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Academıcıans' Vıews on Conceptual and Procedural Learning in Science Educatıon

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Abstract
The aim of this study was to get the views of academics on the importance of balancing and permanence of learning of the conceptual and operational learning. The sample group of the research was composed of eight academics employed in Science and Physics departments in Ağrı İbrahim Çeçen University and Atatürk University. In this study, 12 interview questions which are prepared with the aim of identifying the descriptions and steps of cognitive and operational learning are grouped based on phenomenographic approach which is an explicative approach. As a result of grouping, four different categories (A, B, C and D) have been formed. It is aimed at; identifying the relations between cognitive knowledge and operational knowledge in category A, identifying the importance of cognitive knowledge and operational knowledge in science education in category B, expressiveness of cognitive and operational learning and examination of the influence on each other in terms of permanence in category C, while in category D, it is aimed at examining the influence of learning mathematics and learning physics on each other. According to the results gained from the interviews, it is stated that cognitive learning and operational learning are of crucial importance in science education, operational knowledge includes cognitive knowledge and vice-versa, having gained the cognitive knowledge (or might have) has influence on gaining operational knowledge, whereas having gained the operational knowledge might not have influence on gaining cognitive knowledge, it is necessary that cognitive learning and operational learning be balanced, in case the balance is ruined/disturbed (in case of unbalance) the students might set up positive relations with their permanent learning, various factors emanating from teacher, student, educational system have influence on difficulties experienced by the students in using mathematics for solving physics problems.

Keywords: Constructivist learning, operational learning, science education, physics education, academician views

Introduction

In today's technological age the importance of knowledge is increasing every day and accordingly, the understanding of the concept of "knowledge" and "science" is changing. And this change also changes the expected skills from the individuals. Learning should be towards constructing old and new information in students' minds, giving meaning to relevant concepts

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and operations, and towards making connections between these concepts and procedures. Traditional programmes mostly feature transfer of knowledge. However, new information grows so fast that it is impossible to transfer all this new information. The philosophy of the modern programmes aims to teach the ways to access information rather than transfer of knowledge (URL, Ocak 2015). The new curricula focus on the relationships among the concepts, the meanings behind procedures and on equipping students with procedural skills (MEB, 2009). These prepared curricula overplayed taking more time to the formation of conceptual basis of knowledge thus making connections between the conceptual and procedural knowledge and skills (M.E.B. 2005). In procedural knowledge, knowing the reason of a concept or a process is not necessary, what is important is to know how to use it; whilst in conceptual knowledge, the important thing is comprehension (Baki, 1997).

In his study, Star (2000) indicates that there were various researches on conceptual and procedural knowledge which focus on whether students learn conceptual or procedural knowledge first (cited in: Bekdemir et al. 2010). Whilst some of the studies indicate that students first learn the procedure and later, they learn the meaning behind this procedure; majority of the studies reveal that students first learn the concepts behind a procedure and later they learn the procedure itself (cited in: Bekdemir et al. 2010). Moreover there are also studies showing that these orders were not strictly certain, sometimes procedures and sometimes knowledge were learned first and decisive factor were the conditions in the acquisition of knowledge (cited in: Bekdemir et al. 2010). The next step in studies on conceptual and procedural knowledge was identifying which should be learned first and how learning one of them effects the learning of the other. Majority of these studies revealed that learning procedural knowledge does not ensure adequate knowledge of concept (meaning) knowledge; and on the contrary; acquiring conceptual knowledge plays a significant role in acquiring procedural knowledge. In short, acquiring conceptual knowledge ensures the acquisition of procedural knowledge to a large extent (Kaya, D., Keşan, C., 2012).

