Fen Bilgisi Öğretmen Adaylarının Newton'un Hareket Yasalarındaki Prosedürel Bilgi Durumları ve Bilginin Kontrolü*

İsmail YILMAZ[1] ve Necati YALÇIN[2]

[1] Sorumlu Yazar: İsmail Yılmaz; Sakarya Üniversitesi, Eğitim Fakültesi, Fen Bilgisi Öğretmenliği, Hendek / Sakarya / Türkiye,
E-mail: iyilmaz@sakarya.edu.tr

[2] Gazi Üniversitesi, Gazi Eğitim Fakültesi, Fen Bilgisi Öğretmenliği, Beşevler-Teknikokullar /Ankara/ Türkiye,
E-mail: necyal@gazi.edu.tr

Öz

Bu araştırmada, fen bilgisi öğretmen adaylarının Newton'un hareket yasalarındaki prosedürel bilgi durumları ve bilgini kontrolünün, değişkenlerin aşamalarının değiştirilmesiyle nasıl elde edileceği incelenmektedir. Fen bilgisi öğretmen adaylarının Newton'un hareket yasalarındaki prosedürel bilgi durumları, nicel ve nitel durum çalışmalarıyla belirlenmiştir. Öğretmen adaylarının prosedürel bilgi durumları: bilgi düzeyleri, başarı düzeyleri ve başarı puanlarını etkile ihtimali bulunan nedenler olarak alınmıştır. Başarı puanlarını etkileme ihtimali bulunan nedenler, değişken ve faktörler olarak ikiye ayrılarak incelenmiştir. Öğretmen adaylarının prosedürel bilgi durumlarını belirlemek için kullanılan ölçme araçları ile elde edilen verilerin analizinde, başarı düzeylerinin nicel uygulamada %56, nitel uygulamada.66 (%66) olduğu bulunmuştur. Bilgi düzeyleri, formül değişkeninde .55 (%55) ve .57 (%57), işlem değişkeninde .48 (%48) dir. Öğretmen adaylarının başarı düzeyleri bilgi düzeylerinden daha yüksek olduğu için başarı düzeyleri bilgi düzeylerini temsil etmediği sonucuna ulaşılmıştır. Bu araştırmada bazı faktörlerin, öğretmen adaylarının başarı puanlarını etkilemediği bulunmuştur. Ayrıca bu araştırmada öngörünün de, değişkenler kadar etkili olduğu bulunmuştur.

Anahtar Sözcükler: Prosedürel bilgi, fen bilgisi öğretmen adaylarının bilgi ve başarı düzeyi, başarıyı etkileyen değişkenler, başarıyı etkileyen faktörler, bilginin kontrolü (kontrollü bilgi elde edilmesi)

* Bu araştırma, İsmail Yılmaz'ın doktora tezinin verilerinden türetilmiştir.

Türkçe Uzun Özet

Giriş

Prosedürel bilgi nasıl düşünüleceğinin bilgisidir (Sahdra & Thagard, 2003; Heyworth, 1999). Ayrıca prosedürel bilginin, kavramların yapılandırılmasında ve deklaratif bilgi elde edilmesindeki önemli rolü (Lawson, at all, 2000; Lawson, 1991), beceri ve görevlerdeki performans değişimi ile ilişkisi (Willingham, Nissen & Bullemer, 1989; Berge & Hezewijk, 1999; LeFevre at all, 2006; Phillips & Carr, 1987) gibi nedenlerden dolayı öğretmen adaylarının prosedürel bilgi durumları, Newton'un hareket yasalarıyla belirlenmiştir.

Materyal Metot

Bu araştırmanın verileri, 2009-2010 öğretim yılında, Newton'un hareket yasalarının öğretildiği genel fizik 1 dersini alan, fen bilgisi öğretmenliği birinci sınıf öğrencilerinden, nicel ve nitel durum çalışmasıyla toplanmıştır. Araştırmanın nicel kısmında "bütüncül çoklu durum deseni" ve nitel kısmında ise "bütüncül tek durum deseni" kullanılmıştır. Araştırmanın nicel verileri; öğretmen adaylarının kişisel bilgilerini belirlemeye yönelik yedi maddeli anket ve geçerlilik güvenilirliği yapılmış on iki çoktan seçmeli prosedürel bilgi sorularından oluşan testle toplanmıştır.

Araştırmanın nitel verileri, üç ölçme aracı ile toplanıştır. Bu ölçme araçlarından ilki; "Nitel ölçme aracı 1 (NÖA 1)" dört yarı yapılandırılmış sorudan oluşmaktadır. Bu sorular, araştırmanın nicel kısmında kullanılan prosedürel bilgi testindeki sorularından seçilmiştir. İkincisi; "Nitel ölçme aracı 2 (NÖA 2)", NÖA 1'in sorularının çözümünde kullanılması gereken fizik formülleridir. Diğer bir değişle NÖA 2, NÖA 1'in prosedürleridir. NÖA 2, öğretmen adaylarının NÖA 1'in prosedürleri bilip bilmediğini ölçmek için yirmi üç 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.

Araştırmanın nicel basamağında uygulanan kişisel bilgi anketine verilen cevaplar ile prosedürel bilgi testine verilen cevaplar arasındaki ilişki analizinde, SPSS paket programı kullanılmıştır. Nitel basamakta uygulanan NÖA 1, NÖA 2 ve NÖA 3 ölçme araçları ile elde edilen 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.

Bulgu, Sonuç ve Yorumlar

Araştırmanın nicel basmağında uygulanan prosedürel bilgi testinin sorularının toplam puanına göre: a) Öğretmen adaylarının cinsiyetlerine göre, t-testi analiz sonucunda, erkek öğretmen adaylarının kız öğretmen adaylarına göre anlamlı[1] olarak yüksek puan aldıkları sonucuna varılmıştır. b) Öğrenim gördükleri üniversitelere göre, ANOVA analiz sonucunda anlamlı[2] farklılık bulunmuştur. Bu anlamlı faklılığın üniversitelerin hangileri arasında olduğunu bulmak için Scheffe testi uygulanmıştır. c) Mezun olunan lise türüne göre, ANOVA analiz sonucunda herhangi bir anlamlı[3] farklılık bulunamamıştır. d) "Newton'un hareket yasalarını" çalışma zamanlarına göre, ANOVA analiz sonucunda herhangi bir anlamlı[4] farklılık bulunamamıştır. e) "Newton'un hareket yasalarını" çalışma sitillerine göre, ANOVA analiz sonucunda herhangi bir anlamlı[5] farklılık bulunamamıştır. f) Genel fizik I dersi geçme notlarına göre, korelasyon analizinde, anlamlı olarak pozitif yönde düşük düzeyde bir ilişki (r=.220, p=.000) olduğu bulunmuştur ve g) Genel matematik I dersi geçme notlarına göre, korelasyon analizinde, anlamlı olarak pozitif yönde düşük düzeyde bir ilişki (r=.130, p=.003) olduğu bulunmuştur. Nicel basamakta cinsiyet, üniversite farklılıkları, genel fizik bir başarı notu ve genel matematik başarı notlarının öğretmen adaylarının prosedürel bilgi durumlarında, başarı puanlarını etkileyen faktörler olduğu sonucuna ulaşılmıştır. Mezun olunan lise türü, "Newton'un hareket yasalarını" çalışma zamanı ve sitillerinin, öğretmen adaylarının prosedürel bilgi durumlarında, başarı puanlarını etkileyen faktörler olmadığı sonucuna ulaşılmıştır.

