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Evaluation of Basic Physics Subject Matter Knowledge of Prospective Elementary Science Teachers

Yüksel ÇEKBAŞ[1], İzzet KARA

Pamukkale University, Faculty of Education, Department of Elementary Education, 20070-Denizli, Turkey

Abstract

The purpose of this study is to find out prospective elementary science teachers' base knowledge concerning their field. This research was applied at Education Faculty of Pamukkale University in the Department of Science Teaching. In this research, prospective teachers were given a achievement test in which there were 24 multiple-choice test and 24 open-ended questions. Data were analyzed by using Statistical Package for Social Studies (SPSS). At the end of this research it has been deduced that the knowledge of physics of the teacher candidates is not enough. It is seen that the level of inadequacy of their knowledge changed from class to class, level to level, but when applied to different genders, there was no difference.

Keywords

Subject Matter Knowledge, Science Education, Prospective Elementary Science Teachers, Base Knowledge of Physics.

Introduction

The Elementary Science is known as the whole studies made on the problems faced in the environment. Students study Science and Technology in the 4th year of the school. With the help of this subject, they try to understand the natural events around and solve and comment the basic problems faced. That if they understand the lesson Science and Technology during these years, then that they have a great achievement in the following years in the fields of Biology, Physics and Chemistry is of great importance. Subject matter knowledge means what the teacher should teach the students in that field. The teacher should be a professional in his field and should follow the present events in his field. Also, when needed, he should make a research to answer the questions asked by students (Erden, 2005). Demirel (2008) stated that the teachers should have the subject matter knowledge, the ability to direct the teaching-learning environment and the knowledge about guidance.

In today's life, while commenting on the events related with physics, it is of importance to have a great knowledge on that field. The recent research shows that the teachers with little subject matter knowledge fail in teaching or teach untrue information about the topic (Yaman & Soran, 2000; Büyükkaragöz, 1995; Kılıç, 1997; Kahyaoğlu & Yavuzer, 2004; Küçük, 2005; Uşak, 2005; Özdemir, 2006; Canbazoğlu, 2008). To prevent this, the name of the subject has been changed to Science and Technology. In order to have contemporary students, teachers are educated well or the physical environment is improved. However, still we are inadequate in reaching the expected achievement according to the research.

International Association for the Evaluation of Educational Achievement (IEA), an international based evaluation association prepared an exam in 1999 and Turkey, for the first time, was one of the 38 participant countries. The 8th grades of schools were the participants and the average point of these countries was 488. Taiwan was the first with 569 points, South Africa was the last with 243 points and

[1] Phone: +90 258 296 1186; Fax: +90 258 296 1200; E-mail: ycekbas@pau.edu.tr

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Turkey was the 33rd with 433 points. Bağcı-Kılıç (2003), examined the TIMSS 2000 results and compared it with the other countries, and tried to find the reasons of this failure in the exam. According to the results: Turkey has few hours of Science at schools, teachers try to teach a lot of topics in little time, and the questions in the exam were not only about the knowledge but also about performance.

In Primary Schools, Science is one of the lessons the students are afraid of. As it is more about abstract topics, students find it difficult to understand, which results in failure (Doğru & Aydoğdu, 2003). The failure according to the TIMSS 2000 report made the academicians think and make a research about this topic to change the situation; also some suggested new Science and Technology programs adapted from other countries. Meriç and Tezcan (2005), in their research, compared the situations in Turkey with that of other developed countries such as Japan, USA and England. They all scanned the literature and made a detailed research on this topic. They had the opinions of 107 pre-service teachers at universities. And they suggested a new program on Science teaching. The aim was to improve the students in this field and make the physical environment better to study.

The reason of the failure of Primary level students was because of inadequate teachers. Although adequacy of teachers is always a matter of discussion, there is one certain thing that teachers should have a high level of subject matter knowledge in their fields. Thornton (2003), states that the lessons taught at universities should be applicable and clear. Though teachers have an adequate level of knowledge, it becomes a problem to use this knowledge during the classes.

According to the regulations of Pamukkale University, one student should pass all the courses to get the courses in the 3rd year, thus, they seem to have a great achievement in the course General Physics I and II. This is the same with Chemistry, Biology and Math.

The purpose of the study is to investigate the subject matter knowledge of pre-service science teachers about basic physics concepts. This study try to answer these questions: What is the knowledge level of pre service science teachers? What are the most prosperous and the most abortive subjects of fundamental physics as they are inspected with respect to class level?

