Fen Bilgisi Öğretmen Adaylarının Newton'un Hareket Yasalarındaki Deklaratif Bilgi Durumlarına, Prosedürlerin ve Matematik Mantık Bilgi Durumlarının Etkisinin İncelenmesi*

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Öz

Bu araştırmada; fen bilgisi öğretmen adaylarının Newton'un hareket yasalarındaki deklaratif bilgi ve başarı düzeylerine, matematik mantık bilgi ve başarı düzeylerinin etkisine odaklanılmaktadır. Ayrıca bu araştırmada fen bilgisi öğretmen adaylarının Newton'un hareket yasalarındaki deklaratif bilgi ve başarı düzeylerine, prosedür başarı düzeylerinin etkisene de odaklanılmaktadır. Bu araştırmada, öğretmen adaylarının bilgi düzeylerinin, başarı düzeylerini yeterince desteklemediği sonucuna ulaşılmıştır. Ayrıca prosedür başarı düzeyleri, konu başarı düzeyini desteklemesinin oldukça sınırlı olduğu sonucunu ulaşılmıştır. Bu araştırmada NÖA2 başarı düzeyinin, formül bilgi düzeyine göre yüksek olması, sorunun/çözümün semantik yanı ile ilgili olduğuna işaret etmektedir. Bu araştırmanın bulgularına doğrultusunda; eğitimi sürekli, yöntemlere angaja etmekle iyi bir eğitim sağlanamayabileceğini gösterdiği söylenebilir. Eğitim süreçlerimizi çeşitlendirmenin faydalı olma ihtimali, faydalı olmama ihtimalinden yüksektir. Semiotik bilimi'de eğitim süreçlerine dahil etmeliyiz ki, öğretmen adaylarının anlama süreçlerine gerektiği gibi katkı verilebilsin. Semiotik bilimin bir parçasını oluşturan "semantik"; bu araştırmada tartışılan "formül değişkeninin bilgi düzeyiyle"-"prosedür başarı düzeylerinin" ilişkilendirilmesi, öğretim süreçleriyle bire bir ilişkilendirilebilir.

Anahtar Sözcükler: Deklaratif bilgi; matematik mantık; fen bilgisi öğretmen adaylarının bilgi düzeyleri; fen bilgisi öğretmen adaylarının başarı düzeyleri

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Türkçe Uzun Özet

Giriş

Bu araştırmanın amacı, bilgilerimizin önemli bir kısmını oluşturan "deklaratif bilgilerimizin" geliştirilmesine etki eden faktörlerden bazılarının, alınan örneklem üzerindeki etkilerini belirleyerek, olası çözüm yolları önermektir. Bu araştırmada fen bilgisi öğretmen adaylarının deklaratif bilgilerini etkileyen faktör olarak belirlenen; bilginin mantık yapısının, prosedürlerinin ve değişkenlerinin, öğretmen adaylarının bilgi ve başarı düzeylerine etkileri belirlenmektedir.

Materyal Metot

Bu araştırmanın verileri, 2009-2010 öğretim yılında, Newton'un hareket yasalarının öğretildiği genel fizik 1 dersini alan, fen bilgisi öğretmenliği birinci sınıf öğretmen adaylarından, nitel durum çalışmasıyla toplanmıştır. Araştırmada "bütüncül tek durum deseni" kullanılmıştır. Araştırmanın verileri, üç ölçme aracı ile toplanıştır. Bu ölçme araçlarından ilki öğretmen adaylarının, deklaratif ve matematik mantık bilgilerini ölçecek, "Nitel ölçme aracı 1 (NÖA 1)" on yarı yapılandırılmış sorudan oluşturulmuştur. Ölçme aracının soruları, kıyaslamaya yönelik sorular olup, belirli bir sayısal değer sorulmamıştır. İkincisi; "Nitel ölçme aracı 2 (NÖA 2)", NÖA 1'in sorularının çözümünde kullanılması gereken fizik formüllerinden oluşturulmuştur. Diğer bir değişle NÖA 2, NÖA 1'in prosedürleridir. NÖA 2, öğretmen adaylarının NÖA 1'in prosedürleri bilip bilmediğini ölçmek için otuz altı yarı yapılandırılmış sorudan oluşturulmuştur. Üçüncü ölçme aracı; "Nitel ölçme aracı 3 (NÖA 3)", NÖA 1'deki soruların çözümünde kullanılması gereken, temel matematik bilgilerini ölçmeye yönelik elli yarı yapılandırılmış sorudan oluşturulmuştur. Toplanan verilerin analizinde, Veri Değişkenlerinin Olasılık ve İhtimal Hesaplama İstatistiği (VDOİHİ); Birleşik Aşama Yüzde Hesaplama İstatistiki Yöntemleri (Yılmaz, 2011; Yılmaz&Yalçın, 2011) için geliştirilen yazılım programı kullanılmıştır.

Başarı düzeylerini etkileyen değişkenler: a) Verilenler-istenilenler b) Serbest cisim diyagramı c) tanım d) Formül ve e) işlemler olarak belirlenmiştir. Değişkenlerin, NÖA 1'in sonucuna "ASS" etkisini belirleyebilmek için öğretmen adaylarının bu değişkenlerden aldıkları puanlar hesaplanmıştır. Öğretmen adaylarının değişkenlerden aldıkları puanların, sonucu "ASS'yi" % etkileme ihtimalleri hesaplanarak, Newton'un hareket yasalarındaki deklaratif bilgilerine; prosedür ve matematik mantık bilgi durumlarının etkisi belirlenmiştir.