NÖA 1'deki soruların dört değişkeninin sonuca birlikte etkileri: Fen bilgisi öğretmen adaylarının pozitif aşamalardaki bilgileri, ASS sonucunu %37 etkilediği düşünülmektedir. İlişkisiz bilgileri, ASS sonucunu negatif yönde %6 etkilediği düşünülmektedir. Negatif bilgileri, ASS sonucunu negatif yönde %4 etkilediği düşünülmektedir. Negatif aşamalardaki pozitif bilgileri, ASS sonucunu %4 etkileme ihtimali vardır. Sıfır puanları, ASS sonucunu %53 etkilediği düşünülmektedir. Nitel ölçme aracı 2 bilgisi, ASS sonucunu %54 etkilediği düşünülmektedir. Nitel ölçme aracı 3 bilgisi, ASS sonucunu %82 etkilediği düşünülmektedir.

[1] sonuçların anlamlılık analizi p <.01 düzeyinde yapılmıştır.
[2] sonuçların anlamlılık analizi p <.01 düzeyinde yapılmıştır.
[3] sonuçların anlamlılık analizi p<.01 düzeyinde yapılmıştır.
[4] sonuçların anlamlılık analizi p<.01 düzeyinde yapılmıştır.
[5] sonuçların anlamlılık analizi p<.01 düzeyinde yapılmıştır.

Tartışmalar ve Öneriler

Dört değişkenin VDOHİ birleşik aşama yüzde hesaplama istatistiğinin, görüşmeci için sonuç hesaplamalarıyla elde edilen ve Tablo 1'in değişken toplamları sütununda verilen değerlerden APSS değerlerinin düşük olması, öğretmen adaylarının başarı düzeylerini yansıtan ASS değerinin neden düşük olduğunu açıklar. Bu APSS değeri; doğru sonuca, doğru bilgi (data) ve prosedürlerin açık seçik kaideleri (algoritmalar) çerçevesinde gidilebileceğinin göstergesidir. Bilgideki belirsizlik (SSS) ne kadar çoksa, öğretmen adaylarının sorunun doğru cevabına gitmekte o kadar zorlandıklarını göstermektedir. Doğru cevaba gitmeyi güçleştiren nedenler arasında İSS, ANSS ve NAPSS'nin etkilerinin de olduğu söylenebilir.

Öğretmen adaylarının başarı düzeylerinin bilgi düzeylerini temsil etmemesinin iki nedeni olabilir. Bunlardan ilki ölçme araçlarının sorularının, kıyaslamaya yönelik sorulardan oluşması, başarı düzeyi ile bilgi düzeylerinin farklı olmasına neden olmuş olabilir. Belirli bir sayısal değeri bulmaya yönelik sorulardan oluşturulacak bir ölçme aracı ile elde edilecek sonuçlarla, bu araştırmanın sonuçları karşılaştırılarak sorunun ölçme aracının soru tipine bağlı olup olmadığı belirlenebilir. Başarı düzeylerinin, bilgi düzeylerini temsil etmemesinin ikinci nedeni ise öğretim yöntem ve tekniklerindeki sorunlar olabilir. Ayrıca bilgi ve başarı düzeylerinin düşük oluşunun yanı sıra, verilenler-istenilenler ve serbest cisim diyagramı değişkeninin APS değerlerinin düşük olması da öğretim yöntem ve tekniklerinde bazı sorunların olduğunu gösteriyor olabilir. Aslında bu araştırmadaki başarı düzeyinin, dört değişkenin birlikte hesaplanan APSS değerine göre yüksek oluşu, yöntem ve teknikler lehine başarıyı göstermektedir. Sorun, yöntem ve tekniklerin yetersizliğindedir. Zira hiçbir yöntem veya teknik, herhangi bir bilgi çeşidinin özeliklerini amaç edinerek geliştirildiği söylenemez. Herhangi yöntem veya tekniğin, bilginin: konu ve bilgi türü açısından, ilmi epistemolojik yönü ve seviye özelliklerini dikkate alınarak geliştirilmemesi, yine bilginin semiotik özelliklerinin dikkate alınarak, yöntem veya tekniklerin geliştirilmemeleri araştırmadaki bu sonuçların doğmasına neden olmuş olabilir. Bunlar, yöntem ve tekniklerin yetersizliği olarak değerlendirilip, bu yetersizliklerin giderilmesi yönünde geliştirmelerin yapılabileceği gibi her biri, yöntem ve tekniklerden ayrı ayrı ele alınıp, eğitim ve öğretim süreçlerine dahil edilerek özelleştirilebilir. Eğitim ve öğretim süreçlerinin çeşitlendirilmesinin gerekliliği sadece bu araştırmanın sonuçlarına dayanılarak söylenebilecek bir çıkarım olmayıp, yöntem ve tekniklerin pirimitifliğinede dayandırılabilir. Yöntem ve tekniklerin, sosyal bilim-temel bilim, özürlü-sağlıklı, branş (spor-resim-müzik-fen bilgisi-v.b.) gibi sınırlarının

belirginleştirilmemesi, pirimitif düzeyde olduklarının göstergesi olarak alınabilir.

Bilgi üretim kalitesi ve efisiyansının, kontrol teorisi içerisinde yer alan, maksimizasyonunun yapılabilmesinde, değişkenlerin ANS, SS ve İS değerlerinin minimizasyonu ve APS değerinin maksimizasyonunun, öğretmen adaylarının bilgilerinin kontrolünde, önemli katkıları olabilir. Bu araştırmada verilerine dayanarak, öğretmen adaylarının bilgilerinin kontrolüne başlanacak ilk değişken, verilenler-istenilenler değişkeni olmalıdır. Bilginin kontrolüne, bu değişkenin APS değerinin maksimizasyonuyla başlanmalıdır. APS değerinin maksimizasyonu, ANS, NAPS ve SS skorlarını minimum yapacaktır. Fakat İS'nin minimizasyonunun, APS değerinin maksimisazyonuyla doğrudan bir ilişkisi olmayabilir. İS'nin minimizasyonuna, APS'nin maksimizasyonundaki gibi özel bir stratejiyi gerektirebilir. Bilginin kontrolünde, serbest cisim diyagramı değişkeninin APS değerinin maksimizasyonu verilenler-istenilenler değişkenindeki maksimizasyon ve minimizasyondan sonra yapılmalıdır. Formül değişkeninin APS değerinin maksimizasyonu, önceki iki değişkenin maksimizasyonundan sonra yapılabileceği gibi bu iki değişkenden öncede yapılabilir. Fakat işlem değişkeninin APS değerinin maksimizasyonu en son yapılmalıdır. Formül ve işlem değişkenlerinin APS değerlerinin maksimizasyonu, öğretmen adaylarının hem bilgi düzeylerini hem de başarı düzeylerini artırabileceği gibi başarı düzeylerinin, bilgi düzeylerini temsil etmesine de katkı sağlayabilir.

Prospective Science Teachers' Procedural Knowledge about and Knowledge Control in Newton's Laws of Motion

İsmail YILMAZ[1] and Necati YALÇIN[2]

[1]Correspondence to: İsmail Yılmaz; Sakarya University, Faculty of Education, Science Education, Hendek / Sakarya / Turkey,
E-mail: iyilmaz@sakarya.edu.tr

[2] Gazi University, Gazi Faculty of Education, Science Education / Ankara /Turkey,
E-mail: necyal@gazi.edu.tr

Abstract

The present study investigates how prospective science teachers' procedural knowledge about and knowledge control in Newton's laws of motion can be determined through changes in the stages of the variables. Their procedural knowledge was regarded as a reason that might have an effect on their knowledge levels, achievement levels and achievement scores. The analysis of the data obtained through the measurement tools used to determine their procedural knowledge showed that their achievement level is 56% in the quantitative implementation but 66% in the qualitative one. Their knowledge level is 0.55 (55%) and 0.57 (57%) in the variable "formula" while it is 0.48 (48%) in the variable "operation". This study was concluded that students achievement level does not represent their knowledge level. For this study, the variable "given-asked" is the one in which knowledge control can be started earliest. The first thing to do should be to maximize the APS value of this variable. This maximization will result in the minimization of the ANS, NAPS and SS scores.

