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EVALUATING THE CONTENT-BASED COMPETENCY OF PRESERVICE PHYSICS TEACHERS

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ABSTRACT: The purpose of this study is to evaluate content- based competency of preservice physics teachers at Turkish universities. Therefore, this study was done to examine adequacy of our universities in preparing physics teachers and to discuss the results on the base of preparing preservice high school physics teachers. The subjects of this study were 160 preservice physics teachers (4th year students in the Department of Science Education) from seven Turkish universities.

Physics Competency Test (PCT) which was developed by researcher was used in collecting data. The contentbased competency of all the subjects (160 students) were measured by using Physics Competency Test. Then the data collected were analyzed according to gender and the physics courses taken in the undergraduate programs. In analyzing these data, Minitab and special computer programs developed by the researcher were used. More specifically, the effectiveness of these variables was determined by using the student's t-test and correlation analysis.

The results of these analyses revealed that there is a significant difference in favor of male between the achievements of the male and female preservice physics teachers on the high school level physics. It is also found that university level physics courses are not effective enough to promote knowledge of the preservice physics teachers at the high school level physics. Therefore, it is recommended that contents of the physics courses in the B.Sc. programs should be parallel to the content of the high school physics courses.

KEYWORDS: *Preservice physics teachers, training of high school physics teachers, content-based competency.*

ÖZET: Bu çalışmanın amacı, Türkiyedeki üniversitelerde eğitim gören hizmet öncesi fizik öğretmenlerinin alana dayalı yeterliliklerinin tesbit edilmesidir. Fizik öğretmeni yetiştiren üniversitelerimizin imkanlarını incelemek ve elde edilecek sonuçların geleceğin lise fizik öğretmenlerinin hazırlanmasında yararlı olacak şekilde değerlendirmek ve tartışmak için bu durum çalışmasına girişilmiştir. Bu çalışma Türkiyedeki yedi üniversiteden 160 hizmet öncesi fizik öğretmenini (Fen Bilimleri Eğitimi Bölümü 4. sınıf ögrencileri) kapsamaktadır.

Bu çalışmanın verileri toplanırken araştırmacı tarafından gelıştirilen Fizik Yeterlilik Testi kullanılmıştır. Çalışma kapsamına giren bütün hizmet öncesi fizik öğretmenlerinin (160 ögrenci) yeterlilikleri fizik yeterlilik testi ile ölçülmüştür. Böylece elde edilen veriler, cinsiyet, ve lisans programında alınan fizik derslerine göre analiz edilmiştir. Bu verilerin analizinde Minitab ve araştırmacı tarafından geliştirilen bilgisayar programları kullanılmıştır ve bu değişkenlerin etkileri ögrenci t-testi ve ilişki analizi kullanılarak tespit edilmiştir.

Bu analizlerin sonuçları kız ve erkek hizmet öncesi fizik öğretmenlerinin lise seviyesindeki fizik başarılarında erkeklerin lehinde önemli bir fark olduğunu açıklamıştır. Diger yandan üniversite seviyesindeki fizik derslerinin hizmet öncesi fizik öğretmenlerine lise seviyesindeki fizik bilgilerini kazandırmak açısından yeterince verimli olmadığı anlaşılmıştır. Bundan dolayı, lisans programlarındaki fizik derslerinin içeriğinin lisedeki fizik derslerinin içeriğine paralel olması önerilmiştir.

ANAHTAR SÖZCÜKLER: *Hizmet öncesi fizik öğretmeni, lise fizik öğretmeni eğitimi, alana dayalı yeterlilik.*

1. INTRODUCTION

Unlike Biology, Chemistry and Mathematics, the achievement of students in Physics is very low. A wide variety of factors which might be related to the declining achievement in physics have been stated: the nature of the physics content [1]; scarcity of qualified teachers [2]; severity of physics teachers' grading practices [3]; dissatisfaction developed while taking high school physics courses; characteristics and attitudes of physics teachers [4, 5]; political, social, economic, and intellectual factors; and shortage of teachers adequately prepared to teach physics, i.e. inadequate preservice teachers' preparation to teach physics [6, 7]. Of them all, the last factor is going to be considered in this study.

