video recording within their informed consent. With the aim of giving the students the opportunity to exchange ideas and discuss the matter and, by doing so, making them think loudly, the interview was held at the same time in the same environment with two students together. At the beginning of the study, they were given the opportunity to ask questions about the study and the problems and necessary explanations were made; during the analysis, when necessary, to make students reveal their thoughts, questions were asked; the students' verbal and non-verbal communications with one another and with the researcher were observed and recorded with the help of a video-camera. Later, the audio-video records taken were analyzed in the direction of the goals of the study.

Data Collection Tool

To analyze the students' knowledge construction processes, two different problems were prepared to have the students acquire the concept of momentum in accordance with the RBC model. To be able to observe the abstraction process well, three basic references were taken into consideration in selecting the problems, namely the teaching studies put forward by Altun and Yılmaz (2008) were based on problem-solving, a model selected from real life was studied and because abstraction was realized within the course of time. The first problem was about establishing a relationship between the concepts of mass and velocity under discussion and thinking of both concepts at the same time and hence transition to the concept of momentum. The second problem was developed to audit the comprehension and the use of the concept of momentum as it had to be. Each problem was arranged as a worksheet and was given to the students one after another during the study. For the students to be able to search for the solutions to the problems, testing apparatuses were designed and they were given the opportunity to make tests to find solutions. The students were expected to make the tests appropriate for the problems on these apparatuses and give answers to the problems by evaluating the results. For example, for the first problem, they were expected to put the glass marbles, one big and one small, representing the balls in front of the two identical springs and throw toward the onionskin paper and evaluate the result. In the second problem, they were expected to make a test by putting two identical glass marbles in front of different springs and evaluate the result by looking at the effects of the balls on the onionskin paper.

Analysis of the Data

Since the study was a qualitative one, the analysis of the data was made descriptively. The statements indicating that the answers given the students to the questions were suited to the epistemic actions included in the RBC model were tried to be determined. Moreover, the document analysis was applied to the worksheets handed out to the students and including the problem statements. Hence, whether the students had reached meaningful pieces of knowledge was checked.

Validity and Reliability of the Study

Guba and Lincoln (1989) stated that the concept of "trustworthiness" can express more clearly the validity-reliability concepts in qualitative studies (as cited in Yıldırım, 2010). To achieve trustworthiness in the study, method variation strategies were used by employing expert analysis and participant observation and interview methods together. Moreover, in terms of reliability, after the completion of the study, the observations notes were compared by both researchers as independent from one another with those of the other researcher. As a result, the obtained observation notes were observed to be consistent with one another.

Results and Discussion

As a conclusion, in the knowledge construction, the RBC model explains how abstract knowledge is reached rather than teaching abstract concepts. The RBC model bringing explanations with respect to the abstract knowledge construction claims that this process is realized in three different intermingled steps. In the study, the knowledge construction process related to the concept of momentum was analyzed. It was observed that the students' constructing mental structures in relation to the concept of momentum were in harmony with recognizing, build-with and construction steps. In the study made, the students were able to determine the concepts related to the concept of momentum and the relationships between them. As it is known, establishing relationships between

variables indicates that mental activities are used. When the fact that abstraction covers the processes of needing new structures, constructing new abstract phenomena and combining these abstract phenomena (Dreyfus & Tsamir, 2004) is taken into consideration, it is observed that abstraction was realized in the study. The students recognized the concepts of mass and velocity in the first problem. At the same time, in the first problem, the relationship between these two concepts was put forward. In this step of the abstraction process, the students indicated the relationships between their existing pieces of knowledge verbally and operationally and used these relationships which they had obtained in the solution of the first and the second problems, too. The process revealing the action of building-with appears in the form of the student's constructing a hypothesis or trying to prove his/her verbal statements (Dooley, 2007). In the study, the students repeated the tests a few times for the verification of the obtained pieces of knowledge.

It is considered that the results of the study can be applied to the RBC model by producing appropriate problems suited to real life within the other abstract concepts of physics; they can contribute to the construction of physical concepts in a more qualified way also by using the problem solving skills and hence the existing or likely misconceptions can be prevented.

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