Method

This study is realized at Pamukkale University in the Department of Science teaching. It is about exploring knowledge of science teachers at elementary science teaching and secondary science teaching with respect to science teachers' efficiency towards science teaching. The present study's subjects in the sample were 551 last grade elementary science and secondary science teachers. In order to accomplish the purpose of the study, the data were collected and analyzed by utilizing survey research techniques. 321 of 551 pre-service teachers were girls (58.26%) and the rest were boys (41.74%).

In this research, 65 of the pre-service teachers are in the 1st year, 62 of them are in the 2nd year, 59 are in the 3rd year and 41 of them are in the 4th year (Table 1). In this research, subject matter knowledge test is applied. In order to test their knowledge on topics such as Newton law, power, mass, momentum, sound, electrostatic, magnetism, electricity current, work-energy, literature has been scanned and the achievement test has been prepared. The questions have been developed by Mazur (1997) and some are chosen to test the research topic. The reliability coefficient has been found as KR21, 0.87. In this research, Independent-sample t-test and one-way ANOVA were used. The significance level was accepted as 0.05 for all analyses.

This achievement test has been applied to all 227 last year students in the department of Science Teaching at Pamukkale University. Correct answers were 1 point and the false ones were 0 point. The highest point was 24 in multiple-choice test. In open ended questions one correct answer was 3 point, then 2 and the false ones were 0 again. So, the highest point here was 72.

The second sub-problem of the research was 'the topic with much achievement results and the topic with lower results'. On each topic, there were 2 open ended questions, and two multiple-choice questions. If all is correct for a student then the highest point he gets is (2*1 + 2*3 = 8). To analyze the results, SPSS 11.5 and t-test are used. In the research, the comprehensibility level was (p) 0.05.

Table 1. Pre-service Teachers' Class Distribution

CLASS	Gender	Pre-service Teachers		Total
		n	(%)	n
1st	girl	39	60	65
	boy	26	40	
2nd	girl	32	51.61	62
	boy	30	48.39	
3rd	girl	33	55.93	59
	boy	26	44.07	
4th	girl	21	51.22	41
	boy	20	48.78	

Findings

The achievement level in multiple-choice test for all classes was 56.08% and in open ended questions for all classes again was 48.37% (Table 2). As a result, pre-service teachers are more successful in multiple choice tests than in open ended questions. General rate of achievement is 50.30 percent. As seen from the Table 2, there are no big differences between the 1st and 2nd year students in multiple-choice or open-ended questions. But it is not the same with the 3rd and 4th year students as their comprehensibility level is $p< 0.05$. But as it is $p>0.05$ with the 3rd and 4th year comprehensibility level, a big difference is seen on the table results.

Table 2. The Average Scores and Achievement Level of Prospective Teachers in Multiple Choice Test and Open-Ended Questions According to Their Education Level.

	class	n	$\overline{x}$	(%)
TTOP	1st	65	16.86	70.25
	2nd	62	14.56	60.66
	3rd	59	11.55	48.12
	4th	41	10.90	45.41
	Total	227	13.46	56.08
KTOP	1st	65	40.54	56.30
	2nd	62	35.49	49.29
	3rd	59	32.08	43.34
	4th	41	31.21	43.34
	Total	227	34.83	48.37
GENERAL ACHIEVEMENT	Total	227	48.29	50.30

TTOP: Total Point of Multiple Choice Questions
KTOP: Total Point of Open Ended Questions

As shown in Table 3, the achievement level in both types in the 1st year is the highest one, but in the following years the level decreases. The 3rd year and 4th year achievement rate are similar to each other. The highest the class level is, the lowest is the achievement rate. The 1st year with a lot of hours of General Physics has a high level of achievement. When we look at the 3rd and 4th year, since there is

not any hour of General Physics, the achievement rate decreases and are around the same level. The 1st year students' achievement rate has so much difference according to the 4th year students. While the average of multiple-choice results of the 1st year students is 16.86, that of the 4th year students' is 10.90, which is very low and different from that of the 1st. When it comes to open-ended questions, the 1st year students' average is 40.54, however that of the 4th year students is 31.21. The reason of this big difference seems to be the different rate of questions. While 1 correct answer is 1 point in multiple-choice test, it is 3 point in open-ended question type. There were 125 girls and 102 boys in the research. The comprehensibility level of the rate between gender and the achievement is $p>0.05$. Lastly, that means gender plays no role in this result. It is not surprising to see the result that gender does not give us a clue on the achievement since they are accepted by universities randomly (Table 4).