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Victor [8] reports that preservice teachers are approaching the profession with very limited knowledge in physics and with a low probability of improvement before they enter to the teaching profession. He states further that they continue to avoid physics courses which appear challenging, thus perpetuating inadequate physics backgrounds. This inadequacy is given frequently as the reason for teacher reluctance to teach students physics.

According to McDermott [6], high school teachers, having inadequate background in physics, often transmit to students a dislike of physics. With a negative attitude often firmly established by students, most students do not want to take physics in high school. Incompetent teaching may leave students with series deficiencies that may make physics difficult for them. McDermott attempted, in her study, to counter student perception that physics is extremely hard, the teacher must be able to teach in a way that allows students to achieve adequate master of the topics studied and confidence in their ability to understand and apply what they are learning in their daily life.

The physics background of preservice high school teachers, depending on the physics courses taken, may be strong or weak. Westerback [9] suggests that if the background were weak, an initial step in improving the situation would be to identify the components of the background. Of particular importance is identifying physics courses in the undergraduate program that contribute to weak backgrounds. This information would be valuable in revising physics requirement in the preparation programs or focusing attention upon the physics courses that preservice high school teacher are advised to take. If the physics background is strong, the courses that contribute the strength should remain in the preparation program. In either case strong or weak backgrounds, it appears essential to identify physics courses taken and the preservice teachers' perception of the adequacy of preparation the courses provide.

In 1982, the Ministry of National Education, Province of British Columbia surveyed teachers to seek their recommendations about changes that should be made in their preparation for teaching physics [10]. The purpose of this survey was to provide data from teachers to be used for making precise recommendations to the Faculties of Education. These data would allow recognition at not only reach components of the teacher education programs that teachers believe to deserve the greatest emphasis but also which components have been the most neglected. Because the questionnaire listed 23 components of teacher education programs, this study had potential of proposing as many as 23 recommendations for change.

Spector and Phillips [11] state that typical undergraduate teacher education program for high school physics teachers emphasize content (the accrued body of knowledge) and techniques for and practice in teaching this content.

Redford [12] concludes that "decreasing students performance was associated with teacher competence". He attempts to develop new approaches to teaching of physics and originate programs to strengthen the knowledge of preservice physics teachers. However, neither of these approaches had much effect on improving student performance in physics.

If the educational systems of various countries are examined, it will be seen that the training of the physics teachers is achieved in an interdisciplinary way. Mostly, Department of Physics and Faculty of Education are collaborating in the training of prospective physics teachers. Preservice physics teachers must complete a Bachelor's degree on major science subjects and also obtain state certification. In most institutions, two independent administrative divisions are involved in the process of producing physics teachers: a College or School of Education, and a College of Arts and Sciences (or equivalent). Faculty of Education offers courses on methodology and on the psychological, social and cultural aspects of teaching. Faculty of Arts

and Sciences offers courses in the subject matter. A preservice teacher must take certain education courses and must usually also has an undergraduate major outside of education.

Everyone wants qualified and competent teachers for their schools. Qualified and competent teachers are necessary for students to receive the optimum benefit from schooling [13, 14]. Indeed, competent good teachers are more important than modern buildings, up-to-date audio-visual equipment, and even computers.

Thus, under the light of evidences stated so far, it seems useful to study content-based competency of the preservice physics teachers at various Turkish Universities. The main goals of this study can be outlined as follows;

i) to develop an instrument for measuring competency of the preservice physics teachers at the level of high school physics.

ii) to present arguments and to give the suggestions for better training of physics teachers for high schools in Turkey.

2. METHOD

In this study, the following hypotheses are stated which are all in null hypothesis (Ho):

1. There is no significant difference between the achievement of the male and the female preservice physics teachers involved in this study which was proved by the scores on the Physics Competency Test.

