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DEVELOPING A SCALE FOR PERCEPTIONS OF COMPETENCY IN BIOLOGY TEACHING

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Abstract. *The purpose of this study was to develop a measurement instrument to determine pre-service teachers' perceptions of competency in biology teaching. A total of 835 pre-service teachers participated in this study. The data set obtained at the first stage was analyzed using exploratory factor analysis and the data set obtained at the second stage was analyzed using first-order confirmatory factor analysis and then second-order confirmatory factor analysis. After those analyses, the convergent and discriminant validities of the scale with the determined factorial structures [$\chi 2$ (29, N=608) = 101 p<.000, $\chi 2/df$ = 3.48, RMSEA=0.062, GFI=0.97, CFI=0.99, NNFI=0.98, NFI=0.98] were evaluated and Cronbach's alpha, stratified alpha, and McDonald's omega coefficients were estimated for internal consistency. Thus, a scale consisting of four sub-scales with 67 items in total was developed. The total score for the scale can be calculated by adding the scores of the sub-scales.*

Key words: *biology teaching, biology teachers' competency, scale development.*

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Introduction

The concept of teaching quality is employed in a broad sense of the totality of teaching properties influential in the pre-set normative objectives. Based on research of teaching quality, the acceptable and indispensable factors of teaching are teachers, teaching process (lessons), and learners or students. Teachers have always been the focus of research about teaching quality, which constitutes an extensive and complicated literature, and teachers have always been associated with the quality of teaching (Helmke, 2012). In many studies the focus was on the "search for good teachers" (Geers, Alfs, & Hößle, 2009). Previous research revealed different research traditions such as personality paradigm, process-product paradigm, and expertise paradigm (Doyle, 1977). Of those, the expertise paradigm, which is also addressed in the current research, analyzes teachers' professional knowledge and skills and tries to describe them. Previously, there were efforts to conceptualize and classify professional knowledge that is related to teaching quality. Those studies are based on the classifications by Shulman (1986) and while they initially addressed three fundamental dimensions: content knowledge, pedagogical knowledge, and pedagogical content knowledge (PCK); they were extended to include knowledge of curriculum, knowledge about learners and learning, knowledge of instructional strategies, and knowledge regarding educational goals (Shulman, 1986). Content knowledge is considered essential for the teaching of content and it is believed that if teachers are fully knowledgeable in the course's subject matter, they can make the necessary corrections and explanations on students' scientific errors and communicate the content in an appropriate way. Geers, Alfs, and Hössle (2009) reported that the concept of pedagogical content knowledge was formed by Shulman in the 1980s based on the expertise paradigm, which was adopted by American educational researchers and that pedagogical content knowledge is defined as making the content of a subject clear for students and being able to prepare them for teaching.

National Standards for Science Teaching set by the United States National Research Council (NRC, 1996) influenced science teaching and quality standards of science teachers in many countries including many in Europe. Those standards led to the re-arrangement of teacher training, professional development, and teaching curricula in various countries. Renewal of teacher training programs and teaching curricula in Turkey followed this process in describing general and special teacher competencies (Ministry of National Education (MNE), 2011; MNE, 2008). General competencies for the teaching profession and domain-specific biology teacher competencies were determined and published by General Directorate of Teacher Training, Ministry of National Education with extensive and detailed studies (MNE, 2008). Teacher competencies determined by those studies are shown in Figure 1 as a general framework. Pedagogical knowledge competencies are comprised of 6 basic domains. Those domains consist of sub-dimensions and performance indicators for each dimension. Hence, pedagogical content knowledge competencies for biology teachers (MNE, 2011) are made up of biology content knowledge, PCK regarding biology, and biology literacy knowledge based on pedagogical knowledge competencies.