In Table 5, we see that the subjects in which students are the most successful are momentum, sound and magnetism. Newton laws, power seem to be the subjects in that they are the least successful. Generally, although the secondly mentioned topics are the easiest topics, the achievement rate is low. This may be the reason of other failures in other topics since they are the base. Even though momentum is the topic with the most successful rate, it is just 4.59, which means low.

Table 3. Comparison of the Achievement Results According to the Class Level

question type	class	class level	$\Delta\bar{x}$	standard error	p
TTOP	1st	2nd	2.30	0.91	0.069
		3rd	5.31	0.91	**0.000**
		4th	5.96	0.95	**0.000**
	2nd	1st	-2.30	0.90	0.069
		3rd	3.01	0.92	**0.027**
		4th	3.66	0.95	**0.005**
	3rd	1st	-5.31	0.91	**0.000**
		2nd	-3.01	0.92	**0.027**
		4th	0.65	0.96	0.923
	4th	1st	-5.91	0.95	**0.000**
		2nd	-3.50	0.95	**0.005**
		3rd	-0.65	0.96	0.923
KTOP	1st	2nd	5.05	2.74	0.344
		3rd	8.46	2.79	**0.034**
		4th	9.33	2.89	**0.019**
	2nd	1st	-5.05	2.74	0.344
		3rd	3.41	2.80	0.712
		4th	4.28	2.90	0.548
	3rd	1st	-8.46	2.79	**0.034**
		2nd	-3.41	2.80	0.712
		4th	0.87	2.95	0.991
	4th	1st	-9.33	2.89	**0.019**
		2nd	-4.28	2.90	0.548
		3rd	-0.87	2.95	0.991

When we have a look at the Table 5 and examine the results from class to class, we see that the achievement rate decreases after the 1st year. It is very normal to have this rate in the 1st year since it is the year with frequent subject matter courses. Although pre-service teachers should have a complete knowledge on their subject matter, the level decreases from year to year, their achievement rate seems to decrease, too. Since the university exam includes such topics, when they are in the 1st and 2nd year

of the university, they remember the topics well, but by the last year, the subject matter knowledge they study diminishes.

Table 4. Gender and Achievement Levels According to the Classes

class	gender	n	average	average difference	t	p
1st	boy	26	58.23	1.92	1.22	0.51
	girl	39	56.31			
2nd	boy	30	51.42	1.33	0.94	0.75
	girl	32	50.09			
3rd	boy	26	43.45	-1.34	-1.34	0.49
	girl	33	44.79			
4th	boy	20	41.71	-0.80	-0.90	0.78
	girl	21	42.51			

Table 5. The Average Scores of Prospective Teachers in Each Subject According to Their Education Level

Subjects	CLASS	n	$\overline{x}$	SUBJECTS	CLASS	n	$\overline{x}$
Power	1st	65	4.58	Momentum	1st	65	5.61
	2nd	62	3.67		2nd	62	4.44
	3rd	59	3.16		3rd	59	4.12
	4th	41	3.00		4th	41	4.19
	TOTAL	227	3.60		TOTAL	227	4.59
Kinematics	1st	65	4.84	Oscillation	1st	65	5.13
	2nd	62	4.38		2nd	62	4.08
	3rd	59	3.28		3rd	59	3.81
	4th	41	3.70		4th	41	3.63
	TOTAL	227	4.05		TOTAL	227	4.16
Newton	1st	65	3.72	Work-energy	1st	65	5.18
	2nd	62	2.71		2nd	62	4.46
	3rd	59	2.45		3rd	59	4.52
	4th	41	2.46		4th	41	3.75
	TOTAL	227	2.83		TOTAL	227	4.47
Circler Motion	1st	65	4.35	Sound	1st	65	5.15
	2nd	62	3.31		2nd	62	4.75
	3rd	59	2.72		3rd	59	4.32
	4th	41	3.02		4th	41	3.92
	TOTAL	227	3.35		TOTAL	227	4.53
Mass Inflection	1st	65	5.17	Electrostatics	1st	65	4.41
	2nd	62	4.48		2nd	62	4.21
	3rd	59	3.82		3rd	59	3.56
	4th	41	3.75		4th	41	3.26
	TOTAL	227	4.30		TOTAL	227	3.86
Electricity Current	1st	65	4.61	Magnetism	1st	65	5.18
	2nd	62	4.38		2nd	62	4.56
	3rd	59	3.61		3rd	59	4.31
	4th	41	3.68		4th	41	3.70
	TOTAL	227	4.07		TOTAL	227	4.43