Sonuç ve Yorumlar

Öğretmen adaylarının; Newton'un hareket yasalarıyla ilgili, deklaratif ve matematik mantık bilgi sorularından oluşan ölçme aracıyla elde edilen başarı düzeyi %42 olduğu bulunmuştur. Bu ölçme aracının yanlızca deklaratif bilgi sorunlarında öğretmen adaylarının başarı düzeyi %45, yalnızca matematik mantık bilgi sorularındaki başarı düzeyi %39 dir. NÖA 2 ölçme aracında, öğretmen adaylarının başarı düzeyleri %57 ve NÖA 3'te öğretmen adaylarının başarı düzeyleri %82 olduğu belirlenmiştir. Öğretmen adaylarının bilgi düzeyleriyse %12, %14 ve %24'tür. Öğretmen adaylarının başarı düzeyleri, bilgi düzeylerinden oldukça yüksek olduğu için başarı düzeyleri, bilgi düzeylerini temsil etmemektedir.

NÖA 1'deki soruların beş değişkeninin sonuca birlikte etkileri: Öğretmen adaylarının pozitif aşamalardaki bilgisi, ASS sonucunu %15 etkilediği düşünülmektedir. İlişkisiz bilgisi, ASS sonucunu %15 etkilediği düşünülmektedir. Negatif bilgisi, ASS sonucunu negatif yönde %4 etkilediği düşünülmektedir. Negatif aşamalardaki pozitif bilgisi, ASS sonucunu %1 etkileme ihtimali vardır. Sıfır skoru, ASS sonucunu %77 etkilediği düşünülmektedir. NÖA 2 bilgisi, ASS sonucunu %57 etkilediği düşünülmektedir. NÖA 3 bilgisi, ASS sonucunu %82 etkilediği düşünülmektedir.

Tartışmalar ve Öneriler

Öğretmen adaylarının, NÖA1'in dört deklaratif bilgi sorusunu, tanım bilgi düzeyi 0.21'dir. Tanım bilgi düzeyine, matematik mantık tanım bilgi düzeyinin 0.03 gibi son derece düşük bir katkısı vardır. Ayrıca matematik mantık başarı düzeyinin 0.39'luk bir katkısının olduğu söylenebilir. Deklaratif bilgi sorularının tanım bilgi düzeyinin düşük olmasıyla birlikte, matematik mantık bilgi ve başarı düzeylerinin de düşük olması; öğretmen adaylarının tanımların önerme yapılarını yeterince bilmediğini göstermektedir. Bu durum öğretmen adaylarının soruları, tanımlarla ilişkilendiremediklerini göstermektedir. Bu durum, öğretmen adaylarının sonuca giderken konunun bilimsel alt yapısından yoksun kalmalarına neden olmaktadır. Deklaratif bilgi sorularında İS, ANS ve NAPS skorlarının olmaması, öğretmen adaylarının, soruların bilimsel alt yapısında; herhangi bir yanlış veya hata değil, bilgilerinin yeterince olmadığını göstermektedir. Bu durumun iyileştirilebilmesi için öncelikle konuların öğretiminde tanımların matematik mantık yapının da öğretim süreçlerine dahil edilmesi gerekliliğine işaret etmektedir. İS, ANS ve NAPS bilgilerinin olmaması; tanımların, mantık yapılarının öğretim süreçlerine dahil edilmesinde avantaj sağlayacağı anlamına gelebilir. Öğretmen adaylarının tanım bilgilerinin, prosedürlerinde, bu değişkenin bilgi düzeyine göre daha iyi düzeyde oldukları söylenebilir. Buradaki sorun; prosedürleri kullanarak, bütüne ulaşılamamasıdır yani öğretmen adaylarının "anlama" ile ilgili problemlerinin olduğu söylenebilir. Bu durumun, bilginin alt birimlere ayrılmasında bir probleme işaret etiği söylenebilir. Bilgi alt birimlerine ayrılabilmiş olsaydı, tanım bilgi düzeyiyle, prosedürlerdeki başarı düzeyleri bir birine yakın değerlikli olması gerekirdi. Bu araştırmada bu değişkenin bilgi düzeyinin 0.12 gibi oldukça düşük bir düzeyde olması, alt birimler arasındaki semantik koordinasyondan bahsedilebilmesini engellemektedir. Sorun öğretmen adaylarında var olan bilginin, ezber bilgisi olmasındadır. Bu sonuca, NÖA 1 ve NÖA 2 başarı düzeylerine bakılarak da ulaşılabilir. Bu değişkenin bilgi düzeyindeki problemlerin çözümüne, bilginin mantık yapısından ve prosedürlerinden başlamakla birlikte Tablo 1'de verilen ilk iki değişkenin APS değerlerinin de yükseltilmesinden başlanabilir. Bu değişkenlerin APS skorlarının yükseltilmesinin, öğretmen adaylarının anlama sorununun çözümde önemli katkıları olabilir.

Öğretmen adaylarının deklaratif bilgi sorularının formül bilgi düzeyi 0.27 düşük düzeyde olmakla birlikte, tanım bilgi düzeyine göre yüksektir. Formül bilgi düzeyinin, tanım bilgi düzeyine göre yüksek olmasının bir nedeni, öğretmen adaylarının formül bilgi düzeylerinin, NÖA 2 başarı düzeylerine yakınsama eğiliminde olduğunu göstermektedir. Buradaki sorun, formül prosedürlerinin konuyla ilişkilendirilememesinde yatmaktadır. Deklaratif sorularla ilgili NÖA 2 başarı düzeyinin 0.59'dan, formül bilgi düzeyinde 0.27'ye düşmesi prosedürlerin konu ile ilişkilendirilemediği olarak yorumlanabileceği gibi deklaratif bilginin tanımıyla ilişkili olarak alt birimler arasında semantik koordinasyon kurulamadığı şeklinde de yorumlanabilir. Bu ikinci yorum bize sorunun farklı bir yönünün olduğu ve çözüm yolunun da sorunun bu farklı yönüyle çözülebileceği umudu vermektedir. Bu farklı yön "semantik" ile ilgilidir. Bazen sorunlara farklı açılardan bakmak çözümü kolaylaştırabilir. Formül bilgi düzeyindeki sorunun çözümü, bilginin semantik yapısıyla ilgilidir. Zira bu araştırmanın verilerinden NÖA 2 başarı düzeyinin, formül bilgi düzeyine göre yüksek olması sorunun/çözümün semantik yanı ile ilgili olduğuna işaret etmektedir.