2. There is no significant correlation between the achievement as evidenced in the mean scores of the seven physics topics on the Physics Competency Test and their weekly hours for each Turkish University.

3. There is no significant difference between the achievements of the preservice physics teachers on the conceptual-type and on the numerical-type questions of the Physics Competency Test.

2.1 Subjects

The subjects of this study are the 4th year students in the Departments of Science Education educating physics teachers in Turkey. In this study, among twelve Turkish üniversities having Department of Science Education, only seven of them were examined. These seven Turkish üniversities are METU, Marmara, Boğaziçi, Gazi, Selçuk, Hacettepe and Karadeniz Technical University. The universities are randomly labelled with letters in Tables for ethical reason. The numbers of the 4th year students participated in the test at each university are given in Table 1.

The content-based competency of the subjects (Physics education students) was measured during the second semester of their last year. Physics Competency Test was used to obtain data. The results obtained were analyzed according to gender and the weekly hours of the physics courses taken in the undergraduate program.

2.2. Measuring Tool: Physics Competency Test

Physics Competency Test contains 40 multiple- choice questions that were selected from the questions on the University Entrance Exams. In developing this test, the following steps were involved:

Step 1: In order to decide on the number of questions per physics topic, total teaching hours of each topic, and the weight of each topic were obtained by examining the Physics Program of a college in Ankara.

Step 2: After processing step 1, the early version of the Physics Competency Test containing 57 multiple-choice questions was developed.

Step 3: The early version of the Physics Competency Test was applied to the pilot group chosen; 36 seniors (4th year) in the Department of Physics at METU. The results were analyzed using the computer programs. As a result of item

analysis of 57 questions, 17 questions were omitted. In this way, the final version of the Physics Competency Test contained 40 (30 conceptual-type and 10 numerical- type) questions. The early version of the Physics Competency Test contained eighteen physics topics, the selection of which was based on the physics programs of a high school, whereas this final version of Physics Competency Test was categorized into seven topics, the selection of which was based on the physics programs of the seven universities.

Step 4: The content validity of the Physics Competency Test was examined by the two physics professors at METU. They rated questions as valid or not valid in terms of content accuracy, reliability, the accuracy of the correct response, and the appropriateness of the distracters.

Step 5: The reliability of the Physics Competency Test was computed first by Split Half Theorem and then by Kuder Richardson 21 Formula. In this way, the reliability coefficients were found to be 0.80 and 0.75 respectively. These high coefficients indicate high reliability of the test.

2.3 Variables

The dependent variable of the present study is the achievement of preservice physics teachers at high school level physics. This is continuous in nature. The data for the dependent variable was obtained from Physics Competency Test.

The independent variables involved in this study are (1) the gender of the preservice physics teachers, (2) the total weekly hours of all the physics courses taken. The first independent variable is discrete in nature. The second one was obtained from the B.Sc. Physics Education programs of the seven universities chosen for the study.

2.4. Procedure

The procedure followed in the study of the content-based competency of preservice physics teachers (4th year students) in terms of their gender and the physics courses taken in the undergraduate program can be described as follows:

(1) the Physics Competency Test developed by the researcher was administered to 160 preservice physics teachers.

(2) the B.Sc. physics teachers education programs of the seven Turkish universities were obtained through individual communication with letters.

(3) the method of descriptive statistics was used which will be described in the following section.

(4) special computer programs were designed and developed for formatting the data to the Minitab Statistics Package Program.

3. DATA ANALYSIS

In testing the hypothesis 1 and 3, student's t-test was used at the 0.05 level of significance. Since student's t-test for two independent means and dependent means help us to decide whether the observed difference between the two sample means arose by chance or not. On the other hand, in order to measure the strength of relationship between two variables in the hypothesis 2 correlation analysis was used at the 0.05 level of significance.

3.1 Data

The data that are distributed in Tables 1, 2, and 3 were obtained in the following way:

1) The mean achievement of preservice physics teachers was measured by making use of the Physics Competency Test developed by the researcher. The mean scores (out of 100) of preservice physics teachers (namely, 4th year physics education students) studying in the seven universities are given in the second column of Table 1.