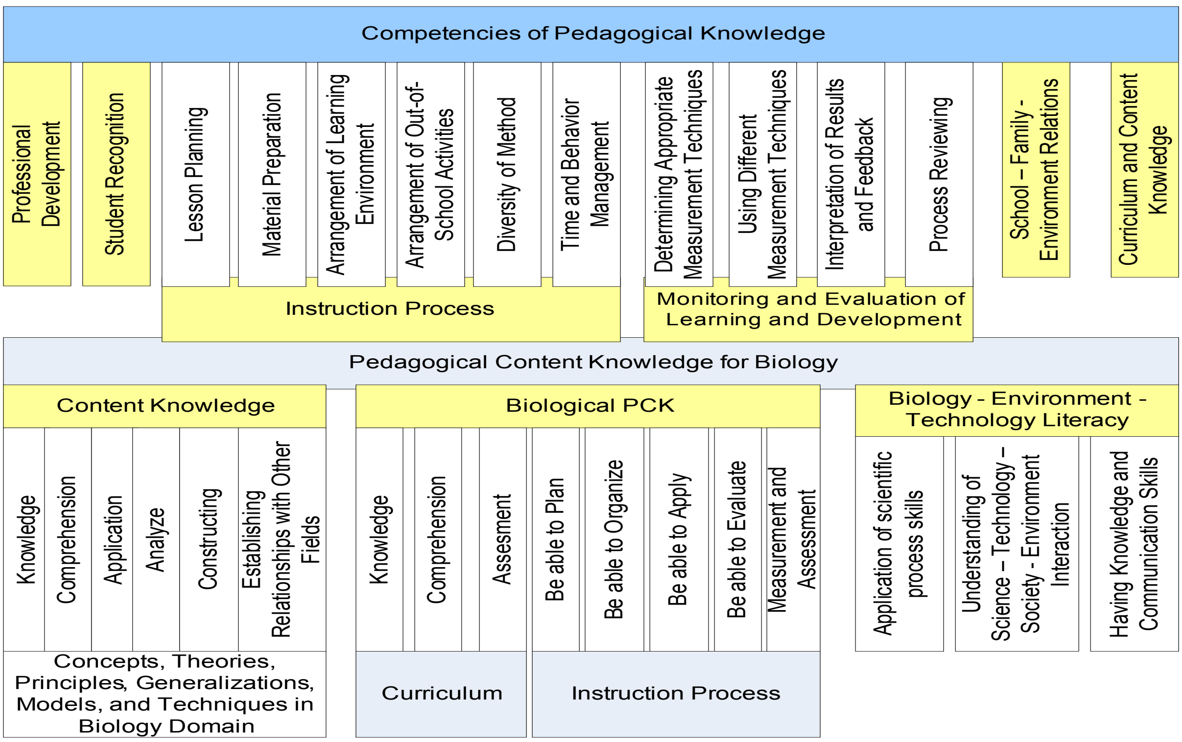

Figure 1: Framework of general and specific domain competencies for teaching profession.

A close examination of the framework for teachers' professional competencies shows that the competencies conform to international standards and the relevant literature. Teachers' and prospective teachers' knowledge of the curriculum and their competencies in employing the curriculum are especially of great importance. In this context, Reinhold (2004) stated that it is necessary to bring in knowledge of the teaching profession based on experience to prospective teachers. Investigating teachers' and prospective teachers' performances and competencies under this framework stands as an important field of study. In previous research, beginning with Shulman (1986), pedagogical content knowledge (PCK), which was defined as the combination of content knowledge and pedagogical knowledge, was called "knowledge of teaching profession." Although PCK is regarded by some researchers as the teaching of a specific topic (Rozenszajn & Yarden, 2014), Magnusson et al. (1999) emphasize that it can be used for the overall discipline. Therefore, it is possible to research PCK as biology teachers' professional development or as their professional knowledge.

In this context, predicting individuals' behaviours emerges as an important field of study within social sciences. Theory of planned behaviour, which was structured by Ajzen and Driver (1990), describes behaviours as the correlational patterns of attitudes, subjective norms, beliefs, perceived control of behaviours, and intention

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variables. Another approach is the perception of self-efficacy, which gained a place in the literature through Bandura's Social Learning Theory. Perception of self-efficacy is defined in the literature as individuals' thoughts of being able to perform a task (Akkoyunlu, Orhan, & Umay, 2005). Studies concerning the measurement of teachers' self-efficacies were performed mostly through scales developed on the basis of this theory (Riggs & Enochs, 1990; Gibson & Dembo, 1984). Those scales were adapted into several languages (Ekici, 2005; Savran & Çakıroğlu, 2001; Diken, 2004). Henson (2001), on the other hand, compared the scales developed in relation to teachers' efficacies in details, and the author also emphasizes changing teacher competencies. Teachers' competencies are described based on PCK (as defined by Shulman, 1986), and techniques such as observations, video analyses and paper and pencil tests, and it is also stressed that those techniques are not appropriate for quantitative research (Borowski et al., 2010). An opinion survey was developed by Ergun, Yurdatapan and Sürmeli (2013) based on science teachers' specific competencies as published in MNE (2008). Şeker, Deniz and Görgen (2004), however, developed the scale for teacher competencies by using items from the criteria for teacher evaluation from the Council of Higher Education (CHE). This current study, however, aims to develop a measurement tool to evaluate pre-service teachers' perceptions of competency in their knowledge of biology teaching. PCK, teacher competencies framework (Figure 1), and the general structure of biology teaching were taken into consideration in developing this instrument. In this way, an analysis of perceptions of competency in biology teaching will be assured, which is important in assessing prospective teachers' competency in biology teaching. Thus, it will be possible to examine pre-service training in terms of providing prospective teachers with the required proficiencies.