Deklaratif bilgi sorularının işlem bilgi düzeyi, 0.12'lik bir değerle bilgi düzeyleri içinde en düşük düzeydir. Bu değişkendeki matematik mantık bilgi düzeyinin, 0.36 gibi en yüksek bilgi düzeyi olmasına karşılık, işlem bilgi düzeyinin (deklaratif bilgi); tanım ve formül bilgi düzeylerinin oldukça gerisinde olması, tanım ve formül değişkenlerinin bilgi düzeyindeki sorunların yansımasının bir sonucudur. Öğretmen adayları bir bilgiyi; alt birimlerine ayıramıyor, alt birimler arasında semantik koordinasyon kuramıyorsa, doğal olarak kodu çözmeleri beklenmemelidir. Fakat deklaratif bilgi başarı düzeylerinin, 0.45 yüksek olması, öğretmen adaylarının başarı düzeylerinin tesadüfi bir sonucun değil ölçüm araçlarının bir sonucudur. Bilgi düzeyiyle, başarı düzeyi arasındaki orantının varlığı belirli bir sayısal sonucun sorulduğu ölçme araçları ile aranmalıdır.

NÖA 1'de başarı düzeyi, 0.42 düzeyindedir. Değişkenlerdeki bilgi düzeylerinin analizinde de vurgulandığı gibi bilgi düzeylerinin, başarı düzeyini yeterince desteklediği söylenemez. Bu sonuçlar, yılmaz(2011), yılmaz(2012) ve yılmaz&yalçın(2012a, 2012b)'ın Newton'un hareket yasaları için yapmış oldukları çalışma sonuçlarıyla benzer sonuçlardır. Literatürdeki bu çalışmalarda, öğretmen adaylarının bilgi düzeylerinin, başarı düzeylerini yansıtmadığı sonuçlarına ulaşılmıştır. Bu araştırmanın ve literatürdeki yılmaz(2011), yılmaz(2012) ve yılmaz&yalçın(2012a, 2012b)'ın öğretmen adaylarının bilgi düzeylerinin, başarı düzeylerini yansıtmadığı sonuçları, beklenmedik sonuçlar değildir. Çünkü eğitim-öğretim süreçlerinde; öğretilen bilgilerin mantık yapıları, işlenmemekte ve konunun mantık yapısının öğrenimi, öğretmen adaylarının kişisel çabalarına bırakılmaktadır.

The effect of Prospective Science Teachers' Achievement Levels in Procedures and Mathematical Logic Knowledge on their Declarative Knowledge about Newton's Laws of Motion

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Abstract

The present paper is focused on the effect of prospective science teachers' knowledge and achievement levels in mathematical logic on their declarative knowledge and achievement levels in Newton's laws of motion. In addition, it focuses on the effect of their achievement level in procedures on their declarative knowledge and achievement levels in Newton's laws of motion. In the study, the procedures required by the students for the subjects about declarative knowledge were measured through two independent measurement tools. These are the QMT2 and QMT3 that measured the procedures for formulas and the procedures for basic math respectively. It was concluded that the students' knowledge level does not support their achievement level in a satisfactory way. Furthermore, it was discovered that their achievement level in the procedures support their achievement level in the subjects in a limited way. Their achievement level in the QMT2 was higher than their knowledge level in formulas, which is related to the semantic aspect of the problem/solution. Incorporating methods into education in a constant manner does not necessarily mean that a decent kind of education will be achieved. Diversification of educational processes is more likely to be useful than not to be useful. Educational processes should also include semiotics so that students are enabled to make contributions to the process by which they comprehend things. Semiotics is linked with the variable "formula". Learning semiotic structures of formulas will result in an increase in students' knowledge level in this variable.

Key Words: Declarative knowledge; mathematical logic; prospective science teachers' knowledge levels, prospective science teachers' achievement levels

Introduction

The history of modern logic is included within the history of math or, more generally, symbolic logic. Modern logic is also called "new logic", "mathematical logic" or "symbolic logic". In fact, it is mathematicians who founded the modern logic. The pioneer of this logic is George Boole. The ideas presented by him are related to the algebraic expression of the laws of thought. Not only Gottlob Frege but also Hermann Rudolf Lotze and Ernst Schröder stated similar opinions to the "algebraic expression of the logic", an idea presented by Boole (Peckhaus, 1999).

Although logic and math started approaching each other with Newton's and Leibnitz's differential calculus and integral calculus- it was Boole and Frege who combined the two. Boole and Frege made attempts to provide a final and clear from to what formal deduction is, which, in turn, resulted in math and logic moving nearer to each other. Boole developed a symbolic system for Aristotle's rules of deduction. Even though Aristotle had articulated his rules of deduction in a clear way, they were in natural language (verbally). However, Boole attempted and managed to develop a symbolic system by extending them beyond this kind of an expression. Frege, on the other hand, improved on Boole's "symbolic system for rules of deduction", came up with "predicate calculus (open-ended propositions)", and laid the foundations for mathematical logic (Ozenli, 1999, s: R1; Heijenoort, 1970, pp: 1-2; Corcoran, 2003). Currently, this calculus constitutes a sufficient part of the logical basis of the whole math (Ozenli, 1999, pp: R1-R2). Mathematical logic is not a formulated abstract logic, but it expresses the content through symbols in a more definitive and decisive way than words do by Frege (Gözkan, 2008, p: 20).