Key Words: Procedural knowledge, prospective science teachers' knowledge and achievement levels, variables in achievement, factors in achievement, knowledge control

Introduction

Collective use of procedural and declarative knowledge improves education (Willingham, Nissen&Bullemer, 1989). Procedural and declarative knowledge can be enhanced through various methods and techniques. They can also contribute to the development of such methods and techniques (Drummond et al., 1998; Howe et al., 2000; Kamouri et al., 1986; Johnson&Star, 2007; Kırkhart, 2001; Andre&Ding, 1991). In order to teach science in a decent way, it is important to study students' procedural knowledge levels. The reason for this is that teaching science is a scientific discipline (Good et al., 1985) including basic definitions of science and that procedural knowledge is a part of scientific knowledge.

The present paper is based on three reasons for studying students' procedural knowledge levels. Firstly, procedural knowledge is part of scientific knowledge. Next, most of our knowledge is in fact procedural (Anderson et al., 2001; Baumard, 1999; Dacin&Mitchell, 1986). Finally, there is a correlation between obtaining controlled knowledge (Anderson 1976, 1983; Baumard, 1999) and comprehension/procedural knowledge during the process of instruction and education (Ozenli, 1994, 1999). Therefore, instructional/educational methods and techniques could benefit from the incorporation of these three reasons into the process of instruction/education within the framework of the principles of induction and deduction.

Obtaining controlled knowledge is related not only to the definition of procedural knowledge but also to variables. Procedural knowledge is obtained through the rules that show how something can be carried out and in which certain instructions or commands are put into practice step by step (Hiebert&Lefevre, 1986; Star, 2002). Thus, it can also be called the kind of knowledge obtained through control. What knowledge "control" means is "*not that the trainee does not have free will! It means the maximization of the quality and efficiency of the trainee's functional behaviors and production within the framework of the theory of control depending on the trainer's criteria and limitations (restrictive conditions)* (Ozenli, 1999)". The maximization of the quality and efficiency of the trainee's production can be achieved either by complying with the instructions included within the characteristics of procedural knowledge step by step or by increasing the APS values in the stages of the variables. This study discusses "control" over the APS values in the stages of the variables.

The relationship between procedural knowledge and comprehension could be established within the framework of cybernetic and mathematical logic as follows:

"*In information or data follow, comprehension refers to the conceptualization of the integration of regularities and cognitive modules, which seem to be relatively independent of each other, within a superstructure semantic web, and thus an understanding into how to decipher the code of what is perceived in semantic memory by transforming "procedural knowledge form" into "declarative knowledge" structure* (Ozenli, 1999)". The definition might suggest that procedural knowledge is a starting point of comprehension.

"*The logical foundations of man's cognitive functions constitute "the operational notion of sanity". It is surely beyond doubt that one must accept the existence of some notable procedural knowledge for the structure of this cognitive domain. Such knowledge automatically represents itself with reconciliation between practical and cognitive axioms through scientific books or publications that include graphical-pictorial, statistical and semantic characteristics. This cognitive automatism is always ready for axiom… Whereas cognitive automatism is a flowchart for activities, comprehension is the conceptualization of the integration of cognitive modules in this chart, which seem to be relatively independent of each other, within a semantic web. This state begins when the connection among the three sets of fundamental knowledge, namely "pictorial-graphical", "procedural-declarative" and "verbal", is established* (Ozenli, 1999)".

Procedural knowledge is about how to think (Sahdra&Thagard, 2003; Heyworth, 1999). Furthermore, it plays a key role in constructing concepts and obtaining declarative knowledge (Lawson et al., 2000; Lawson, 1991). It is also related to skills and performance change in tasks (Willingham, Nissen&Bullemer, 1989; Berge&Hezewijk, 1999; LeFevre et al., 2006; Phillips&Carr, 1987). Therefore, students' procedural knowledge levels were determined through Newton's laws of motion.

Methodology

The data for the study were collected from 1st grade prospective science teachers taking the lesson Physics 1, in which Newton's laws of motion are covered, through quantitative and qualitative case studies. "Holistic multi-

state design" and "holistic single-state design" were used for the quantitative and qualitative parts of the study respectively. The quantitative data were collected through a 7-item questionnaire designed with the purpose of collecting personal information about students and a test which consisted of 12 multiple-choice questions on procedural knowledge, whose reliability and validity had been established beforehand (Cronbach Alpha "α": 0,82). The questionnaire on personal information included questions as to a) gender, b) university, c) type of high school d) time spent on studying Newton's laws of motion e) styles of studying Newton's laws of motion f) achievement score in general physics 1 g) achievement score in general math 1. Procedural knowledge is the kind of knowledge that explains how a certain process can be carried out within the framework of specific and clear procedures (Ozenli, 1999). Ten of the questions on procedural knowledge were chosen from the literature in order to determine those students who fit that description (Halloun, Hake, Mosca&Hestenes, 1995; Baharestani, 1999). The remaining two questions, on the other hand, were composed by the researcher. The questions on procedural knowledge were based on comparisons about motion as affected by friction force, free fall, projectile motion, constant velocity motion, centripetal force, accelerated motion and spring force. No numerical value was asked for.

The qualitative data for the study were collected through three different measurement tools. The first one is "The Qualitative Measurement Tool 1 (the QMT 1) which is comprised of four semi-structured questions. These questions were chosen among the questions used for the test on procedural knowledge. The second one, "The Qualitative Measurement Tool (the QMT 2)", includes formulas for physics required to solve the problems in the QMT 1. In other words, the QMT 2 includes the procedures for the QMT 1. The QMT 2 is comprised of 23 semi-structured questions to measure whether students have a clear idea about the procedures for the QMT 1. The third measurement tool, "The Qualitative Measurement Tool 3 (the QMT 3)", contains 50 semi-structured questions to measure their basic knowledge about math which is required for the questions in the QMT 1. 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 population of the study was comprised of 1st grade prospective science students from the faculties of education located in Turkey. The sample of the study from whom the quantitative data were collected was comprised of 599 1st grade students studying at the department of Science Teaching, faculty of education, at seven universities in Turkey, during the second term of

the educational year 2009-2010. These students had already taken general physics 1 and general math 1. The universities were randomly selected on the basis of provincial achievement and achievement of the universities themselves. The sample of the study from whom the qualitative data were collected was comprised of 7 voluntary students who had answered the questions included within the quantitative data collection tools and whose answers differed in achievement score in general physics 1, achievement score in general math 1 and answers to the questions in the questionnaire.

The present study was implemented in two stages, namely the quantitative one and the qualitative one. At first, the data for the study were collected through the questionnaire on personal information and test on procedural knowledge (the quantitative stage). Afterwards, the QMT 1, the QMT 2 and the QMT 3 were implemented (the qualitative stage). Through these measurement tools, the data were collected in one session with two parts, namely the written one and the interview-based one. During the former, the students were informed about the measurement tools. After that, they were asked to solve the problems in the QMT 2, the QMT 3 and the QMT 1 respectively. During the second part, the data were collected through interviews in which the students were asked to explain how they solved the problems in the QMT 1. When suitable, their answers were compared with the data from the QMT 2 and the QMT 3 and they were addressed with certain questions. Furthermore, when the need arose, the students were asked to explain some of the data obtained from the QMT 1. For example, free-body diagram could have been used by one of the students for solving one of the problems. This student was asked to draw the free-body diagram if he/she had not used it for the question in the QMT 1. The other six students underwent the written part and the interview-based part in the same order.