Results

According to the research made here, we see that year by year the achievement level of the students decreases. When examined, the multiple-choice test results average is 16.86 in the first year, 14.56 in the second year, 11.55 in the third year and 10.90 in the last year. The same result can be seen in open-ended questions: the average is 40.54 in the 1st year, 35.49 in the 2nd year, 32.08 in the third and 34.83 in the last year. So this means a general decrease in both types of questions. When we have a look at both types of question achievement rate in general, we see a 56.08 percent of achievement in

multiple-choice tests and a 48.37 percent of achievement rate in open-ended questions. In the Student Selection Exam (OSS) and in academic life the students are often faced with multiple-choice test and so it is understood that they are inadequate in expressing their knowledge or thought on a topic. Even the best test result is not adequate for a pre-service teacher.

In this research, the gender factor is studied but a big difference between the genders is not seen. In both genders, the upper the class level is, the lower is the achievement rate. Boys have a 58.23 percent of achievement rate in the 1st year, and the girls have 56.31 percent of achievement in the same year. However, in the last year this rate is like: 41.71 in boys and 42.51 in girls.

In the research, the achievement is examined in subject matter. Especially, the base topics in Physics such as Newton laws and Circler Motion and Power have low level of achievement. There were two open-ended and two multiple-choice tests in each topic. The achievement rate in Power is 3.60, in Newton Laws 2.83 and it is 3.35 in Circler Motion. This situation may be the reason of the whole failure. Inadequacy in these topics makes it difficult to understand the other topics. That base knowledge about Physics is given in the first years and forgotten during the following years can be seen clearly from the results. The academic achievement becomes lower in the second year and stays there in the 3rd and 4th years. When needed to talk about the low achievement rate in general, it can be stated that it is due to inadequacy in visual materials. Yakar (2005) and Kahraman (2007) states that computer based education helps a 30-35 percent of achievement when we think of the other materials to be used during the courses.

Pre-service teachers study just to pass the classes and they do not use their knowledge to find a job. And after graduation, they have to pass the exam called KPSS, however, their subject matter knowledge is not asked in the exam, which keeps them away from their field and they do not feel that they have to study their own subject matters or have knowledge about their base topics.

References

Bağcı-Kılıç, G. (2003). Üçüncü Uluslar arası Matematik ve Fen Araştırması (TIMSS): Fen Öğretimi ve Bilimin Doğası [Third International Math and Science Symposium], *İlköğretim-Online*, 2 (1), p.42-51.

Büyükkaragöz, S., Sünbül, A.M., Kesici, S., (1995). Eğitim Fakültesi Öğrencilerinin Yetenek ve İlgi Düzeyleri ile Üniversite Tercih Sıralaması Arasındaki İlişkiler [Education Faculty Students' Ability and Interest Levels and Relations Between University Preference Classification], *H.Ü. II. Eğitim Bilimleri Kongresi*, 6-8 Eylül 1995, Ankara.

Canbazoğlu, S. (2008). *Fen Bilgisi Öğretmen Adaylarının Maddenin Tanecikli Yapısı Ünitesine İlişkin Pedagojik Alan Bilgilerinin Değerlendirilmesi* [Evaluation of Science Teacher Candidates' Pedagogical Subject Matter Knowledge on the Unit of Granular Structure of Matter], Yüksek Lisans [Master Thesis], Gazi Üniversitesi, Ankara, 202p

Demirel, Özcan (2008). *Planlamadan Değerlendirmeye Öğretme Sanatı* [Teaching Art from Planning to Evaluation], Pegem A Yayınları, Ankara, 366p.

Doğru, M. ve Aydoğdu, M. (2003). Fen Bilgisi Öğretiminde kullanılan yöntemlerde karşılaşılan sorunlar ile ilgili öğrenci görüşleri [Student Views Concerning Problems Met in Methods Used in Science Teaching], *Pamukkale Üniversitesi, Eğitim Fakültesi Dergisi*, (13) 150-158

Erden, Münire. (2005). *Öğretmenlik Mesleğine Giriş* [Introduction to Teaching Profession], Epsilon Yayıncılık, İstanbul, 199p.