Methodology of Research

Process: Development of the Scale

First, a structure compatible with the aforementioned theoretical framework was formed in developing the scale. Within the scope of our study, literature relevant to pedagogical content knowledge (Nakiboglu & Karakoç, 2005; Shulman, 1986) and MNE general competencies for teaching profession, biology domain-specific teacher competencies, science and technology (3rd-8th grades), and secondary education biology (9th -12th grades) curricula were reviewed. The theoretical framework researched was extended by describing the general structure of biology teaching based on the literature (Eschenhagen, Kattmann & Rodi, 2007; Köhler, 2004). Accordingly, the structure's conformity with theoretical framework, prospective teachers' perceptions of competency in teaching biology, and the dimensions of the scale for perceptions of competency in biology teaching (PCBT) are described operationally below.

Biology Content Knowledge (BCK): This dimension measures prospective teachers' self-evaluations of their theoretical and applied content knowledge in relation to biology.

Implementing the Curriculum (IC): This dimension measures teachers' self-evaluations about their planning, application and evaluations in relation to the process of teaching biology and science curricula.

Scientific Process Skills (SPS): This dimension measures prospective teachers' perceptions of their efficacy in suitably teaching the skills of applying scientific study methods and scientific process skills.

Measurement and Evaluation (ME): This dimension measures prospective teachers' self-evaluations of ability to use fundamental measurement techniques in biology education and of ability to measure the gains included in the curriculum.

This stage was followed by writing the items to measure the theoretical structure described. Items for biology teaching compatible with didactic necessity were constructed. The items for measuring each dimension were written by the researcher in cooperation with an educational program expert and an expert in the field. A measurement and evaluation expert revised the form in terms of conformity with the structure to be measured, the overall length of data collection tool, reduction the items written, and the design of the stimulus to be provided. Consequently, an item pool of 118 statements including 16 statements about biology content knowledge, 27 statements about implementing curriculum, 36 statements about scientific process skills, and 29 statements about measurement and evaluation was formed. The same group of experts was consulted for conformity with the operational structure determined based on the theoretical framework, and thus the content validity of the scale was achieved qualitatively. Optimization of the initial form in terms of the number of items was recommended, but then it was decided to do this in accordance with statistical analyses.

Scale Construction

The items written for biology content knowledge (BCK), implementing the curriculum (IC), scientific process skills (SPS), and measurement and evaluation (ME) sub-dimensions were constructed as separate forms for the PCBT scale. Items in each form were grouped in common item premises, and thus they were easier to read. For instance, the first 19 items in the ME subscale were presented in the pattern "I can measure students' achievement by using ----," thus measuring prospective teachers' perceptions of competency in using various evaluation tools was targeted. Items 20-39 were given in the pattern "I can measure students' ----," thus efforts were made to measure prospective teachers' perceptions of competency in measuring students' diverse skills. The extent to which students agreed with the statements given in the items was indicated in 5-point Likert scale. The data collection tool in which all sub-scales were included was prepared as a two-page optical form. A general introductory part, demographic questions about gender, highest degree received, etc. and the subscales were also included in the form.

Study I: evidence

Data Analysis

Exploratory factor analyses (EFA) were conducted in order to attain the construct validity of the scale. The 118 items about the variable of the perceptions of competency in biology teaching were not considered as a single scale in the EFA application. Instead, the dimensions of biology content knowledge (BCK), implementing the curriculum (IC), scientific process skills (SPS), and measurement and evaluation (ME) were considered as separate sub-scales; and unweighted least squares estimation method was used for analysing the factor structures of those scales and promax rotation was used to reveal the factor loads of the scales. In determining the number of dimensions manifesting themselves in the data sets obtained from the scales, scree plots were analysed. The analyses conducted accordingly for dimensions of differing numbers were evaluated, and the numbers of dimensions for which the items were meaningfully in the best combination were found. After that, correlation coefficients between dimensions of each sub-scale were reported. Reliability for those sub-scales and their dimensions was determined by using Cronbach's Alpha and stratified alpha coefficients.

Sample of Research

Data were collected from 232 pre-service teachers for study I. The programs that pre-service teachers attended contained courses related to science and biology as well as courses on teaching. Biology courses are taught by elementary school teachers and science teachers under the name of science and technology courses while they are taught by biology teachers in secondary education under the name of Biology in Turkey.

Table 1. The distribution of the participants according to universities, departments, grade levels, and gender.