The students' procedural knowledge about Newton's laws of motion was determined depending on the reasons that might have an effect on their knowledge levels, achievement levels and achievement scores. Whether students can obtain controlled knowledge or not will be discussed over the APS values in the stages of the variables. Their knowledge levels were determined through the APS value of the variables "formula" and "operation", two variables measured in the qualitative stage. Since the variable "given-asked" constituted the data for the study and the variable "free-body diagram" was merely a method to make it easier for the students to solve the problems, the APS values in neither of these variables were considered as knowledge level. Their achievement levels, on the other hand, were determined through quantitative and qualitative stages. Their achievement levels were discovered

through the test on procedural knowledge and the QMT 1 in the quantitative stage and qualitative stage respectively. Their achievement in the qualitative stage was discovered through the written part. The correct answers provided by the students to the questions included in the test on procedural knowledge were regarded as "The ratio of correct answers to the test in Table 1" whereas the correct answers they provided to the questions included in the QMT 1 were accepted as "The ASS Value by Percentage". Their achievement levels in the QMT 2 and the QMT 3 were determined as well.

The reasons that might have an effect on their achievement score were divided into two groups, namely variables and factors in achievement. In this study, the factors in achievement were determined through the quantitative and qualitative stages. Some of the factors measured through the quantitative stage cannot be changed. Even so, they can be improved, which is actually one of the objectives of education. On the other hand, the factors measured through the qualitative stage[6] can be changed.

Some of these factors were measured with the items included in the questionnaire on personal information. The other factors in achievement were measured through the QMT 2 and the QMT 3 during the written part of the qualitative stage. An attempt was made to determine whether there was a significant correlation between the items included in the questionnaire on personal information and the test on procedural knowledge. The factors between which there was a significant correlation are those factors which have an influence on achievement. On the other hand, the factors between which there was no significant correlation are factors which do not have an influence on achievement. A calculation was made into the effects of the factors "the QMT 1" and "QMT 2", which were measured in the qualitative stage, on the result (ASS) by percentage, i.e. on achievement level.

In this study, the variables in achievement were measured through the written and interview-based parts in the qualitative stage. The variables in achievement are as follows: a) given-asked b) free-body diagram c) formulas for solutions to the questions d) operations required for solutions to the questions. The students' scores in these variables were calculated in order to determine the effect of the variables on the score in the QMT 1 (ASS). Their procedural knowledge about Newton's laws of motion was determined with a consideration into the fact that their scores in the variables might have an

[6] This study considers the QMT 2 and QMT 3, which were measured in the qualitative stage, as factors in achievement. They can also be accepted as variables in different studies.

effect on the result (ASS). Knowledge control, on the other hand, was evaluated on the basis of the APS, ANS, NAPS, SS, IS values of the variables.

An interval scale was used for their achievement scores in general physics 1 and general math 1. A nominal scale was used for their gender, university, type of high school, time spent on studying Newton's laws of motion, styles of studying Newton's laws of motion, the test on procedural knowledge, the QMT 1, the QMT 2 and the QMT 3.

SPSS was used for the analysis of the correlation between the answers to the questionnaire on personal information and the test on procedural knowledge. The data obtained through the QMT 1, the QMT 2 and the QMT 3 were analyzed through a software program developed for Probability and Possibility Calculation Statistics for Data Variables (VDOIHI); Statistical Methods for Combined Stage Percentage Calculation (Yılmaz, 2011; Yılmaz&Yalçın, 2011).

Findings and Conclusion

The students' achievement levels regarding their procedural knowledge about Newton's laws of motion were determined through their (599 students) answers to the questions included within the test on procedural knowledge about Newton's laws of motion. The study found that the students had an achievement level of 56% in the quantitative stage. In other words, those students participating in the quantitative stage of the study got 4,025 points out of twelve questions on procedural knowledge (each correct answer was scored 1). The maximum point that can be obtained from the test is 7,188 (the number of students X the number of questions). Therefore, the students had an achievement level of 0.56 in the test on procedural knowledge. Table 1 presents the proportion of the correct answers provided by the students to the maximum score that can be obtained from the measurement tool implemented in the quantitative stage of the study, and findings and results obtained through the measurement tools in the written and interview-based parts in the qualitative stage.

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

Points/ Variable	Given-Asked			Free-Body Diagram			Formulas			Operations			Sum of Variables		
	Written	Interview	Difference %	Written	Interview	Difference %	Written	Interview	Difference %	Written	Interview	Difference %	Written	Interview	Difference %
P	33,00	55,00	66,67	13,00	29,00	123,0	63,00	73,00	15,87	100,0	100,0	0,00	209,0	257,0	22,97
BGS	350,0			147,0			147,0			273,0			917,0		
İS(S)	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,02	0,00	0,15	0,15	0,00	0,06	0,06	0,00
APS(S)	0,12	0,16	33,33	0,12	0,23	91,67	0,55	0,57	3,64	0,48	0,48	0,00	0,34	0,37	8,82
ANS(S)	0,00	0,00	0,00	-0,18	-0,22	22,22	-0,01	-0,01	0,00	-0,05	-0,05	0,00	0,03	0,04	33,33
NAPS(S)	0,00	0,00	0,00	0,05	0,10	100,0	0,02	0,02	0,00	0,07	0,07	0,00	0,03	0,04	33,33
SS(S)	0,88	0,84	-4,54	0,81	0,44	-45,68	0,43	0,37	-13,95	0,40	0,40	0,00	0,58	0,53	-8,62
QMT2 S	0,54														
QMT3 S	0,82														
The Response Rate to the Test	0,56														
ASS	0,66	0,66													

The achievement levels of the students participating in the qualitative stage of the study were determined through their answers to the questions in the QMT 1. The achievement levels in the qualitative stage were determined through the written part. It was discovered that the seven students participating in the written part had an achievement level of 66% in the questions on procedural knowledge about Newton's laws of motion. In other words, the students participating in the qualitative stage of the study got 18.48 points out of the answers they provided to the four questions on procedural knowledge. The fraction "0.48" resulted from the fact that one of the questions required two different pieces of knowledge. Each correct answer was scored 1. Then, the total score was divided by two, which yielded this fraction. In other words, this fraction was obtained because the students got a score of 0.5 when they provided a correct answer to this particular question. The maximum score that can be obtained from the questions on procedural knowledge is 28 (the number of questions X the number of questions). The students had an achievement level of 0.66 in the questions on procedural knowledge in this stage. Their achievement levels in the QMT 2 and the QMT 3 were 54% and 82% respectively.

Their knowledge level in the variable "formula" was 0.55 (55%) and 0.57 (57%) whereas it was 0.48 (48%) in the variable "operation". Since their achievement levels in the variable "formula" and in the test on knowledge are similar, a connection could be established between the former and the latter. Nevertheless, their knowledge level in the variable "operation" experienced a decrease, so it cannot represent their knowledge level. The achievement level measured in the qualitative stage is higher than knowledge level in the variables "formula" and "operation". Seeing that their knowledge level especially in the variable "operation" was lower than the one in the variable "formula", and there was a great discrepancy between their achievement level and knowledge level, it was concluded that their achievement level does not represent their knowledge level, 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.