Mathematical logic has a wide range of meanings, which can be grouped into three stages. The first one refers to a language that includes making deductions during the process of developing theories. The next one refers to the foundations of math. The third one refers to algorithm theories (Uspensky, 1992). These studies not only contribute to the development of mathematical logic but also successfully prove to be areas in which it can be applied and practiced.

There are two different opinions as to the selection of symbols for all applications of mathematical logic. According to the first one, logical formulations should be taken into account and mathematically defined within a series of symbols. The second one stipulates that deducting new formulas from previous ones should be mathematically defined. In these opinions, symbol combinations are sentences; they allow for deductions in similar logical languages as well as writing computer software (McCarthy, 1988). A successful use of mathematical logic should include propositions presented through mathematical symbols. It is essential that these symbols be universal and can be used for identifying other laws (Ledesma et al., 1997).

Scientific theory is an "interpreted axiomatic system". It refers to the entire body of logical terms such as →, V, ↔, Λ, Ǝ, etc., and theoretical and observational terms from which all the concepts and theories required by a scientific discipline could be derived through descriptions and deductions (Ozenli, 1994, pp:35-38). Mathematical logic constitutes the logical structure of science in an adequate manner (Ryall, 1958, p: 1; Gözkan, 2008, pp: 180-185; Heijenoort, 1970, pp: 1-2).

Knowledge is divided into two types, namely procedural knowledge and declarative knowledge. Most of our knowledge is procedural or declarative (Dacin&Mitchell, 1986). Collective use of procedural and declarative knowledge improves education (Willingham, Nissen&Bullemer, 1989). Furthermore, types of procedural and declarative knowledge could have an influence on creative thinking (Runco&Chand, 1995). Teaching science is a scientific discipline that includes fundamental definitions of science, and declarative knowledge could be produced through scientific methods (Good, at all, 1985).

Declarative knowledge is suggestive or actual knowledge (Sahdra&Thagard, 2003; Phillips&Carr, 1987). It is what we recognize and explain. It is also called explicit knowledge (Anderson, 1995, p: 234). Declarative knowledge is a type of knowledge that we are aware of and explain in a clear way (Baumard, 1999, p: 62). Unlike procedural knowledge, declarative knowledge is the actual knowledge (cited in Sahdra&Thagard, 2003). Declarative knowledge is divided into three sub-categories, namely common, technologic and field of interest (Garzas&Piattini, 2007). Declarative knowledge is a type of knowledge constructed by a partition of the data into its sub-units, a semantic coordination between such sub-units, and an analysis of the data code within the framework of possibilities through inductive and deductive processes at a certain epistemological level within the semantic web of scientific disciplines(Ozenli, 1999, A11). The logic of declarative knowledge is based on that of mathematics (McCarthy, 1988; Nilsson&Fikes, 1970; Bonner&Kifer, 1993).

The studies in the literature have reported that procedural and declarative knowledge are closely intertwined and one could be derived from the other (Li, at all, 1994; Berge&Hezewijk, 1999; Dacin&Mitchell, 1986; Sahdra&Thagard, 2003; Willingham, Nissen&Bullemer, 1989; Thagard, 2005; Hao, Li&Wenyin, 2007; Lawson, at all, 1991; Hanisch, Kramer&Hulin, 1991).

According to Anderson (1983, 1993), declarative knowledge is the basis of data transfer. Declarative knowledge is used at various educational stages. Declarative knowledge can be enhanced through various methods and techniques. They can also contribute to the development of such methods and techniques (Drummond, at all, 1998; Howe, at all, 2000; Kamouri, at all, 1986; Johnson&Star, 2007; Kırkhart, 2001; Andre&Ding, 1991). A collective use of procedural and declarative knowledge improves education (Willingham, Nissen&Bullemer, 1989).

The purpose of this study is to investigate the effects of some of the factors in the development of "declarative knowledge", which constitutes an important part of our knowledge, on the sample, and to focus on certain solutions based on the findings. Another objective is to identify the effect of procedures, which have an influence on and form the logical structure and part of declarative knowledge, and of variables in knowledge on students' knowledge and achievement levels; and to find ways to improve and develop our declarative knowledge.

Materials and Methods

The present paper will study the students' knowledge levels in two different categories, namely declarative knowledge and mathematical logic concerning Newton's laws of motion and their knowledge and achievement levels. The "Qualitative Measurement Tool 1(QMT1)" was developed in order to measure their knowledge and achievement levels. The tool consisted of four and six questions on declarative knowledge and mathematical logic knowledge respectively. The findings obtained through the tool were analyzed in three different ways, namely declarative knowledge, mathematical logic, and declarative knowledge and mathematical logic together. They were presented in Table 1. The ASS values in Table 1 represent the students' achievement levels. On the other hand, the APS values of the variables "definition", "formula" and "operation" are their knowledge levels.