	N	%		N	%
Gender			**Departments**		
Male	75	32	Elementary teaching	103	44
Female	156	67	Science teaching	97	42
Grade Level			Biology teaching	31	13
1st year	36	16	**Universities**		
2nd year	34	15	Erzincan University	201	87
3rd year	94	41	Hacettepe University	30	13
Final (4th or 5th year)	64	28			

This is reflected into teacher training in the form of including Biology teaching in such diverse teacher training programs as elementary teaching, science teaching, and biology teaching. The fact that Science and Biology curricula are designed on the principle of spiral curriculum causes students to form their prior knowledge of biology concepts on unit basis beginning especially at earlier ages. Attitudes and scientific process skills available in the basic structures of curricula are more important in the years of teaching at earlier ages. Biology teaching offered to students in those grade levels is also more important for the following years. This case makes biology teaching competency of preservice teachers who are trained for every stage of teaching important. Hence, the distribution of participants on the basis of gender, grade levels, departments, and universities attended is shown in the Table 1. According to Table 1,67% of the study group was female whereas 32% of them was male; and the study group was composed of pre-service teachers attending the differing grade levels of Elementary School Teaching, Science and Technology Teaching, and Biology Teaching departments of two different universities.

Study II

Purpose

The scales, which were structured according to EFA results, were analysed through CFA, thus the factor structures formed in the sub-scales were confirmed, and the numbers of items were optimized at this stage. A second purpose of the study was to show that the sub-scales formed according to the theoretical framework measure the perceptions of competency in biology teaching.

Sample of Research

In the second part of the study, a new set of 617 pre-service teachers were contacted. The related descriptive information is shown in Table 2. The participating pre-service teachers were selected from eight different state universities in different geographical regions of Turkey. Four of the nine state universities that train biology teachers were included, and data were collected from the Science Teaching and Elementary Teaching departments of eight universities with Elementary Teaching departments. The study group contained pre-service teachers of every grade level, but mainly pre-service teachers of 2nd, 3rd and 4th grade levels.

Table 2. The distribution of the participants according to universities, departments, grade levels, and gender.

Variables	Frequencies	Percentages	Variables	Frequencies	Percentages
Universities			**Departments**		
Aksaray	84	13.6	Elementary teaching	115	18.6
Balıkesir	72	11.7	Science teaching	259	42.0
Erzincan	77	12.5	Biology teaching	230	37.3
Atatürk	68	11.0	**Grade levels**		
Hacettepe	73	11.8	1st year	36	5.8
Kastamonu	114	18.5	2nd year	159	25.8
Konya	25	4.1	3rd year	189	30.6
Gaziosmanpaşa	146	23.7	4th year	185	30.0
Gender			5th year	36	5.8
Male	149	24.1			
Female	458	74.2			

One fourth of the pre-service teachers in the study group were male and approximately three quarters were female. The pre-service teachers attended the Elementary Teaching, Science Teaching, and Biology Teaching departments of the universities.

Data Analysis

The model formed by calculating the total scores for the items of the sub-scales whose structures were analysed with EFA and CFA applications separately was analysed through first-order CFA. Then predicting biology teachers' perception of competency (PCBT) as a higher order structure was analysed through second-order factor analysis. Indicators concerning the model-data fit obtained with confirmatory factor analysis are produced in different ways. It is recommended that some of those fit indicators should be reported and that fit should be decided accordingly (Aşkar & Yurdugül, 2009). Chi squares with df; RMSEA; NNFI; NFI; CFI; GFI values were used in this study to decide the model fit. Values suggested by Hu and Bentler (1999) were used for the limit values of fit indices. The convergent and discriminant validities of the scale were calculated by using the CFA results. The internal consistencies of the scales obtained in this way were re-analysed with McDonalds Omega coefficients.

Results of Research

EFA Findings

As it is evident from the scree plot of the sub-scale of biology content knowledge (BCK) shown in Figure 2, the first eigenvalue is considerably higher than the second and others, and the scree plot follows a horizontal line beginning with the third eigenvalue. In addition, the factor loadings for the BCK sub-scale, the explained variances and eigenvalue statistics are shown in Table 3. Although the scree plot for BCK scale and the factor loadings were analyzed with repeated analyses, a two-factor, significant item integrity was not attained. As can be seen in Table 3, the eigenvalue for the first dimension is 10.29, and the variance explained is 62.3%. For this reason, the BCK sub-scale was considered as having one factor.

When the scree plot for the sub-dimension of implementing the curriculum (IC) shown in Figure 3 was taken into consideration, it became evident that the analyses with 1, 2, 3 or 4 factor solutions should be considered. When a 4-factor solution was performed, it was seen that the items loaded on 4 dimensions, which were designed altogether and were placed in an order, gathered under the same factors. It was found that the factor loadings for IC sub-dimension range between 0.49 and 0.96, and that the other factors shared loadings smaller than 0.28. The variances explained by 4 factors whose eigenvalues were bigger than 1 ranged between 3.25% and 50.81%.

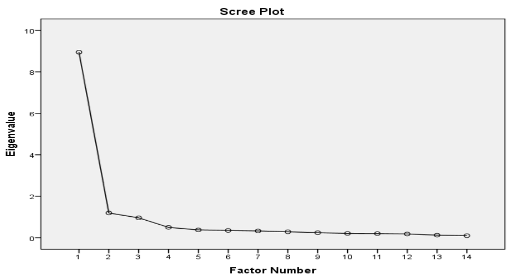

Figure 2: Scree-Plot of BCK.