This paragraph includes the factors that might have an effect on the students' achievement scores in their procedural knowledge about Newton's laws of motion. The t-test analysis showed that the male students got significantly[7] higher scores than the female ones (Table 2). The analysis of

[7] The analysis of significance was conducted at the level $p<.01$.

variance yielded significant[8] differences in the students' procedural knowledge depending on the university they study at (Table 3). Scheffe' test was conducted in order to determine between which universities the difference existed (Table 4). The test concluded that the students from the 1st university got significantly[9] higher scores in the questions on procedural knowledge than those from the 5th one; those from the 3rd one than those from the 5th one; those from the 4th one than those from the 2nd, 5th and 6th ones; and those from the 7th one than those from the 5th one. The ANOVA reported no significant[10] difference in scores depending on the type of high school the students had graduated from (Table 5). Similarly, the analysis reported no significant[11] difference in scores depending on the amount of time spent on studying Newton's laws of motion (Table 6). Likewise, no significant[12] difference in scores existed between different styles of studying Newton's laws of motion (Table 7). The correlation analysis of the scores in general physics 1 yielded a slightly significant and positive correlation. (r=.220, p=.000) (Table 8). Similarly, the correlation analysis of the scores in general math 1 yielded a slightly significant and positive correlation (r=.130, p=.003) (Table 9). It was concluded that gender, differences in university, achievement score in general physics 1 and general math 1 are factors that have an influence on the students' procedural knowledge. However, the type of high school they graduated from, time spent on and styles of studying Newton's laws of motion are not factors in their procedural knowledge.

Table 2. The t-test results by gender

Gender	***N***	***X***	***SS***	***sd***	***t***	***p***
Female	442	5.50	2.09	.099	3.47	.001
Male	157	6.19	2.23	.178		

**p<.01

[8] The analysis of significance was conducted at the level p<.01.
[9] The analysis of significance was conducted at the level p<.01.
[10] The analysis of significance was conducted at the level p<.01.
[11] The analysis of significance was conducted at the level p<.01.
[12] The analysis of significance was conducted at the level p<.01.

Table 3. The ANOVA results byby üniversities students study at

University	***N***	***X***	***SS***		**Sum of Squares**	***Sd***	**Mean Square**	***F***	***p***
1. University	172	6.30	1.96	Between the groups	427.01	6	71.17	17.98	.000
2. University	59	5.27	1.93						
3. University	66	5.53	1.87	In Groups	2343.22	592	3.95		
4. University	70	6.81	2.25						
5. University	78	3.94	2.04						
6. University	66	5.15	1.84	Total	2770.24	598			
7. University	88	3.93	1.99						

**p<.01

Table 4. Procedural knowledge questions total points Scheffe test results by universities study at

University	**University**	**The Mean Difference**	***p***
1. University	5. University	2.35	.000
3. University	5. University	1.58	.001
4. University	2. University	1.54	.004
4. University	5. University	2.86	.000
4. University	6. University	1.66	.001
7. University	5. University	1.98	.000

Table 5. The ANOVA results by the type of high school which students graduated

The Type of High School	**N**	**X**	**SS**		**Sum of Squares**	**Sd**	**Mean Square**	**F**	**p**
High School	269	5.64	2.13	Between the groups	17.42	2	8.71	1.88	.152
Anatolia and Science High school	258	5.84	2.18	In Group	2752.81	596	4.61		
Second Language High School	72	5.30	2.06	Total	2770.24	598			

Table 6. The ANOVA results by the amount of time spent on studying Newton's laws of motion

The Amount of Time Spent	N	X	SS		Sum of Squares	Sd	Mean Square	F	p
After Class	200	5.64	2.03	Between the groups	.775	2	.388	.083	.920
Before Exam	304	5.72	2.16	In Groups	2769.46	596	4.64		
Before and After Class and Before Exam	95	5.67	2.36	Total	2770.24	598			

Table 7. The t-test results by style of studying Newton's laws of motion

Style of Studying	N	X	SS	sd	t	p
Listening Class	263	5.76	2.19	.135	.752	.452
Listening Class and using different materials	336	5.63	2.11	.115		

Table 8. Correlation results between students general physics I grades and procedural knowledge test

	Procedural Knowledge Q.
General Physics I	.220**

** p<.01

Table 9. Correlation results between students general mathematics I grades and procedural knowledge test

	Procedural Knowledge Q.
General Mathematics I	.130**

** p<.01

The factors in the QMT 2 and the QMT 3 determined in the qualitative stage were interpreted on the basis of the findings obtained in the written part. The students' knowledge about the QMT 2 is thought to affect their scores in the QMT 1, i.e. their achievement level, by 54%. Their knowledge

about the QMT 3 is thought to affect their scores in the QMT 1, i.e. their achievement level, by 82%.

The effects of the variables measured through the written part on the result "ASS" are as follows:

It is thought that the students' knowledge in the positive stages of the variable "given-asked" 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 "free-body diagram" has an effect of 12% on the ASS value. Their unconnected knowledge cannot affect the ASS value (0%). Their negative knowledge is thought to affect the ASS value negatively by 18%. Their positive knowledge in the negative stages might have an influence of 5% on the ASS value. It is thought that zero score has an effect of 81% on the ASS value.

It is thought that the students' knowledge in the positive stages of the variable "formula" has an effect of 55% on the ASS value. Their unconnected knowledge is thought to affect the ASS value negatively by 2%. Their negative knowledge is thought to affect the ASS value negatively by 0.90%. 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 43% on the ASS value.

It is thought that the students' knowledge in the positive stages of the variable "operation" has an effect of 48% 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 5%. Their positive knowledge in the negative stages might have an influence of 7% on the ASS value. It is thought that zero score has an effect of 40% on the ASS value.

The collective effects of the four variables of the questions in the QMT 1 on the result are as follows: Their knowledge in the positive stages has an effect of 34% on the ASS value. Their unconnected knowledge is thought to affect the ASS value negatively by 6%. Their negative knowledge is thought to affect the ASS value negatively by 3%. Their positive knowledge in the negative stages might have an influence of 3% on the ASS value. It is thought that zero score has an effect of 40% on the ASS value. Their knowledge about the QMT 2

is thought to have an effect of 54% on the ASS value whereas their knowledge about the QMT 3 is believed to have an effect of 82% on the ASS value.

The effects of the variables measured through the interview-based part on the result "ASS" are as follows:

It is thought that the students' knowledge in the positive stages of the variable "given-asked" has an effect of 16% 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 the negative stages cannot have an influence on the ASS value (0%). It is thought that zero score has an effect of 84% on the ASS value.

It is thought that the students' knowledge in the positive stages of the variable "free-body diagram" has an effect of 23% on the ASS value. Their unconnected knowledge cannot affect the ASS value (0%). Their negative knowledge is thought to affect the ASS value negatively by 22%. Their positive knowledge in the negative stages might have an influence of 10% on the ASS value. It is thought that zero score has an effect of 44% on the ASS value.

It is thought that the students' knowledge in the positive stages of the variable "formula" has an effect of 57% on the ASS value. Their unconnected knowledge is thought to affect the ASS value negatively by 2%. Their negative knowledge is thought to affect the ASS value negatively by 0.8%. 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 37% on the ASS value.

It is thought that the students' knowledge in the positive stages of the variable "operation" has an effect of 48% 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 5%. Their positive knowledge in the negative stages might have an influence of 7% on the ASS value. It is thought that zero score has an effect of 40% on the ASS value.

The collective effects of the four variables of the questions in the QMT 1 on the result are as follows: Their knowledge in the positive stages has an effect of 37% on the ASS value. Their unconnected knowledge is thought to affect the ASS value negatively by 6%. 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 4% on the ASS value. It is thought that zero score has an effect of 53% on the ASS value. Their knowledge about the QMT 2 is thought to have an effect of 54% on the ASS value whereas their knowledge about the QMT 3 is believed to have an effect of 82% on the ASS value.