Table 1. Students, scores of variables of QMT1 and achievement levels

Points/ Variable	Given-Asked			Free-Body Diagram			Definition			Formulas			Operations			Sum Of Variables		
	Declarative	Mathematical Logic	Declarative and Mat. Log.	Declarative	Mathematical Logic	Declarative and Mat. Log.	Declarative	Mathematical Logic	Declarative and Mat. Log.	Declarative	Mathematical Logic	Declarative and Mat. Log.	Declarative	Mathematical Logic	Declarative and Mat. Log.	Declarative	Mathematical Logic	Declarative and Mat .Log.
P	2,00	2,00	4,00	0,00	0,00	0,00	90,0	10,0	100,	58,00	0,00	58,00	30,00	197,0	227,0	180,0	209,0	389,0
BGS	294,0	177,0	471,0	28,00	0,00	28,00	497,0	154,0	651,0	217,0	126,0	343,0	315,0	436,0	751,0	1351,0	893,0	2244,0
İS(S)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,01	0,30	0,44	0,37	0,08	0,21	0,15
APS(S)	0,07	0,03	0,05	0,00	0,00	0,00	0,21	0,03	0,12	0,27	0,00	0,14	0,12	0,36	0,24	0,16	0,14	0,15
ANS(S)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-0,10	-0,14	-0,12	0,02	-0,05	-0,04
NAPS(S)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,02	0,03	0,02	0,00	0,01	0,01
SS(S)	0,93	0,97	0,95	1,00	0,00	1,00	0,79	0,97	0,88	0,71	1,00	0,85	0,77	0,44	0,60	0,80	0,72	0,77
QMT2 S	0,59	0,54	0,57															
QMT3 S	0,82	0,82	0,82															
ASS	0,45	0,39	0,42															

The knowledge level regarding the variable "definition" shows whether scientific facts can be expressed verbally. Therefore, the achievement level regarding the procedures measured through the "The Qualitative Measurement Tool (the QMT2)" and "The Qualitative Measurement Tool 3 (the QMT3)" will be associated with the knowledge level in the variable "definition". The students' knowledge level in the variable "definition" in the QMT1 will be evaluated also in association with the IS, ANS, NAPS and SS values of the variable. The knowledge level in the variable "formula" will be evaluated on the basis of, firstly, the knowledge level concerning the formulas in the questions included within the QMT1 on declarative knowledge, then of the achievement level in the procedures measured through the QMT2 and QMT3, and of the achievement level in mathematical logic. Afterwards, the knowledge level regarding the formulas in the QMT1 will be evaluated in association with the IS, ANS, NAPS and SS values of this variable. The knowledge level in the variable "operation" will be evaluated on the basis of, firstly, the knowledge level regarding the formulas in the questions included within the QMT1 on declarative knowledge, then of the achievement level in the procedures measured through the QMT2 and QMT3, and of the achievement level in mathematical logic. Afterwards, the knowledge level regarding the operations in the QMT1 will be evaluated in association with the IS, ANS, NAPS and SS values of this variable.

The students' achievement level will be assessed in association with their achievement level in the questions included within the QMT1 on declarative knowledge, the knowledge level concerning the variables in achievement, the achievement levels in the procedures measured through the QMT2 and QMT3, and the achievement levels in mathematical logic. The achievement level in the QMT1 will be evaluated in association with the knowledge level concerning the variables in achievement, and the achievement levels in the QMT2 and QMT3.

The data for the study were collected through a qualitative application during the educational year 2009-2010 from 1^{st} grade prospective science teachers who had taken the course "General Physics 1", in which Newton's laws of motion were taught. The study was based on the "holistic single-state design". The data were collected through three measurement tools. The first one, the QMT1, consisted of ten semi-structured questions on the students' declarative and mathematical logic knowledge. The questions on declarative knowledge were based on comparisons about accelerated motion, spring force, Newton's laws, center of mass, centripetal force, gravitational force, potential energy and Kepler's laws. Since mathematical logic includes propositions made through mathematical symbols (Corcoran, 2003; Ledesma et al., 1997), the questions on mathematical logic were based on presenting certain propositions that either included Newton's laws or did not contrast with them and on asking students to establish the connections among the formulas for physics which were required for these propositions. These questions were developed by the researcher. The questions on mathematical logic knowledge included Kepler's laws, work-energy, linear momentum, potential energy, force, kinetic energy, gravitational force, spring force, and centripetal motion. The questions included within the measurement tool were based on comparisons, and no statistical value was asked for. The second measurement tool, the QMT2, tested whether students were familiar with the formulas for physics which were required for solving the problems in the QMT1. In other words, the QMT2 included the procedures for the QMT1. The QMT2 was comprised of 36 semi-structured questions to measure whether students had a clear idea about the procedures for the QMT1. Twenty-six of these questions included the procedures for the questions included in the QMT1 on declarative knowledge and were intended to test whether students were familiar with them or not. These twenty-six questions also included the procedures for the questions included in the QMT1 on mathematical logic. The third measurement tool, the QMT3, contained 50 semi-structured questions to measure the students' basic knowledge about math, which was required for the questions in the QMT1. Forty-one of these questions were borrowed from the literature (Haeussler&Paul, 1993; Karakaş, 2001). The remaining 9 questions were composed by the researcher.

The data for the study were collected during the spring term of the educational year 2009-2010 from seven 1st grade prospective science teachers who had taken the courses "General Physics 1" and "General Math 1". Firstly, the students were informed about the measurement tools. Afterwards, they were presented with the QMT2, QMT3 and QMT1 respectively and asked to solve the problems in the tools. The data were analyzed through a software program developed for the Probability and Possibility Calculation Statistics for Data Variables (VDOIHI); Statistical Methods for Combined Stage Percentage Calculation (Yılmaz, 2011; Yılmaz&Yalçın, 2011).

The factors in the students' achievement level were identified as a) given-asked, b) free body diagram, c) definition, d) formula, and e) operation. Their scores in these variables were taken into consideration in order to determine the effect of the variables on the result of the QMT1 (ASS). The effect of their mathematical logic knowledge on their declarative knowledge about Newton's laws of motion was determined with a consideration into the fact that their scores in the variables might have an effect on the result (ASS).