Kahraman, Ö. (2007). *İlköğretim 7. Sınıf Fen Bilgisi Dersi Fizik Konularının Öğretilmesinde Bilgisayar Destekli Öğretimin Öğrenci Tutum ve Başarısına Etkisi* [Effect of Computer Supported Teaching on Student Attitude and Success in the Teaching of Primary Education 7th Grade Science Lesson Physics Topics], Yüksek Lisans Tezi [Master Thesis], Pamukkale Üniversitesi, Denizli, 186p

Kahyaoğlu, H. & Yavuzer, Y. (2004). Öğretmen Adaylarının İlköğretim 5. Sınıf Fen Bilgisi Dersindeki Ünitelere İlişkin Bilgi Düzeyleri [Teacher Candidates' Knowledge Levels Concerning Units in Primary Education 5th Class Science Lesson], *İlköğretim-Online*, 3(2), 26-34: http://ilkogretim-online.org.tr

Kılıç (Özdilek), F. (1997). *İlköğretim Okullarına Sınıf Öğretmeni Olarak Atanmakta Olan adayların Öğretmenlik Meslek Bilgisi Düzeyleri ile Öğretmenlik Mesleğine yönelik Tutumları* [Teaching Profession

Knowledge Levels of Candidates Being Appointed to Primary Schools As Class Teacher and Their Attitudes Towards Teaching Profession], Yüksek Lisans Tezi [Master Thesis], Anadolu Üniversitesi, 112s

Küçük, M. (2005). Farklı Öğrenim Seviyelerindeki Öğrencilerin ve Fen Bilgisi Öğretmen Adaylarının Yerçekimi Kuvveti Hakkında Sahip Oldukları Kavramların İncelenmesi [Examination of Concepts About Gravitation Force Which Students In Different Education Levels and Science Teacher Candidates Have], *Türk Fen Eğitimi Dergisi*, 2(1).

Mazur, E. (1997). *Peer Instruction*, Prentice Hall, USA, 253s.

Meriç, G., Tezcan, R. (2005). Fen Bilgisi Öğretmeni Yetiştirme Programlarının Örnek Ülkeler Kapsamında Değerlendirilmesi (Türkiye, Japonya, Amerika ve İngiltere Örnekleri [Evaluation of Science Teacher Education Programs in the Context of Sample Country Samples such as Turkey, Japan, America and England]), *BAÜ, Fen Bil. Enst. Dergisi.*7, 1.

Özdemir, Z. (2006). *Fen Bilgisi Öğretmen Adaylarının Bazı Biyoloji Konularındaki Alan Bilgilerinin Değerlendirilmesi* [Evaluation of Subject Matter Knowledge of Science Teacher Candidates on Some Biology Topics], Yüksek Lisans Tezi [Master Thesis], Gazi Üniversitesi, Ankara, 127p

Sekeran, U. (1992). *Research Methods for Business: A Skill Building Approach*, 2nd Edition, John Wiley & Sons, USA, 480p.

Thornton, S., J. (2003). *What Counts as Subject Matter Knowledge Teaching*, Annual Meating of the American Educational Research Association, Chicago.

Uşak, Muhammet. (2005). *Fen Bilgisi Öğretmen Adaylarının Çiçekli Bitkiler Konusundaki Pedagojik Alan Bilgileri [Pedagogical Subject Matter Knowledge of Science Teacher Candidates on Flowered Plants]*, Doktora Tezi [Doctorate Thesis]. Gazi Üniversitesi. Ankara, 156s

Yakar, H. (2005). *Newton Hareket kanunlarının öğretilmesinde Bilgisayar Destekli Öğretimin öğrenci başarısına etkileri [Effects of Computer Supported Teaching on Student Success in the Teaching of Newton Motion Laws]*, Yüksek Lisans Tezi [Master Thesis], Pamukkale Üniversitesi Fen Bilimleri Enstitüsü, Denizli, 82p

Yaman, M., Soran, H. (2000). Türkiye'de Ortaöğretim Kurumlarında Biyoloji Öğretiminin Değerlendirilmesi [Evaluation of Biology Teaching in Secondary Education Associations in Turkey], *H.Ü. Eğitim Fakültesi Dergisi*, 18, 229-237.

WEB. (2006). http://www.iea.nl