It should not be considered that directly giving the formulas related to topics and concepts will ensure teaching the concepts. While making operations using formulas in teaching, it is necessary to evaluate them not within conceptual knowledge but in procedural knowledge. Thus, formulas in solving problems can be seen as elements of connecting procedural knowledge and conceptual knowledge. When formulas are seen as a part of teaching concepts, the formula written properly by the students may be the case leads the teachers that students understood the concept correctly. While designing teaching, teaching concepts should not be seen sufficient to solve problems and students should be provided with procedural knowledge as well. While involving procedural knowledge within conceptual knowledge network understanding the text in the problem and dividing the problem into meaningful pieces will make it easier to solve the problem (Bozan and Küçüközer, 2007). When the knowledge of procedures and rules are included in a child's conceptual knowledge the child can also explain not only how the procedures were done but also why they were made. Failure to gain the conceptual basis of the procedural knowledge and failure to establish the relationship between concept and procedural knowledge causes unable to establish the models and unable to decide where to use the operations; and this situation manifested itselt as the failure in solving the problem particularly. For a child who learns the procedures as rules and who cannot make the connection with procedures and concepts, we can say that the child did not construct the relevant concepts or although these concepts are constructed, the connection between the concept and procedures has not been made or at the same time all of the several of those aforementioned might have been realized (Soylu, Y., Aydın, S. 2006).

The purpose of this study is to identify the lecturers' opinions on the importance of balancing conceptual and procedural learning. Learning through making connection between conceptual and procedural learning will be the permanent learning and the things learned will be easily transferred to real life cases. Students will not have difficulty in transferring what they learned into other areas.

Method

Research Model

Qualitative research method was used in this study. Qualitative research is a research method in which such qualitative data collection methods as observation, interview and document analysis are used and perceived; and a process towards revealing cases in a natural environment and in a holistic way. Qualitative measurement methods in which making generalizations is not a primary objective are models in which observations and interviews are used and which aim at creating concepts and theories. It is difficult to explain these behaviors with numbers; measurements show us how many people behave in a certain manner yet they do not answer the question: "Why?". Researches aiming at understanding the "why" behind human and group behaviors are called "qualitative" research (Akman G.N., 2015). One of the ways of taking data in a qualitative research are the data on the perceptions that the invividuals involved the research group think about the process (Yıldırım ve Şimşek, 2008: 40).

In the qualitative research, concepts and theories are created at the end (inductive) (Akman G.N., 2015). Qualitative research method was chosen as it reflects the "reality" of a special case, as it is easy to produce theories using the results, as it ensures the comprehension of different factors and as the feasibility of the research results is high.

Population and Sample

The sample group of the study was eight lecturers working at Science, Physics Education and Physics Departments at Ağrı İbrahim Çeçen University and Ataturk University. The lecturers were mostly experts in their field of study and have experience. Two of the faculty members participated the questionnaire were professors at physics education department, two of them were associate professors at the department of physics, one of them was associate professor at the department of science and 3 of them were assistant professor at the department of science education.

The reason behind choosing science, physics education and physics departments for the study is that in these fields the conceptual and procedural knowledge/learning is used intensively. In other words, the problems in these areas generally require the use of conceptual and procedural knowledge intensively.

Data Collection

In this study individual interviews were used to identify the relationship between conceptual and procedural learning and the definitions of procedural learning; and as the technique semi-structured interviews were used. Semi-structured interview form including 12 open-ended questions was prepared. Erkuş, A. (2005) indicated that in semi-structured

interviews some part of the interview was structured whilst other parts were not to ensure students to provide free reaction (cited in: Evrekli et al. 2009). Initially 14 questions were prepared after a review of the literature and after the necessary changes were made, the questions were reduced down to 12. While the questions were prepared, first of all, expert opinions were taken to see whether the questions fit for the purpose of the measurement. Later, based on the criticisms of the experts the test was revised and prepared. In their study, Özgüven, (1998); Şencan, (2005) expressed the content validity as the determination of measurement tool that measures what you want to be able to measure the degree of structure in accordance with the representativeness of a balanced expert opinion (cited in: Evrekli vd. 2009).

Therefore, two expert opinions were taken to ensure content validity of the questions in the semi-structured interview form. After expert opinions were taken, some of the questions that did not fully met the desired results were removed from the form. And some questions were combined in accordance with correspondence of the results. Some questions which were seen as difficult to understand were revised. Two questions asking for certain information were totally excluded. Two questions in which hosting rates of Conceptual and procedural knowledge were asked were revised therefore they were based on exact information.There were no time limitations during the interview. The lecturers were given enough time to state their opinions and the interview medium was designed conveniently. Each meeting with one lecturer lasted around 30-60 minutes.