Results and Interpretation

The measurement tool that consisted of questions on declarative and mathematical logic knowledge about Newton's laws of motion yielded that the students had an achievement level of 42%. Their achievement level in the questions included within the measurement tool on declarative knowledge was 45% whereas they had an achievement level of 39% in the questions on mathematical logic knowledge. It was discovered that the students had an achievement level of 57% and 82% in the QMT2 and QMT3 respectively. On the other hand, their knowledge levels were 12%, 14% and 24% respectively. Since their achievement levels are considerably higher than their knowledge levels, the former does not represent the latter.

The effects of the variables measured through on the result "ASS" are as follows (in Table 1):

It is thought that the students' knowledge in the positive stages of the variable "given-asked" has an effect of 5% on the ASS value. Their unconnected knowledge cannot affect the ASS value (0%). Similarly, their negative knowledge cannot have an influence on the ASS value (0%). Their positive knowledge in negative stages cannot have an influence on the ASS value (0%). It is thought that zero score has an effect of 95% on the ASS value.

Since the students had no positive knowledge about the variable "free-body diagram", the ASS score was not affected by this variable.

It is thought that the students' knowledge in the positive stages of the variable "definition" has an effect of 12% on the ASS value. Their unconnected knowledge cannot affect the ASS value (0%). Similarly, their negative knowledge cannot have an influence on the ASS value (0%). Their positive knowledge in negative stages cannot have an influence on the ASS value (0%). It is thought that zero score has an effect of 88% on the ASS value.

It is thought that the students' knowledge in the positive stages of the variable "formula" has an effect of 14% on the ASS value. Their unconnected knowledge is thought to affect the ASS value negatively by 1%. Their negative knowledge cannot affect the ASS value (0%). Their positive knowledge in the negative stages cannot affect the ASS value (0%).It is thought that zero score has an effect of 85% on the ASS value.

It is thought that the students' knowledge in the positive stages of the variable "operation" has an effect of 24% on the ASS value. Their unconnected knowledge is thought to affect the ASS value negatively by 37%. Their negative knowledge is thought to affect the ASS value negatively by 12%. Their positive knowledge in the negative stages might have an influence of 2% on the ASS value. It is thought that zero score has an effect of 60% on the ASS value.

The collective effects of the four variables of the questions in the QMT1 on the result are as follows: Their knowledge in the positive stages has an effect of 15% on the ASS value. Their unconnected knowledge is thought to affect the ASS value negatively by 15%. Their negative knowledge is thought to affect the ASS value negatively by 4%. Their positive knowledge in the negative stages might have an influence of 1% on the ASS value. It is thought that zero score has an effect of 77% on the ASS value. Their knowledge about the QMT2 is thought to have an effect of 57% on the ASS value whereas their knowledge about the QMT3 is believed to have an effect of 82% on the ASS value.

Discussion and Implications

The student had a knowledge level of 0.21 in the variable "definition" concerning the four questions on declarative knowledge in the QMT1. Their knowledge level in the definitions was not provided with much contribution by their mathematical logic knowledge concerning the definitions (0.03). Furthermore, it can be argued that their achievement level in mathematical logic (0.39) made little contribution to their knowledge level in the definitions. The reason why their knowledge level in the definitions concerning the questions on declarative knowledge was low is that they had low knowledge and achievement levels in mathematical logic, which suggests that the students do not have sufficient knowledge about the structure of the propositions included within the definitions. In turn, they could not associate the questions with the correct definitions, which led them to lack the scientific background knowledge that they needed in order to come up with a conclusion. The students did not have any IS, ANS or NAPS scores regarding the questions on declarative knowledge, which suggests that they do not have any misconceptions about the scientific background knowledge required for the questions, but they simply do not have enough of it. Their knowledge and achievement levels in mathematical logic indicate that they are not good at association. In order to improve their levels, it is suggested that mathematical logic should be incorporated into to the educational process. The fact that they did not have any IS, ANS or NAPS scores is an advantage that the students will enjoy when mathematical logic is incorporated into the educational process. Learning logical structures of definitions could increase the students' knowledge level in questions on their declarative knowledge and mathematical logic knowledge, which was 0.12, in parallel with the content of the teaching process. The contributions of the QMT2 and QMT3 to their knowledge level in definitions were 0.57 and 0.82 respectively. It can be argued that the students are more advanced in the procedures for knowledge about the definitions than their knowledge level in the variable “definition”. The problem is that they cannot move from parts to whole; in other words, they have problems with “comprehension”. It can also be concluded that they have problems with separating knowledge into its sub-units. If they had been able to separate knowledge into its sub-units, their knowledge level in definition would have been closer to their achievement level in procedures. This indicates that the students have problems with the very first stage of declarative knowledge. The priority should be given to overcoming this problem rather than seeking for other solutions to other problems related to the students’ knowledge about definitions. Once the problem has been coped with, studies should be conducted on methods of establishing a semantic coordination between the sub-units and encoding knowledge. The students’ low knowledge level in the questions on their declarative knowledge and mathematical logic knowledge (0.12) means that they could not have established a semantic coordination between the sub-units. The problem is that the students’ knowledge is based on memorization, which can be concluded from their achievement levels in the QMT1 and QMT2. In order to improve their knowledge levels in this variable, it is necessary to increase the APS values of the first two variables in Table 1 as well as providing solutions related to the logical structure of knowledge and procedures. An increase in the APS values of these two variables could lead to a corresponding contribution to overcoming the problem with comprehension.