Discussion and Implications

The APS value of the variable "given-asked" in the interview-based part increased by 33,33% when compared to the written part. However, the IS, ANS and NAPS values did not change and had a value of 0, which suggests that there is no correlation between the stage scores of this variable. The variable was affected only by the positive stage. This variable is the data on the procedural knowledge and includes clues as to the prerequisites for solving the problems. The fact that the IS and ANS values are not included among these prerequisites indicates that the process of problem-solving was not affected by the errors in the prerequisites, which, in turn, suggests that the effect on the ASS value was caused only by the variables specified. In other words, this suggests that the effect on the ASS value was not caused by an uncertain variable or factor. The APS results were low in both the written part and interview-based part, which suggests that the amount of data perceived by the students is low and the ASS value will be low, too. Alternatively, this suggests that not knowledge but foresight will be important in the ASS value in the event that measurement tools do not require a statistical value. The reason is that the ASS value was 0.66 although the PSS values obtained by calculating the four variables collectively were 0.34 and 0.37, which suggests that foresight is as influential as the variables. If the purpose of education is to ensure the transition from data to knowledge through scientific processes, increasing the APS values of the variables in the present study can be argued to be the educational purpose of the study. The reason is that an increase in the APS value will decrease the influence of foresight and increase the effect of scientific processes on the transition from data to knowledge. The correlation between the APS and foresight is the starting point of obtaining controlled knowledge throughout the process of education.

The APS values of the variable "free-body diagram" were low in the written part and interview-based part, which indicates that the variable should be attached as much priority as the variable "given-asked" in order to enable students to move from data to knowledge. The APS value of the variable "free-body diagram" in the interview-based part increased by 91,67% when compared to the written part, which resulted in a correlative increase in the ANS and NAPS values. The increases in the percentages of the ANS and APS were similar and directly proportional to each other. The increase in the percentage of the ANS was inversely proportional to the one in that of the APS. The increase in the percentage of the NAPS was higher than the one in that of the ANS, which reflects the tendency of the negative stage to turn into the positive stage. The fact that the negative stage is open to positive change could

be an advantage of trainers during the process of education. When they are aware of the fact that the negative stage is open to positive change and when they are able to increase the APS value, the variable might undergo a quick transformation.

The APS values of the variable "formula" in the written and interview-based parts were in parallel with the values in the QMT 2, which measures whether the students have a clear idea about the formulas they require for solving these questions. The parallelism indicates that the two measurement tools are reliable. The APS values and the QMT 2 values provide information about the students' knowledge level about the rules of procedural knowledge. The fact that the APS and ASS values were similar suggests that they are directly proportional to each other. This correlation means that the students' problems with procedural knowledge are caused by other variables or factors. There is a slight difference between the written and interview-based parts, which indicates that the students' knowledge in the positive stage is closed to change. In other words, it indicates how difficult it is to change their memorized knowledge. Furthermore, it suggests that improvements in the other variables are so important in order for their achievement level in solving questions to get improved.

The APS value of the variable "operation" in the written and interview-based parts was lower than that of the variable "formula", which suggests that the students have problems with carrying out operations with these formulas. These problems could be the low amount of data they could perceive in the variable "given-asked" and their limited ability to make use of the free body diagram. The problems with the variable "operation" could be related to the characteristics of the variable itself. The definition of the regular knowledge could account for this relation. It suggests that a certain process cannot be carried out within the framework of specific and clear principles (algorithms). In other words, it shows that students have difficulty in establishing connection between their pieces of memorized knowledge. If one of the objectives of education is to enable students to transform knowledge into comprehension by using data and/or procedures (memorized knowledge and operations), the fundamental variable for this process is "operation", which is a dependent one since it is affected by the others. Furthermore, this variable is the fundamental one whereby a control over knowledge can be achieved. The IS value in this variable might suggest that students unconsciously make an attempt to get rid of the SS situations in the variable "formula". It can also be interpreted as the follow-up of the IS knowledge in the latter variable. The value of the QMT 2, which is used to measure whether students have an idea about the procedures

for the variable "operation", was the highest of all measured throughout the present study. Nevertheless, the APS values of this variable was lower than those of the variable "formula", which suggests that students have problems with using their knowledge about math in formulas. The problem that "a certain process cannot be carried out within the framework of specific and clear principles" is also the case for their knowledge about math. The fact that the APS values did not differ between the written and interview-based parts might have been caused by the high value of the QMT 3. No difference exists between the stage values of the written and interview-based parts for this variable, which suggests that the students were not affected by the researcher while they were trying to come up with a solution.

The APSS values of the four variables are low, which explains why the ASS value, an indicator of the students' achievement level, is low. This APSS value is an indicator of the fact that students are able to come up with the solution to the questions within the clear principles (algorithms) of accurate data and procedures. The more ambiguity exists in knowledge (SSS), the more difficulty students have in coming up with a proper solution. Among the reasons for the difficulty in coming up with the correct solution are the effects of the ISS, ANSS and NAPSS.

In the quantitative stage of the study, there is a significant difference between the data obtained from the students from seven different universities, which suggests that they have different types of and problems with knowledge. In other words, their problems with knowledge are not caused by chronic problems. For instance, the problem the students have with understanding Newton's laws of motion might be caused by the educational differences at the universities or individual problems of students rather than the difficulty presented by the subject itself. This is a positive condition for education, for it is fixable or improvable. In addition, an important educational result is presented by the fact that different educational processes yield different results.

It is possible that there are two reasons for the fact that the students' achievement level does not represent their knowledge level. Firstly, the difference between their achievement level and knowledge level might have resulted from the fact that the questions included within the measurement tools are based on comparison. It is recommended that a different study should be conducted with a measurement tool which consists of questions on finding a certain statistical value and therefore a comparison could be made between the results of that kind of a prospective study and the present one in

order to check whether the problem is caused by the type of the questions included in the measurement tool. In that case, however, it can be concluded from the APS values of the variables in the present study that the achievement levels to be obtained through such a measurement tool based on certain statistical values will be low. The second reason why their achievement level does not represent their knowledge level might be the problems with the educational methods or techniques. Besides the low level of knowledge and achievement, the APS values in the variables "given-asked" and "free body diagram" were low, which suggests that there are certain problems concerning the educational methods or techniques. In fact, the achievement level measured by this study was higher when compared to the collective APSS value of the four variables, which is an achievement on the part of the methods and techniques. The problem is that methods and techniques are insufficient, for no method or technique can be argued to have been designed for the characteristics of a certain type of knowledge. The results of the present study might have been caused by the fact that no method or technique is designed with a consideration into the scientific epistemological or semiotic aspects of knowledge in terms of subject and knowledge type. These should be considered as the insufficiency of methods and techniques. Therefore, certain improvements could be made. Alternatively, each of them could be assessed independent of others, incorporated into the process of education and instruction, and customized. The necessity that educational and instructional processes should be more varied and diversified is not an assumption that can be presented only by the results of this study. In contrast, it can be based on the primitiveness of methods and techniques. The boundaries of methods and techniques are clear-cut and different for social science-fundamental science, disabled-healthy, or different branches (sports, painting, music, science, etc.), which suggests that they are primitive.

The minimization of the ANS, SS and IS values and the maximization of the APS value could make a great contribution to knowledge control and the maximization of the quality and efficiency of knowledge production, which is included in the theory of control. For this study, the variable "given-asked" is the one in which knowledge control can be started earliest. The first thing to do should be to maximize the APS value of this variable. This maximization will result in the minimization of the ANS, NAPS and SS scores. Even so, there might not be a direct correlation between the minimization of the IS and the maximization of the APS. The former might require a specific strategy. Afterwards, the APS value of the variable "free-body diagram" should be maximized. The APS value of the variable "formula" could be maximized either

earlier or later than these two variables. However, the APS value of the variable "operation" should be maximized later than the other variables. The maximization of the APS values of the variables "formula" and "operation" could increase both the students' achievement level and knowledge level, and thus help the former to represent the latter.