The interview questions were categorized according to phenomenographic approach which is an interpretive approach. In their studies, Koballa et al. (2000) indicate that phenomenographic researches deal with what people perceive, understand when they face with phenomena in the universe they live in and what their experiences are; and that in phenomenographic researches definition of a phenomena by an individual is not considered as either right or wrong. Koballa et al. (2000) categorized the definitions that individuals suggested related to a phenomenon (such as learning and teaching) to be researched; and indicated that categorizing the definitions made what people think clearly (cited in: Cekmez et al. 2012). Phenomenographic approach deals with the worldview of the individual and with how individuals interpret cases; in other words, it deals with the phenomenology of the individual. In phenomenographic approach the researcher tries to understand the cases or phenomena without imposing pre-concepts or theoretical ideas; in a way it is experienced by the individual (Cekmez et al. 2012). Ashworth & Lucas (1998) indicate that the purpose of phenomenographic research is to qualitatively explain how various phenomena were understood in different ways and to systematically categorize different perceptions according to the emerging categories (cited in: Cekmez et al. 2012).

The validity of the measurement tool was ensured through two expert opinions with expertise in the area. Later the test was revised based on expert opinions and reorganized. To get more precise results from the study, only one assessment tool was preferred.

Analysis of Data

Marton and Booth (1997) indicate that in phenomenographic analyses, quantitatively in each category, the distinctiveness in understanding the phenomena should be inferrible and the categories should be minimum (cited in: Cekmez et al. 2012). To categorize the interview questions in this study; first interviews with the lecturers were made according to phenomenographic approach and later the interviews were deciphered; and the data were

categorized. The mixed ideas in the categories were reorganized. To do that, the data were put into tables and analyzed; and the relationships between the categories were explained. As a result of the grouping, 4 different categories (A, B, C and D) emerged. In category A there were questions identifying the relationship between conceptual and procedural knowledge (questions 1, 2, 5, 6 and 7); in category B there were questions identifying the importance of conceptual and procedural knowledge in science education (questions 3 and 4); in category C, there were questions questioning the impact of conceptual and procedural knowledge on one another in ensuring permanence (questions 8, 9, 10 and 11) and in category D, there were questions questioning the impact of learning physics and mathematics on one another (question 12).

Findings And Interpretation

In this section, the interview questions categorized based on phenomenographic approach were analyzed and the common features identified between questions were given in Table 1; whilst the sampling of the answers to categories are given in Table 2, Table 3, Table 4 and Table 5.

Tabl 1: Common features identified between the questions

Categories	Common features identified between the questions
Category A	Identifying the relationship between conceptual knowledge and procedural knowledge.
Category B	Identifying the importance of conceptual and procedural knowledge in science education.
Category C	The impact of conceptual and procedural knowledge on one another and on ensuring permanence.
Category D	Examining the impact of learning physics and mathematics on one another.

Analysis of Category A

The result of the analysis of the answers to questions 1, 2, 5, 6 and 7, which aimed at identifying the relationship between conceptual knowledge and procedural knowledge, revealed that conceptual knowledge incorporated procedural knowledge and procedural knowledge incorporated conceptual knowledge and that the ratio of impacting one another could change based on the branch and the subject. It was found that because all learning started with the learning of the concepts, it was not possible to construct other learning areas without having conceptual knowledge. It was also found that acquired conceptual knowledge might effect the acquisition of procedural knowledge and yet, the procedural knowledge might not effect the acquisition of conceptual knowledge. And also it was found that it was conceptual knowledge to be learned first and that when conceptual and procedural learning were not balanced, the things learned became temporary and difficult to relate to real life.

Some of the questions under this category and examples from the answers to these questions are given in Table 2 below.

Table 2: Examples of the answers to the questions in Category A

2nd question: Does procedural knowledge incorporate conceptual knowledge?
Contrary to conceptual knowledge, procedural knowledge incorporates conceptual knowledge. In fact, I believe that this ratio will be in favor of conceptual knowledge. Although it is necessary to successfully use the processes in order to develop procedural skills in solving a physics problem, without having conceptual knowledge, it is not possible to improve problem solving skills only by having procedural skills.
7th question: What kind of problems could be faced when conceptual knowledge is not balanced with procedural knowledge?