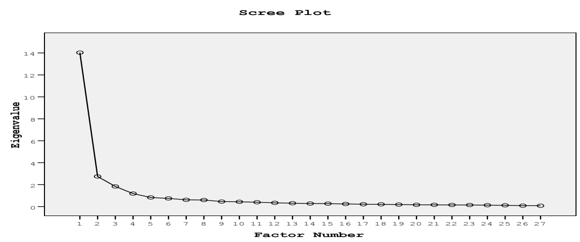

Figure 3: Scree-Plot of IC.

Figure 4: Scree-Plot of SPS.

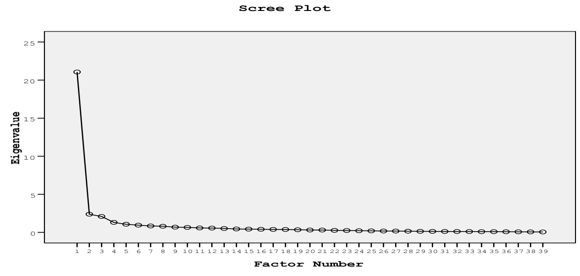

Figure 5: Scree-Plot of ME.

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The scree plot (Figure 4) for SPS sub-dimension shows that the data is a two-factor data. As a result of the factor analysis, a two-dimension factor analysis in which groups of items load on the same dimension was derived. An examination of the factor loadings shown in Table 3 demonstrates that the factor loadings range between 0.49 and 0.90, and that the eigenvalue for the first dimension is 18.45, the variance explained is 50.16%, and the eigenvalue for the second dimension is 4.26 and the variance explained is 10.78%.

Scree plot for ME sub-scale made it necessary to examine the one, two and three dimensional factor analyses (Figure 5). Following the examinations, it was found that a three-factor solution was consistent with the structure of the scale. On examining the three-factor solution, it was found that items 1-8 loaded on one factor, items 9-19 loaded on a second factor, and items 20-39 loaded on a third factor. Items 1-8 were about measurement tools as open-ended questions, multiple-choice questions that had been used for a long time, whereas items 9-19 were about measurement tools as structured grid, diagnostic branched tree that began to spread with re-structuring the curricula but are not commonly used. Therefore, it was concluded that the measurement and evaluation scale displayed a three-dimensional structure. As it is clear from Table 3, factor loadings for ME sub-scale are ranged between 0.43 and 0.93, first three eigenvalues are ranged between 2.09 and 21.06 with explained variances between 4.49 and 53.06.

Table 3. Factor loadings of the subscales.

	BCK		IC				SPS		ME		
Items	**1**	**2**	**1**	**2**	**3**	**4**	**1**	**2**	**1**	**2**	**3**
Item 1	0.16	0.66		0.76		0.13		0.75			0.71
Item 2		0.83	-0.12	0.90				0.86			0.86
Item 3		0.85	-0.19	0.88		0.16	-0.10	0.82			0.88
Item 4		0.90		0.81				0.81	-0.11	0.21	0.77
Item 5		0.88	0.19	0.80		-0.18	-0.14	0.90		0.17	0.65
Item 6	0.13	0.73	0.26	0.72		-0.13		0.79			0.81
Item 7	0.44	0.41	0.49	0.28				0.73			0.77
Item 8	0.51	0.35	0.82					0.76		0.32	0.43
Item 9	0.57	0.24	0.77				-0.10	0.87		0.81	
Item 10	0.51	0.30	0.67	0.11	0.14			0.74	-0.13	0.71	0.22
Item 11	0.56	0.24	0.83					0.85		0.77	0.11
Item 12	0.85		0.87					0.78		0.68	0.17
Item 13	0.62	0.20	0.83					0.77		0.51	0.24
Item 14	0.84		0.81			0.15		0.73	0.20	0.62	
Item 15	0.97	-0.11	0.76			0.10	0.26	0.49	0.17	0.75	-0.12
Item 16	0.85		0.14		0.14	0.57	0.19	0.63		0.79	
Item 17			0.15			0.82	0.28	0.52		0.82	
Item 18				0.11		0.71	0.36	0.51		0.93	
Item 19			-0.10	0.11		0.80	0.66		0.25	0.56	
Item 20					0.15	0.74	0.71		0.61	0.16	
Item 21			0.28	-0.12		0.70	0.85		0.63		0.21
Item 22					0.76		0.82		0.61	0.14	0.12
Item 23.					0.96		0.81		0.58	0.16	0.17
Item 24			0.13	-0.13	0.73		0.79		0.45	0.33	
Item 25			0.11	-0.13	0.68	0.12	0.80		0.55	0.18	
Item 26					0.77		0.76		0.63	0.29	