Acknowledgement

This study is derived from correspondence's doctoral thesis.

References

Anderson, J.R. (1976). Language, Memory and Thought, Hillsdale, NJ: Erlbaum.

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

Anderson, L.W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J. and Wittrock, M. C. (2001). A Taxonomy for Learning, Teaching and Assessing, New York, Longman, pp: 27-29.

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.

Baharestani, H.H. (1999). *Relationships Among Reasoning Ability, Meaningful Learning and Computer Based Instruction Students' Understanding of Newton's Laws* (Unpublished Doctor's Thesi). The University of San Francisco, The Faculty of The School of Education Learning and Instruction, San Francisco, 112, 9970526.

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.

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.

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

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, ss: 3-14.

Halloun, I., Hake, R., Mosca, E. and Hestenes, D. (1995). The Force Concept Inventory (Revised 1995) in Mazur 1997 and Password Protected at Http://Modeling.Html Accessed on 2001.

Heyworth, R. M. (1999). Procedural and Conceptual Knowledge of Expert And Novice Students for The Solving of A Basic Problem In Chemistry, International Journal of Science Education, 21(2), 195-211.

Hiebert, J. and Lefevre, P. (1986). Conceptual and Procedural Knowledge in Mathematics: An Introductory Analysis. in J. Hiebert (Ed.), Conceptual and Procedural Knowledge: The Case of Mathematics, Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 1-27.

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, s: 100.

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

Lawson A. E. (1991). Constructivism and Domains of Scientific Knowledge: A Reply to Lythcott and Duschl, Science Education, 75(4), 481-488.

Lawson, A. E., Alkhoury, S., Benford, R., Clark, B.R. and Falconer, K.A. (2000). What Kinds of Scientific Concepts Exist? Concept Construction and Intellectual Development in College Biology, Journal of Research in Science Teaching, 37(9), 996-1018.

Lefevre, J. A., Smith-Chant, B.L., Fast, L., Skwarchuk, S.L., Sargla, E., Arnup, J.S., Penner-Wilger, M.,Binsanz, J. and Kamawar, D. (2006). What Counts as Knowing? The Development of Conceptual and Procedural Knowledge of Counting from Kindergarten Through Grade 2, Journal of Experimental Child Psychology, 93(4), 285-303.

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

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

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.

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

Star, J. R. (2002). Re- "Conceptualizing" Procedural Knowledge in Mathematics, Reports-Descriptive, 1-8.

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

Effect of Science and Technology Club on Students' Science and Technology Literacy and Attitudes towards Science*

Özlem BELHAN [1] ve Canan LAÇİN ŞİMŞEK [2]

[1] Sakarya Üniversitesi, Eğitim Bilimleri Enstitüsü, İlköğr. Fen Bilgisi Eğitimi ABD
E-mail: y097047010@sakarya.edu.tr

[2] Sakarya Üniversitesi, Eğitim Fakültesi, Fen Bilgisi Öğretmenliği

E-mail: csimsek@sakarya.edu.tr

Abstract

The purpose of this study is to determine whether The Science and Technology Club has effect on the scientific and technology literacy and the attitude towards science of primary school students or not. The study is an experimental study, in this study pre-test–post-test control group pattern is used. A total of 48 students randomly selected by assigning were included in the survey, 24 students from the experimental group and 24 students from the control group. In the experimental group, activities of the Science and Technology Club were applied; whereas in the control group, activities of the other clubs were applied. In this study, Scientific Literacy Scale and Attitude Towards Science of Scale were used for data collection. Scientific Literacy Scale and Attitudes Toward Science Scale was applied as pre-test and post-test to control and experimental groups. In analysing data, t-test, Mann Whitney U-Testi for Independent Samples and ANCOVA were used. End of the study, it was found that there were no diffrences between experimental and control groups, but, in the other hand both experimental and control groups science and technology literacy have been increased. There were no differences in attitutes to science.

Key Words: Science and technology education, science and technology club, science and technology literacy, attitude.

* Bu çalışma 27-30 Haziran Niğde'de yapılan 10. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi'nde bildiri olarak sunulmuştur.

Extended Summary

Purpose

The purpose of this study is to determine whether The Science and Technology Club has effect on the scientific and technology literacy and the attitude towards science of primary school students or not. The study was applied to the second level students of an elementary school which attached to the Ministry of National Education in Kandıra town of Kocaeli province in the second term of 2010-2011 educational year.

Method

The study is an experimental study one, in this study pre-test – post-test control group pattern is used. A total of 48 students randomly selected by assigning were included in the survey, 24 students from the experimental group and 24 students from the control group. In the experimental group, activities of the Science and Technology Club were applied; whereas in the control group, activities of the other clubs were applied. İn this study, Scientific Literacy Scale developed by Keskin (2008) and Attitude Towards Science of Scale by Duran (2008) were used for data collection.

Results

End of the study, it was understood that studies of The Science and Tecnology Club has effect on the scientific and technology literacy science on the second level of primary school students, but, in the other hand both experimental and control groups science and technology literacy have been increased. That studies of The Science and Tecnology Club has effect on the attitude towards science on the second level of primary school students.

Discussion

Considering the posttest science literacy average point of students in an experimental group, we can state that there is an increase at the least and the posttest science literacy average point is higher than students in control group. These findings suggest that the studies conducted in Science and Technology Club for this study have a meaningful effect on science literacy of students. However, a statistical difference between the groups is not formed. In order to observe a meaningful difference in terms of science literacy between experimental group and control group, it can be considered that the study should be continued for longer periods and the studies conducted in Science and Technology Club should be designed differently. Despite the fact that there is an increase in attitude points of students towards science, it can be

argued that the reason of not forming a meaningful difference between groups may be due to the short time of study. It is normal that a major difference in attitudes of students who initially have positive attitudes towards science in a short period of time is not formed. Consequently, to make a change in attitude on a certain topic, a long term study should be conducted. It is observed that the studies in Science and Technology Club had an effect on the development of attitudes of female students towards science but this change did not generate a meaningful difference statistically.

Conclusion

Students may be encouraged to follow the scientific magazines and documentaries in science and technology area. As part of club work, a variety of activities could be designed for students to make scientific experiments and to make use of their creativity. Furthermore, by extending this study to a longer period of time, the effect of Science and Technology Club on the science literacy of students and their attitude towards science could be observed more clearly.

Bilim-Fen ve Teknoloji Kulübü'nün Öğrencilerin Fen ve Teknoloji Okuryazarlığına ve Fene Yönelik Tutumlarına Etkisi

Özlem BELHAN [1] ve Canan LAÇİN ŞİMŞEK [2]

[1] Sakarya Üniversitesi, Eğitim Bilimleri Enstitüsü, İlköğr. Fen Bilgisi Eğitimi ABD
E-mail: y097047010@sakarya.edu.tr

[2] Sakarya Üniversitesi, Eğitim Fakültesi, Fen Bilgisi Öğretmenliği
E-mail: csimsek@sakarya.edu.tr

Öz

Bu çalışma, ilköğretim okullarında yer alan "Bilim-Fen ve Teknoloji Kulübü"nün öğrencilerin fen ve teknoloji okuryazarlıklarına ve fene yönelik tutumlarına etkisini test etmek amacıyla yapılmıştır. Araştırmada ön test–son test kontrol gruplu model kullanılmıştır. Araştırmaya deney grubundan 24, kontrol grubundan 24 öğrenci olmak üzere toplam 48 öğrenci katılmıştır. Deney grubunda Bilim-Fen ve Teknoloji Kulübü'nün çalışma planı uygulanırken, kontrol grubunda diğer kulüplerin çalışma planları uygulanmıştır. Deney ve kontrol gruplarına Fen Okuryazarlık Ölçeği ve Fene Yönelik Tutum Ölçeği ön test ve son test olarak kullanılmıştır. Verilerin analizinde t testi, Mann Whitney U testi ve ortak değişkenli varyans analizi (ANCOVA) kullanılmıştır. Çalışma sonunda deney ve kontrol grubu arasında fark oluşmazken, hem deney hem de kontrol grubunda fen ve teknoloji okuryazarlıklarının arttığı görülmüştür. Kulübün, fene yönelik tutuma ise etkisinin olmadığı tespit edilmiştir.