The students had a low knowledge level in the variable “formula”(0.27), although it was higher than the one in the variable “definition”. The discrepancy in the knowledge level between these two variables suggests that the students’ knowledge level in the variable “formula” tends to converge with their achievement level in the QMT2. The problem lies in the fact that the procedures for formulas could not be associated with the subjects. One can conclude this from the fact that the students’ knowledge level in the formulas (0.27) was lower than their achievement level in the QMT2 (0.59). There might be two reasons for this discrepancy. Firstly, the students might not have associated the procedures with the subjects. The second potential reason is that they might not have been able to establish a semantic coordination between the sub-units. The second point of view suggests that there is another aspect of the problem and makes one hope that a different solution can be developed for it. This “another aspect” is related to “semantics”. Taking a different approach to problems sometimes facilitate solutions. The solution to the problem with the students’ knowledge level in the variable “formula” is related to the semantic structure of knowledge. The reason for this is that their achievement level in the QMT2 was higher than their knowledge level in the formulas, which is related to the semantic aspect of the problem-solution. Incorporating methods into education in a constant manner does not necessarily mean that a decent kind of education will be achieved. Diversification of educational processes is more likely to be useful than not to be useful. Educational processes should also include semiotics so that students are enabled to make contributions to the process by which they comprehend things. Semiotics should be associated with the variable "formula" throughout the teaching processes. Such an association could enable knowledge and achievement levels to converge with each other. Moreover, it is likely to increase these levels. The fact that the IS, ANS and NAPS values of this variable are almost zero supports the idea that semiotics should be incorporated into educational processes.

The students had a knowledge level of 0.12 in the variable "operation", the lowest score of all the variables. In the variable, their knowledge level proved to be considerably lower than their knowledge levels in the variables "definition" and "formula" although they had the highest mathematical logic knowledge, which is, in fact, a result of the problems students had in the variables "definition" and "formula". Unless students are able to separate a piece of knowledge into its sub-units and establish a semantic coordination between these sub-units, it is quite natural that they will not be able to encode knowledge. On the other hand, the students' achievement level (0.45) was higher than their knowledge levels in all the variables, which is not a coincidence but a result of the measurement tools employed throughout the study. A potential existence of a connection between their knowledge levels and achievement levels should be studied through other measurement tools that include questions that require students to come up with certain statistical values. In the study, knowledge and achievement levels were quite different from each other, which suggests that, apart from validity and reliability studies on measurement tools, these two levels should be considered as different qualities that need to be measured. An attempt should be made to make future measurements yield similar knowledge and achievement levels. The reason for this is that the students' achievement levels are not supported by either their knowledge levels or their achievement levels in the logical structure and procedures.

The students had an achievement level of 0.42 in the QMT1. As already emphasized during the analysis of their knowledge levels in the variables, it cannot be argued that their knowledge levels support their achievement levels in a satisfactory way, which is also supported by the findings of the studies conducted by Yılmaz (2011), Yılmaz (2012) and Yılmaz and Yalçın (2012a, 2012b). These studies found that prospective teachers' knowledge levels do not represent their achievement level. These results are not surprising, since the logical structures of knowledge are not included in the educational-instructional process, and students can only learn the logical structure of a subject through their own personal efforts. Learning individuals cannot be expected to comprehend concepts without an awareness of the logical structure on which the knowledge is based.. Unlike their knowledge levels, their achievement level (0.57) in the QMT2, in which procedures for formulas were measured, was higher than their achievement level in the QMT1. Their achievement level in the former can be said to support their achievement level in the latter. Even so, the achievement level the students had in the procedures included within the QMT2 could not be observed in the QMT1, which suggests that the students have problems with carrying out operations through their memorized knowledge. Potential solutions to this problem have been discussed in the section on the students' knowledge levels in the variables. Finally, the students had an achievement level of 0.82 in the QMT3, an important finding in that it presents the boundaries of their memorized knowledge. In the light of the findings of the present study, it can be argued that their achievement level in the procedures (memorization) support their achievement level in the subjects only in a limited way.

References

Anderson, J. R. (1983). The Architecture of Cognition, Cambridge, MA: Harvard University Press.

Anderson, J. R. (1993). Rules of The Mind, Hillsdale, NJ: Lawrence Erlbaum Associates Inc.

Anderson, J. R. (1995). Cognitive Psychology and Its Implications, Fourth Edition, W. H. Freeman and Company, New York, p: 234.

Andre, T. and Ding, P. (1991). Student Misconceptions, Declarative Knowledge, Stimulus Conditions and Problem Solving in Basic Electricity, Contemporary Educational Psychology, 16(4), 303-313.

Baumard, P. (1999). Tacit Knowledge in Organizations, Sage Publication, London, pp. 62-98.

Berge, T. T. and Hezewijk, R. V. (1999). Procedural and Declarative Knowledge: An Evolutionary Perspective, Theory and Psychology, 9(5), 605-624.

Bonner, A. J. and Kifer M. (1993). Transaction Logic: Unifying Declarative and Procedural Knowledge (Extended Abstract), AAAI Technical Report FS-93-01, 17-25.

Corcoran, J. (2003). Aristotle's Prior Analytics and Boole's Laws of Thought, History and Philosophy of Logic, 24(4), 261-288.

Dacin, P. A. and Mitchell, A. A. (1986). The Measurement of Declarative Knowledge, Advances in Consumer Research, 13, 454-459.

Drummond, S. R., Hernandez, G., Velez, M. and Villagran, G. (1998). Cooperative Learning and The Appropriation of Procedural Knowledge by Primary School Children, Learning and Instruction, 8(1), 37-61.

Garzas, J. and Piattini, M. (2007). An Ontology for Understanding and Applying Object-Oriented Design Knowledge, International Journal of Software Engineering and Knowledge Engineering, 17(3), 407-421.

Good, R., Herron, J. D., Lawson, A. E. and Renner, J. W. (1985). The Domain of Science Education, Science Education, 69(2), 139-141.

Gözkan, H. B. (2008). Aritmetiğin Temelleri, YKY, İstanbul, pp. 180-185.

Haeussler, E.F. and Paul R. S. (1993). Ekonomi ve Işletme Öğrencileri Için Matematiksel Analize Giriş, Türkçesi: Çakır, H. ve Öztürk, A., İstanbul, Ekin Kitabevi Yayınları, pp: 3-14.