	BCK		IC				SPS		ME		
Items	**1**	**2**	**1**	**2**	**3**	**4**	**1**	**2**	**1**	**2**	**3**
Item 27					0.73		0.82		0.64	0.30	-0.16
Item 28							0.73		0.61		0.12
Item 29							0.75		0.62		0.26
Item 30							0.80		0.68	-0.20	0.24
Item 31							0.72		0.72		0.14
Item 32							0.76		0.76	0.18	
Item 33							0.83	-0.11	0.77		
Item 34							0.72		0.81		
Item 35							0.78		0.74	-0.15	0.20
Item 36							0.83		0.72		
Item 37									0.83	-0.16	
Item 38									0.91	0.12	-0.30
Item 39									0.88		
Eigenvalue	10.29	1.14	14.03	2.75	1.838	1.19	18.45	4.26	21.06	2.38	2.09
Explained variances (%)	62.3	5.38	50.81	9.08	5.70	3.25	50.16	10.78	53.06	5.13	4.49

Correlations between the Dimensions of the Subscales

The sub-dimensions formed as a result of the EFA analyses of the sub-scales were examined separately within each sub-scale. Upon examining the inter-factors correlation matrix of the sub-scale of IC, which was derived as four dimensional, it was found that there were correlations at the level of 0.54 between the first and second dimensions, at the level of 0.68 between the first and third dimensions, at the level of 0.65 between the first and fourth dimensions, at the level of 0.47 between the second and third dimensions, at the level of 0.49 between the second and fourth dimensions, and at the level of 0.73 between the third and fourth dimensions. These values indicate medium level correlations between sub-dimensions, and they show that the scores from those dimensions can be added up and they can be used in deriving a total score. The correlation coefficient between the two dimensions for the sub-scale of SPS, which displayed a two-dimensional structure, was calculated as 0.62. Considering the correlation matrix between the factors of the ME scale, it was found that three dimensions observed in the scale had medium-level correlations between them (0.72; 0.70; 0.65). Those values show that the scores received from these sub-dimensions can be added up and thus a total score can be calculated.

CFA Findings
Sub-scales

First-order CFA analyses of the scales whose factorial structures were analysed with EFA were done, and the reported modifications for the tested model data fit were evaluated, and thus the fit indices shown in Table 4 were reached. This process was described in every application.

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Table 4. Model-Data fit values for the scale of PCBT and its sub-scales.

Fit Criteria	Perfect fit	Acceptable fit	BCK	IC	SPS	ME
$\chi2$/d	$\chi2$/d <3	3< $\chi2$/d <5	2.711	2.8	2.70	2.292
RMSEA	0<RMSEA<0.05	0.05<RMSEA<0.08	0.064	0.055	0.53	0.046
NNFI	0.97≤NNFI≤1	0.95<NNFI<0.97	0.98	0.98	0.98	0.96
NFI	0.97≤NFI≤1	0.95<NFI<0.97	0.98	0.98	0.97	0.95
CFI	0.97≤CFI≤1	0.95<CFI<0.97	0.99	0.99	0.98	0.97
GFI	0.95≤GFI≤1	0.90<GFI<0.95	0.96	0.93	0.94	0.94

RMSEA index was found to be .127 and GFI to be 0.81 by analyzing the path diagram that was formed in accordance with the EFA results of the BCK scale. Considering the minimum decreases in the model chi square values shown in parentheses following the evaluation of the modification indices, improvements were reported in the covariance of the items bck14-bck15 (122.6), bck13-bab14 (54.8), bck2-bck1 (56.5); bck10-bck11 (26.6); bck3-bck (40.9). Accordingly, the items were evaluated in terms of significance and scale content; items 2, 4, 11, 13, 15 were removed from the data set; the error variances of the items bck1-bck3, bck9, and bck12 and bck14 were related, and the analysis was repeated. According to the results, the model-data fit rose to the perfect level for all indices [($\chi2$ (41, N=608) = 144.51 p<.000, $\chi2$/df = 2.711, RMSEA=0.064, GFI=0.96, CFI=0.99, NNFI=0.98, NFI=0.98].

For the four-dimensional structure determined according to the EFA results of the IC scale, RMSEA was found to be 0.074 and CFI to be 0.86 by analysing the path diagram with the analysis of modification indices, items IC21, IC27 and IC15 were found to be related to other dimensions; items IC5-IC6(54.7), IC21-IC22 (65.6), IC13-IC12 (31.8), IC11-IC12 (226.0), IC8-IC9 (19.5) were found to be reported to be improved for error variances. Accordingly, items IC1, IC6, IC12, IC13, IC15, IC20, IC21, IC23, and IC27 were removed from the data set, and the analysis was repeated. According to the results, the model-data fit rose to the perfect level for all indices [($\chi2$ (146, N=608) = 412.35 p<.000, $\chi2$/df = 2.800, RMSEA=0.055, GFI=0.93, CFI=0.99, NNFI=0.98, NFI=0.98].