Table 1. Means of Scores on the Physics Competency Test

University	n	PCT Mean	S.D
A	5	61.40	17.10
B	35	46.23	12.83
C	17	39.40	9.20
D	29	37.43	13.40
E	6	35.42	9.40
F	31	48.90	13.33
G	37	46.23	10.85
Total	160	45.15	10.47

PCT: Physics Competency Test

2) The Physics Competency Test containing 30 conceptual and 10 numerical questions was used to obtain the achievements of the subjects in conceptual-type questions and in numerical-type questions. The results were graded out of 100 and they are given in Table 2.

3) B.Sc. Physics Education Programs of the seven universities training physics teachers in the Department of Science Education were processed to obtain the weekly hours of the seven physics topics (namely, Mechanics, Electricity, Magnetism, Optics and Waves, Thermodynamics, Atoms and Nucleus, Solid State) containing theoretical hours performed in classroom, and practical hours carried out at laboratories to be taken during the 4-year undergraduate program. These data are given in Table 3.

Table 2. Distribution of Means of Preservice Physics Teachers' Achievement on Conceptual-Type Questions and on Numerical-Type Questions

University	Conceptual Achievement	Numerical Achievement
A	52.80	70.00
B	43.86	48.60
C	31.20	47.60
D	30.06	44.80
E	26.33	44.50
F	44.50	53.30
G	44.06	48.40
Average	38.97	51.02

Table 3. Means of Preservice Physics Teachers' Achievement on the Seven Physics Topics and Weekly Hours of hese Topics at Seven Universities

		Mechanics	Electricity	Magnetism	Optics &Waves	Thermody namics	Atoms Nucleus	Solid
A	M	73.1	62.3	56.0	50.0	76.0	57.0	0.0
	WH	9	11	3	6	9	6	0
B	M	65.0	55.0	47.0	52	58.0	33.6	12.0
	WH	11	9	2	4	6	9	3
C	M	49.8	43.0	41.0	39	53.0	43.0	7.0
	WH	16	20	0	11	3	14	11
D	M	50.2	36.3	43.3	32.3	49.3	31.3	19.3
	WH	20	18	0	8	3	18	4
E	M	49.6	26.9	15.6	4.3	49.6	66.5	0.0
	WH	16	6	3	12	9	16	0
F	M	61.1	50.8	47.8	64.8	53.8	34.3	29.8
	WH	6	18	11	5	5	8	0
G	M	70.6	57.2	49.2	42.2	49.2	41.7	13.2
	WH	24	18	4	8	4	26	8

* M means average, and WH means weekly hours

4) In order to obtain the mean achievement of the subjects of the seven universities on the seven physics topics, the results of Physics Competency Test were used. That is, the mean score (out of 100) on each physics topic was obtained. These are given in Table 3 in the upper-row.

3.2 Test of Hypothesis 1

Hypothesis 1, "there is no significant difference between the achievements of the male and the female preservice physics teachers involved in this study which was proved by the scores on the Physics Competency Test", was tested using a student's t-test for two independent samples. The results are given in Table 4.

Table 4. The Results of Testing Hypothesis 1

Gender	n	Mean	Sd	Df	t
Male	105	48.80	13.70	134	3.60*
Female	55	41.20	10.80		

(*) significant at the 0.05 level

As it can be seen from Table 4, male preservice physics teachers' achievements on the Physics Competency Test were greater than those of the female preservice physics teachers. The analysis indicates that the difference between on the means of achievement scores of the male and female students was statistically significant at the 0.05 level of significance. Then we reject the null hypothesis.

3.3 Test of Hypothesis 2

Hypothesis 2 which was stated as, " there is no significant correlation between the achievement as evidenced in the mean scores of the seven physics topics on the Physics Competency Test and their weekly hours for each university", was tested by using correlation analysis. The results are given in Table 5.