Anahtar Kelimeler: Fen ve teknoloji öğretimi, bilim-fen ve teknoloji kulübü, fen ve teknoloji okuryazarlığı, tutum

Giriş

Günümüzde bilim ve teknoloji hızla ilerlemektedir. Bu nedenle bireylerin her türlü bilimsel bilgiyi öğrenmesi neredeyse imkânsız, bilim ve teknoloji alanındaki gelişmeleri de takip edebilmesi oldukça güç olmaktadır. Bilim ve teknolojinin hızla ilerlediği bu yüzyılda, bireylerin çağa ayak uydurabilmesi için fen ve teknoloji okuryazarı olmaları zorunlu hale gelmiştir. UNESCO (1994), giderek bilim ve teknoloji ile şekillenen dünyada insanların yaşadıkları topluma yabancılaşmamaları ve değişim yüzünden şaşkına dönüp, bulanıma girmemeleri için, fen ve teknoloji okuryazarlığı tüm dünyada kabul edilen bir gereklilik olmalıdır, önerisinde bulunmuştur. Bu durum fen eğitimine verilen önemi de artırmıştır.

Fen bilimleri eğitiminde en büyük gelişme ikinci dünya savaşından sonra yaşanmıştır. Rusya'nın, 1957'de ilk uyduyu uzaya fırlatması, gelişmiş batı ülkelerini harekete geçirmiştir. Teknolojik yarışta geri kalmak istemeyen bu ülkeler, çareyi fen bilimleri eğitim-öğretimine çok önem verilmesine ve yeni yaklaşımlarla çağdaş hale getirilmesinde görmüşlerdir (Çepni, Ayas, Johnson ve Turgut, 1997).

Gelişmekte olan ülkelerin günümüz politikaları ve eğitim programları incelendiğinde, en yoğun çabanın, bilim ve teknolojinin özel bir grup insanın uğraşı olmaktan çıkarılarak en azından ilgi gösterme, aşina olma biçiminde toplumun geneline yayılması yolunda ortaya konulduğu görülmektedir. Yani amaç "fen okuryazar" bireyler yetiştirerek, eğitimin en alt kademelerinden itibaren toplumun tüm bireylerini yoğun teknolojik, bilimsel gelişmelere ayak uydurabilecek seviyeye getirebilmektir (Turgut, 2005).

Fen okuryazarlığı terimi 1950'lerin sonlarına doğru ortaya çıkmıştır. 1950'lerde Paul DeHart Hurd (1958) "fen okuryazarlığı" terimini "Amerikalı Okullar İçin Bilimsel Okuryazarlığın Anlamı" isimli yayınında kullanmıştır. Hurd'un yanı sıra Rockefeller Report Fund, McCurdy da fen okuryazarlığı teriminden bahsetmiştir (DeBoer, 2000). 1950'lerin sonlarında fen okuryazarlığa olan ilginin güçlenmesinin nedeni Sovyetler'in Sputnik projesine karşı Amerika'nın bilime kamusal destek sağlama girişimidir (Laugksch, 2000). Bunun yanı sıra Hurd (1998), fen ve teknoloji okuryazarlığının köklerinin, modern bilimin batı toplumlarına girmeye başladığı 1500'lü yıllara kadar uzandığını ifade etmektedir.

Fen ve teknoloji okuryazarlığı konusunun çok kapsamlı olmasından dolayı literatürde birçok tanım yer almaktadır. 2004 Fen ve Teknoloji

Programında fen ve teknoloji okuryazarlığı, genel bir tanım olarak; bireylerin araştırma-sorgulama, eleştirel düşünme, problem çözme ve karar verme becerileri geliştirmeleri, yaşam boyu öğrenen bireyler olmaları, çevreleri ve dünya hakkındaki merak duygusunu sürdürmeleri için gerekli olan fenle ilgili beceri, tutum, değer, anlayış ve bilgilerin bir birleşimidir (MEB, 2005). Çepni, Bacanak ve Küçük (2003), konuyla ilgili literatür çalışmaları sonucunda fen ve teknoloji okuryazarlığı tanımını aşağıdaki gibi yapmışlardır:

"Fen kavram, teori, yasa ve bilimsel araştırma yöntemlerini bilme; fen, teknoloji ve toplumun birbirleri üzerindeki etkilerini ve aralarındaki ilişkileri anlama; okulda teorik olarak öğrenilen bilgileri günlük yaşamda problem çözmede, fenle ilgili toplumsal sorunların açıklamasını yapmada ve karar vermede kullanabilme; fen içerikli makale, dergi ve kitapları yazabilme, okuyabilme ve anlayabilme; bilimsel tartışmalarda tartışmaya katılabilme, kendi fikirlerini söyleyebilme ve söylenenleri yorumlayabilme; tarafsız, eleştirel ve yaratıcı düşünebilme için ihtiyaç duyulan bilgi ve becerilere sahip olma".

Fen okuryazarı bir birey profesyonel anlamda fen, matematik ve teknoloji icra etmek zorunda değildir (AAAS, 1993). Nasıl okuryazar olan bir kişinin en azından adını soyadını yazabilmesi gerekiyorsa fen okuryazarı olan bir kişinin de fen bilimleriyle ilgili birçok anahtar (temel) bilimsel kavramları bilmesi gerekmektedir. Örnek olarak, DNA yazısını gördüğü zaman kişi bunun sadece D, N ve A harfleri olarak değil canlılardaki yönetici moleküllerden birisi olan kalıtsal maddenin esasını oluşturan, canlılara ait her türlü özelliğin nesilden nesile geçmesini sağlayan, bunları kontrol eden önemli bir molekül olduğunu bilmelidir (Türkmen, 2006).

Fen ve teknoloji okuryazarı olan bir kişi, bilimin ve bilimsel bilginin doğasını, temel fen kavram, ilke, yasa ve kuramlarını anlayarak uygun şekillerde kullanır; problemleri çözerken ve karar verirken bilimsel süreç becerilerini kullanır; fen, teknoloji, toplum ve çevre arasındaki etkileşimleri anlar; bilimsel ve teknik psikomotor beceriler geliştirir; bilimsel tutum ve değerlere sahip olduğunu gösterir (MEB, 2006).

Öğrencilerimizin fen ve teknoloji okuryazarı olarak yetişebilmeleri için sadece bilgi, anlayış ve beceri kazanmaları yeterli değildir. Öğrencilerde belirli bilimsel tutum ve değerler de geliştirilmelidir (MEB, 2006). Bilim ve teknolojideki hızlı ilerlemeye paralel olarak tüm dünyada fen eğitimine verilen önem artmış, eğitim bilimindeki gelişmeler tutum, motivasyon gibi öğrenci özelliklerinin öğrenme sürecindeki rolünü ortaya koymuştur (Altınok, 2004). Tutum, bireylerin belli bir kişiyi, grubu, kurumu veya bir düşünceyi kabul ya da reddetme seklinde gözlenen, duygusal bir hazır oluşluk hali veya eğilimidir