RMSEA value was found to be 0.094 and GFI to be 0.74 by analysing the path diagram, which was formed in accordance with the EFA results of the SPS scale. Improvements determined by examining the modification indices were evaluated. Items thought to be similar in meaning were removed from the data set by considering content validity. Thus, items sps2, sps3, sps13, sps16, and sps18, sps19, sps20, sps21, sps22, sps23, sps27, sps30, sps34, and sps36 were removed from the data set and the analysis was repeated. According to these results, the model-data fit rose to the acceptable level for all indices [($\chi2$ (134, N=608) = 358.90 p<.000, $\chi2$/df = 2.70, RMSEA=0.053, GFI=0.94, CFI=0.98, NNFI=0.98, NFI=0.97].

Table 5. Factor loadings of the subscales.

	BCK	IC				SPS		ME		
Items	1	1	2	3	4	1	2	1	2	3
Item 1	0.69	0.80				0.65		0.49		
Item 2	0.73	0.86				0.64		0.54		
Item 3	0.73	0.80				0.62		0.54		
Item 4	0.79	0.67				0.70		0.56		
Item 5	0.82		0.69			0.63		0.66		
Item 6	0.79		0.71			0.68			0.64	
Item 7	0.69		0.78			0.66			0.67	
Item 8	0.69		0.77			0.73			0.52	
Item 9	0.66		0.73			0.50			0.49	
Item 10	0.67		0.72				0.67			0.57
Item 11	0.49		0.66				0.62			0.66

	BCK	IC				SPS		ME		
Items	**1**	**1**	**2**	**3**	**4**	**1**	**2**	**1**	**2**	**3**
Item 12				0.78			0.70			0.63
Item 13				0.80			0.68			0.56
Item 14				0.74			0.68			0.51
Item 15				0.79			0.68			0.59
Item 16					0.69		0.64			0.57
Item 17					0.76		0.69			0.47
Item 18					0.76		0.66			0.57
Item 19					0.75					0.63

RMSEA value was found to be 0.069 and GFI to be 0.81 by analysing the path diagram that was formed in accordance with the EFA results of the ME scale. The items for which high levels of improvement were reported in relation to error variances and loads on other dimensions by examining the modification indices were evaluated in terms of meaning and content, and the ones to be removed were selected. Accordingly, a total of 20 problematic items were removed from the data set, and the analysis was repeated. According to these results, the model-data fit rose to the acceptable level for all indices [($\chi 2$ (149, N=608) = 341.51 p<.000, $\chi 2/df$ = 2.292, RMSEA=0.046, GFI=0.94, CFI=0.97, NNFI=0.96, NFI=0.95]. Standardized path coefficients for these sub-scales are shown in Table 5. According to Table 5, the factor loadings of the items describing the dimensions of the sub-scales range between 0.47 and 0.86, and significantly different from zero (p<0.05). Thus, standardized factor loadings confirm that each dimension of the sub-scales is described well by relevant items. These factor loadings provide strong evidence that construct validity is achieved.

First-Order CFA

Perceptions of competency in biology teaching to be measured in this study and the factorial structures of the four sub-scales, which were described operationally, were analyzed separately. Whether or not the sub-scales whose reliability and validity were proven by findings were the dimensions claimed to measure the PCBT in this study was examined by deriving the total scores for these subscales. First order CFA path diagram prepared for this is shown in Figure 6 with standardized path coefficients. According to these results, it was found that the model-data fit was at acceptable or perfect levels for all indices [($\chi 2$ (29, N=608) = 101 p<.000, $\chi 2/df$ = 3.48, RMSEA=0.062, GFI=0.97, CFI=0.99, NNFI=0.98, NFI=0.98]. The connection diagram for this model is shown with standard path coefficients. As is shown in Figure 6, each component is loaded on the expected dimension. The relevant factor loads are above 0.50, and are significantly different from zero (p<0.05). Besides, it was also observed that there were medium or high levels of correlations between dimensions (0.53 – 0.84) (Figure 6). When examining these values, it becomes clear that the correlations between the sub-scales are appropriate. This shows that the factorial validity of the PCBT scale is proven.