When conceptual knowledge is not balanced with procedural knowledge, the first thing that could arise is the case of not being able to use the conceptualized symbols existing in the nature of physics problems in the right place. Secondly, the connection between the concepts can be formed with the process steps. In this case, the relationship from one process step to another cannot be constructed. In addition, it is necessary to test whether the results are compatible with physical reality after the physics problems are solved. Even the compatibility of the solution to physical reality reveals the necessity of balancing with conceptual knowledge.

Analysis of Category B

The result of the analysis of questions 3 and 4 which aimed at identifying the importance of conceptual and procedural knowledge in science education, it was found that both conceptual and procedural knowledge were very important in science education. Conceptual knowledge is important because for all learning domains, the basic level of learning starts with the learning of the concepts and without learning the concepts no other learning occurs. Cases or facts are named with a concept and transferred to knowledge dimension and the next processes occur after these concepts are learned. As the permanence of what is learned is one of the objectives of our education system harmonizing procedural knowledge with conceptual knowledge is very important in terms of meaning.
The questions under this category and examples from the answers to these questions are given in Table 3 below.

Table 3: Examples of the answers to the questions in Category B

3rd Question: What is the importance of conceptual learning in science education?
Conceptual learning is a learning domain itself and concepts and conceptual learning occur in almost all teaching methods used in science education. Therefore, conceptual learning is highly important.
4th Question: What is the importance of procedural learning in science education?
Science education is mainly related to learning concepts that can be measured. Measurement is most often carried out through laboratory activities in physics, chemistry and biology. In order to ensure the results of the experiment carried out in laboratory in theory, procedural knowledge should be used at a high level.

Analysis of Category C

The result of the analysis of the questions related to meaningful conceptual and procedural learning and their impact on one another in ensuring permanence, it was found that conceptual learning alone would be enough to ensure meaningful and permanent learning in conceptual subjects; yet in courses such as chemistry and physics, which require not only learning concepts but also practicing and operations, conceptual learning would only be theoretical and would not be transferred to practice. In applied courses in which conceptual learning is not adequate by itself, it is necessary to support them with procedural learning. If both conceptual and procedural learning are acquired in a balanced way, a positive connection can be made with the meaningful learning of the students; and it can be said that permanent and meaningful learning is ensured. As complete learning means that information is learned in a way that it does not require to be reminded, if it is difficult to remember something, for example, if the students have difficulty in remembering formulas or small details, it means complete learning did not occur. Learning could start with conceptual learning and can be strengthened with procedural learning. When conceptual and procedural learning are combined meaningfully for meaningful and permanent learning, desired learning will emerge. While procedural knowledge will help the acquisition of conceptual knowledge; conceptual knowledge will make procedural knowledge meaningful and support it. As it is understood

from the answers, there is a positive relationship between acquisition of conceptual and procedural knowledge and meaningful learning.

The questions under this category and examples from the answers to these questions are given in Table 4 below.

Table 4: Examples of the answers to the questions in Category C

9th Question: Is the permanent and meaningful learning level of those students who learned conceptual and procedural learning high?
It is possible to say that students with high level of conceptual and procedural learning levels sustain the achievement they have in secondary school and high school; and that they study at faculties which admit students with higher scores. In addition, conceptual and procedural learning guide one another as a step to each other. Therefore, successful students in grade 1 continue their success in other courses in the next grades. Besides, it is seen in the literature that students who learned conceptual and procedural learning have a high level of permanent and meaningful learning.
11th Question: Is procedural learning adequate by itself to ensure meaningful and permanent learning?
There are almost no subjects in science that require only procedural learning. Therefore, procedural learning itself is never enough for permanent and meaningful learning.