Table 5. The Results of Testing Hypothesis 2

University	(r) between means of PPTA on the seven topics and their weekly hours
A	0.83*
B	0.46
C	0.40
D	0.09
E	0.72
F	0.18
G	0.40

(*) significant at the 0.05 level

PPTA: Preservice Physics Teachers' Achievements

The analysis reveals that for the universities B, C, D, E, F, and G, there is no significant correlation between the means of achievement scores on the seven physics topics and their weekly hours. On the other hand, we reject the null hypothesis for the university A. In other words, there is significant correlation between the means of achievements on the seven physics topics and their weekly hours at the 0.05 level of significance.

3.4 Test of Hypothesis 3

Hypothesis 3 which was stated as, "there is no significant difference between the achievements of the preservice physics teachers on the conceptual-type and on the numerical-type questions of the Physics Competency Test" was tested using a student's t-test for dependent sample. The results are given in Table 6.

Table 6. The Results of Testing Hypothesis 3

Achievement	n	Mean	Sd	df	t
Numerical	160	51.02	17.52	159	6.96*
Conceptual	160	38.97	12.76		

(*) significant at the 0.05 level

As it is shown in Table 6., the null hypothesis 3 is rejected. In other words, there is a significant difference between the preservice physics teachers' achievements on the conceptual-type and on the numerical-type questions of the Physics Competency Test at the 0.05 level of significance.

3.5 Interpretation of the Findings

(1) The gender of the preservice physics teachers showed a significant difference in their achievement, and the variations of the means of the male and female preservice physics teachers. The male preservice physics teachers achieved significantly higher scores than that of the female ones.

(2) The findings obtained for the universities B, C, D, E, F and G reveal no significant correlation between the mean achievements scores of the seven physics topics and their weekly hours in the B.Sc. programs. On the other hand, the measurements carried out at the university A showed a significant correlation on this matter.

(3) The conceptual achievements of preservice physics teachers at the seven universities are lower than their achievements on numerical questions. This indicates that preservice physics teachers have conceptual difficulties and present physics courses do not help them overcome conceptual difficulties.

4. DISCUSSION AND CONCLUSIONS

McDermott [6, 15] suggests that the content of the high school physics course should be close matched to that of university physics course, but study of the same material in university is not adequate preparation for teaching it in high school. The breath of topics covered university physics course allows little time for acquiring a sound grasp of the underlying concepts. In the same work, she also concludes that a first year introductory physics course is admittedly insufficient for teaching a high school physics course, however, it does not follow that advanced physics courses provide useful preparation for preservice physics teachers.

The Physics Competency Test developed in this study consists of 40 multiple-choice questions, spread over seven different topics of physics, i.e., Mechanics, Electricity, Magnetism, Optics and Waves, Thermodynamics, Atoms and Nucleus, Solid State. In this work, the mean achievement scores on these topics were correlated with their weekly total (theoretical plus practical) hours of relevant supporting physics courses existed at B.Sc. programs of the seven Turkish universities. No significant correlation were found at the six universities except the university A. That is, the findings obtained at the university A showed a significant correlation on this matter. Therefore, it is suggested that program developers should examine B.Sc. physics education programs at this university to understand the underlying cause.

As it is indicated by McDermott [6], besides laboratory work, the type of instruction also plays important role on the achievement of preservice physics teachers in physics. Since most of the physics courses they have taken were taught in the lecture format, preservice teachers have to become familiar with lecturing as a mode of instruction. Lecturing, however, is less effective for adolescent. As a result, instructor in a course should not transmit information by lecturing and preservice physics teachers should take active role. As it was expressed before, the achievement of the preservice physics teachers on the physics competency test came out to be unexpectedly very low. As it was discussed above, this may be caused by type of instruction. Because ineffective methods used in teaching physics such as lecture method may contribute this poor results at Turkish universities.