Hanisch, K. A., Kramer, A. F. and Hulin, C. L. (1991). Cognitive Representations, Control and Understanding of Complex Systems: A Field Study Focusing on Components of Users' Mental Models and Expert/Novice Differences, Ergonomics, 34(8), 1129-1145.

Hao, T., Li, H. and Wenyin, L. (2007). Acquiring Procedural Knowledge from Historical Text, Third International Conference on Semantics, Knowledge and Grid, 491-494.

Heijenoort J. (1970). Frege and Gödel Two Fundamental Texts in Mathematical Logic, Harvard University Press, Cambridge, pp. 1-2.

Howe, C., Tolmie, A., Tanner, V. D. and Rattray, C. (2000). Hypothesis Testing in Science: Group Consensus and The Acquisition of Conceptual and Procedural Knowledge, Learning and Instruction, 10(4), 361-391.

Johnson, B. R. and Star, J. R. (2007). Does Comparing Solution Methods Facilitate Conceptual and Procedural Knowledge? An Experimental Study on Learning to Solve Equations, Journal of Educational Psychology, 99(3), 561-574.

Kamouri, A. L., Kamouri, J. and Smith, K. H. (1986). Training by Exploration: Facilitating The Transfer of Procedural Knowledge Through Analogical Reasoning, International Journal of Man-Machine Studies, 24(2), 171-192.

Karakaş, H. I. (2001). Matematiğin Temelleri, Sayı Sistemleri ve Cebirsel Yapılar. Ankara, METÜ Press, p: 100.

Kirkhart, M. W.(2001). The Nature of Declarative and Nondeclarative Knowledge for Implicit and Explicit Learning, The Journal of General Psychology, 128(4), 447-461.

Lawson, A. E., Mcelrath, C. B., Burton, M. S. and James, B.D. (1991). Hypothetico-Deductive Reasoning Skill and Concept Acquisition: Testing A Constructivist Hypothesis, Journal of Research in Science Teaching, 28(10), 953-970.

Ledesma, L., Perez, A., Borrajo, D. and Laita, L.M. (1997). A Computational Approach to George Boole's Discovery of Mathematical Logic, Artificial Intelligence, 91(2), 281-307.

Li, J., Ang, J. S. K., Tong, X. and Tueni, M. (1994). AMS: A Declarative Formalism for Hierarchical Representation of Procedural Knowledge, IEEE Transactions on Knowledge and Data Engineering, 6(4), 639-643.

Mccarthy, J. (1988). Mathematical Logic in Artificial Intelligence, Daedalus, 117 (1), 297-311.

Nilsson, N. J. and Fikes, R. E. (1970). STRIPS: A New Approach to The Application of Theorem Proving to Problem Solving, Artificial Intelligence Group, Technical Note 43, SRI Project 8259, Stanford Research Institute, California, USA.

Ozenli, S. (1994). İlim ve Teknolojinin Olumlu Ilkeleri, Adana, pp: 35-38.

Ozenli, S. (1999). İlmi Sohbetler. Adana, Karakuşlar Otomotiv Tic. ve San. Ltd. Şti.

Peckhaus, V. (1999). 19th Century Logic Between Philosophy and Mathematics, The Bulletin of Symbolic Logic, 5(4), 433- 450.

Phillips, A. G. and Carr, G. D. (1987). Cognition and The Basal Ganglia: A Possible Substrate for Procedural Knowledge, Canadian Journal of Neurological Science, 14(3), 381-385.

Runco, M. A. and Chand, I. (1995). Cognition and Creativity, Educational Psychology, 7(3), 243-267.

Ryall, J. (1958). An Investigation of The Laws of Thought, Dover Publications, New York, p:1.

Sahdra, B. and Thagard, P. (2003). Procedural Knowledge in Molecular Biology, Philosophical Psychology, 16(4), 477-498.

Thagard, P. (2005). How to Collaborate: Procedural Knowledge in The Cooperative Development of Science, Southern Journal of Philosophy, 44(S1), 177-196.

Uspensky, V.A. (1992). Kolmogorov and Mathematical Logic, The Journal of Symbolic Logic, 57(2), 385-412.

Willingham, D. B., Nissen, M. J. and Bullemer, P. (1989). On The Development of Procedural Knowledge, Journal of Experimental Psychology, 15(6), 1047-1060.

Yılmaz, I. (2011). *Fen Bilgisi Öğretmen Adaylarının Newton'un Hareket Yasalarını Öğrenmelerinde Kurallı Bilgiden Açıklayıcı Bilgiye Geçişte*

Karşılaştıkları Problemlerin İncelenmesi (Yayınlanmamış Doktora Tezi). Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara, 414012. http://tez2.yok.gov.tr/

Yılmaz, İ. (2012). A Study On Prospective Science Teachers' Knowledge and Achievement Levels in Mathematical Logic in Electricity-Related Subjects, Journal of International Education Research, 8(4), in Press

Yılmaz, I. and Yalçın, N. (2011). Probability and Possibility Calculation Statistics for Data Variables (VDOIHI); Statistical Methods for Combined Stage Percentage Calculation, International Online Journal of Educational Sciences, 3 (3), 957-979. http://www.Iojes.net//userfiles/article/IOJES_550.pdf

Yılmaz, İ. and Yalçın, N. (2012). Mathematical Logic Knowledge of Science Teacher Candidates in Newton's Laws of Motion, International Journal of Applied Science and Technology, 2(3), 99-105.

Yılmaz, İ. and Yalçın, N. (2012). The Relationship of Procedural and Declarative Knowledge of Science Teacher Candidates in Newton's Laws of Motion to Understanding, American International Journal of Contemporary Research, 2(3), 50-56.