Analysis of Category D

The result of the analysis of the questions related to the impact of learning physics and learning mathematics on each other, it was found that the reasons behind weak mathematical knowledge of students were insufficient basic mathematical knowledge among students required for procedural knowledge steps; that basic mathematical knowledge among lecturers required for science, physics and chemistry education at undergraduate level was insufficient; that students see mathematics as a non-physical course and believe that the mathematical knowledge they learn would not be used in everyday life. In addition, that students have difficulty in using derivatives and integral in science classes and that the mathematics knowledge of those students who are admitted to a science department although they studied a verbal area at high school is insufficient are among important factors. Having different learning styles of the students in Mathematics and Physics cause the students in physics have difficulties when solving physics problems.

The questions under this category and examples from the answers to these questions are given in Table 5 below.

Table 5: Examples of the answers to the questions in Category D

12th Question: What are the reasons behind the fact that students have difficulty in using mathematics while solving a physics question?
The first reason of the difficulty of solving physics problems by using math is that the mathmatical operations have done by the processes sequentially but in physics every case has its own characteristics in the same problem. . There are not sufficient number of physics courses in mathematics education programme. Therefore, mathematics teachers carry out teaching operations without considering the concepts. Secondly, in solving a physics problem, mathematical operations are used meaningfully and in way that requires higher order skills. Lecturers giving physics courses are already doing high levels of mathematical operations. So, in physics education the conceptual dimension of mathematical courses can be emphasized and thus, the classes could be conducted more meaningfully and the correct use of process steps in physics problems can be ensured.

Result, Dıscussıon And Suggestıons

Based on the findings of the study, the following results are obtained. Suggestions are made based on these findings.

It was seen that lecturers thought that both conceptual and procedural learning were important yet, conceptual knowledge formed the basis of learning and that procedural learning alone would not be adequate without conceptual knowledge. In other words, conceptual learning will effect procedural learning positively. Learning requires the learning of conceptual knowledge first. And procedural knowledge will not effect acquiring conceptual knowledge. In teaching, procedural knowledge and conceptual knowledge should be harmonized well. Neither conceptual nor procedural learning alone is not enough.

It was seen that in their answers lecturers said that conceptual and procedural learning were important in science education and that for all learning domains, the basic level of learning started with the learning of the concepts, so procedural learning should be constructed on the learning of these concepts. Although the objectives in the education system are foreseen as comprehension, problem-solving and adapting existing knowledge to new conditions, due to the structure of the examinations in our existing education system, not sufficient time is provided to students for solving problems in such areas as physics and mathematics in which procedural knowledge is mostly used. And therefore students memorize the knowledge and cannot construct adequate procedural and conceptual knowledge.

Lecturers indicated that conceptual learning could be adequate by itself for meaningful and permanent learning only while learning conceptual subjects; yet in in courses like physics, chemistry and mathematics which require applications and operations in addition to learning concepts, conceptual learning would remain just as a theory. Because the conceptual knowledge acquired would not be transferred to application and operations, conceptual learning alone would not be enough in applied courses. And similarly, since procedural learning would not give the answer to "why" question, neither procedural nor conceptual learning alone would be sufficient for permanent and meaningful learning. During teaching, both procedural and conceptual learning should be involved and while teaching procedural knowledge, there should be practices that involve showing the relationships between the concepts. In conceptual learning, before starting to teach a new subject, it is necessary to determine whether the students have the required prior knowledge to internalize the new information. And during the teaching, the instruction should be towards educating students who are active, who make research, make deductions, question, interpret, think creatively and analytically.

According to the lecturers, the reasons behind students' problems in using mathematics while solving physical problems were the insufficiency of students' basic mathematics knowledge required in procedural knowledge processes; that the teaching processes of physics and mathematics were different; students saw mathematics as an intangible course; the knowledge learned in mathematics was only used procedurally; the students did not know where and how to use the mathematic knowledge they learned; it was difficult to transfer the mathematics knowledge learned into solving physic problems; students who were admitted to a science department although they studied a verbal area at high school did not have basic mathematics knowledge. In other words, putting emphasis on conceptual learning as much as procedural learning will contribute students' better understanding of the problem and permanent learning by enabling them to connect it with other subject areas. In physics, it is important to equip students with the concepts explaining the operation rather than focusing on the operations of the solutions.

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