From the analysis of the results, the preservice physics teachers' ability on conceptual type questions was found very poor than that of

numerical type questions. This implies that preservice physics teachers have conceptual difficulties likely to be encountered by students and present physics courses may not provide the appropriate kind of preparation for them. So, to promote conceptual understanding of preservice physics teachers, the physics courses taken by preservice physics teachers should be revised, and some new courses should be placed in the undergraduate program. Various researchers such as Sequeira and Leite [16]., and Wandersee [17] supported this idea. Sequeira and Leite, [16] found that preservice physics teachers' conceptual understanding causes has a large effect on their achievement in physics. Study of Wandersee [17] indicated that conceptual development has some similarity with the development of concepts that have occurred in the history of science, although it does not follow exactly the same stages. Unfortunately, preservice physics teachers have not taken even a course on the history of science. Therefore, action should be taken to give teachers a better preparation on the history of science and to provide them with adequate teaching materials so that conceptual understanding in physics becomes more effective.

Welch and Walberg [4] indicate that history of science should be an appropriate part of a high school physics course. The study of historical developments in science takes away time that could be more wisely spent in learning physics concepts.

It should not be forgotten that the most important parameters in transferring the conceptual aspects of physics to preservice physics teachers are instructors. He/She should be able to use the contemporary methods of teaching, such as the ones in which the students are active both in classroom and in laboratory.

In the light of findings, it is clear that the physics education programs in the universities should be improved. The suggestions given below may be used to improve the undergraduate programs of the Department of Science Education for better training of high school physics teachers.

(1) The content of the physics courses in the B.Sc. programs should be modified and be parallel to that of high school physics courses to get higher efficiency. Although the advanced physics courses help preservice physics teachers deepen their understanding of physics, they may not provide the preservice physics teachers with useful preparation for high school physics [6, 13].

(2) Program should include some part of high school curricula that are available at presents. Because the experience working through the material helps preservice physics teachers identify the difficulties the students are likely to encounter in physics [6].

(3) History of science course should be given to the preservice physics teachers in the undergraduate program to develop their conceptual understanding [4, 14, 15].

(4) The program should have a special physics course for teachers that develop an awareness of the conceptual and reasoning difficulties, likely to be encountered by students.

(5) The instructor in a course for teachers should not transmit the information only by lecture method. Chance should be given preservice physics teachers to discover the advantages of learning by active participation rather than by passive absorption.

It is anticipated that the present difficulties faced in the training of physics teachers can come serious consequences both for the future of the profession and the nation. Of course, improvement can take place only if the underlying problems of inadequate teacher preparation are successfully known. In Turkey, there are serious problems in educating physics teachers at universities. It was noted that the physics courses existed in 4-year B.Sc. programs of the relevant department (both Department of Physics and Departments of Science Education) are generally not appropriate both in content and level for physics teacher candidates. In fact, since most of

the courses arranged and given by the Department of Physics, it is likely that they do not pay attention for the problems of physics education. This conclusion is reasonable since the Department of Physics are founded for educating only physicists and scientists, not teachers. Giving responsibilities to the Department of Physics on educating physics teachers can only solve this problem originating from the system. Continuous effort should be conducted by the researchers especially on developing more efficient B.Sc. programs for educating physics teachers and the effects of these programs should also be traced.

The results obtained and conclusions attained from the analysis, should be evaluated and considered within the limits of this study. Continuous effort is necessary for further researches. Therefore, the recommendations for further researches are listed below:

(1) Further research should be conducted on larger and randomly selected samples to evaluate content-based competency of preservice physics teachers.

(2) In a further research, factors effecting on preservice physics teachers competency on the high school level physics, such as the quantity and the quality of the instructors, the adequacy of the laboratory equipment, and the type of instructions at universities should be investigated.

(3) Researches towards evaluating content-based competency of preservice teachers in different disciplines should be conducted.

(4) Some of the conclusions arrived should be taken into consideration by the science educators, especially when developing new preservice education programs for physics teachers in Turkey.

(5) The Ministry of National Education and universities preparing teachers should cooperate in better training of high school teachers.

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