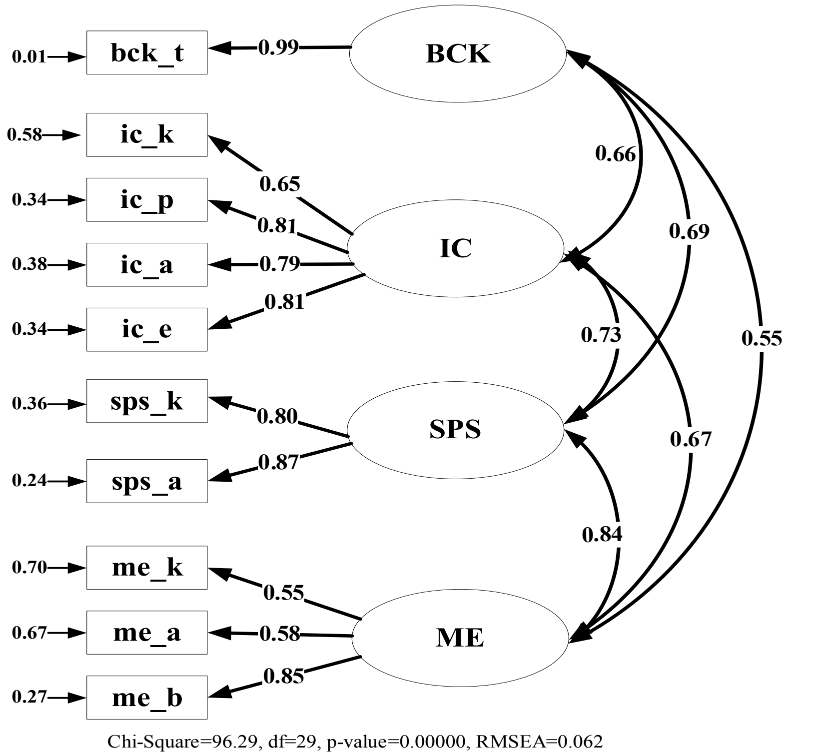

Figure 6: The factor structure of the scale for perceptions of competency in biology teaching.

The standard path coefficients for the sub-scales of perceptions of competency in biology teaching, AVE values, correlations between the sub-dimensions, and the square roots of the AVE values were calculated. The findings are shown in Table 6.

Table 6. Correlations between Sub-scales, the AVE Values, and the Square root of the AVE.

	BCK	IC	SPS	ME	AVE
BCK	(0.91)				0.83
IC	0.66	(0.85)			0.72
SPS	0.69	0.73	(0.90)		0.82
ME	0.55	0.67	0.84	(0.85)	0.72

( ): shows the square root of theAVE values

It is also clear that the square roots of the AVE values are bigger than the correlations with other sub-dimensions. This case is thought to be evidence for discriminant validity.

Second-Order CFA Findings

Prediction of biology content knowledge, implementation of the curriculum, scientific process skills, and measurement and evaluation by the perception of competency in biology teaching (PCBT) as a higher order structure was analysed using second-order CFA. For that analysis, perception of competency in biology teaching (PCBT) was added to the model as the higher-order latent variable. It was found that the model-data fit was at acceptable or perfect levels for all indices [($\chi 2$ (31, N=608) = 133.67 p<.000, $\chi 2$/df = 4.31, RMSEA=0.071, GFI=0.96, CFI=0.98, NNFI=0.97, NFI=0.98]. The factor loadings between the first-order latent variables in the model are shown that perception of competency in biology teaching predicts scientific process skills at the highest level (β = 0.95, t = 5.20, p < .05), and that it explains the change in SPS at the highest rate. While the values for the dimensions of measurement and evaluation (β = 0.84, t = 9.32, p < .05) and implementing the curriculum (β = 0.81, t = 12.72, p < .05) are very close, biology content knowledge (β = 0.73, t = 14.65, p < .05) has the lowest value. The rate of variance of BCK explained by PCBT is approximately 0.53. The explained variance for IC is approximately 0.65, the explained variance for SPS is approximately 0.91, and the explained variance for ME is approximately 0.71.

Reliability

Reliability was estimated by calculating Cronbach's alpha coefficient, and McDonald's omega coefficient based on EFA and CFA results, separately. When examining the dimensional structure of data by applying factor analyses, it was seen that biology content knowledge sub-scale has one dimension, implementing the curriculum sub-scale has four dimensions, scientific process skills sub-scale has two dimensions, and measurement and evaluation sub-scale has three dimensions. In accordance with those findings, the numbers of items for each sub-scale and Cronbach's alpha coefficients are shown in Table 7.

Table 7. Reliability results.

	EFA Results		CFA Results		
Scales	Number of items	Cronbach's α	Number of items	Cronbach's α	McDonalds Omega
Biology content knowledge	16	0.96	11	0.919	0.917
Implementing the curriculum	27	0.96	19	0.841	0.974
1st dimension (1-6) IC.K	6	0.93	4	0.859	0.864
2nd dimension (7-15) IC.P	9	0.95	7	0.884	0.952
3rd dimension (16-21)IC.A	6	0.92	4	0.859	0.860
4th dimension (22-27) IC.E	6	0.93	4	0.828	0.829
Scientific process skills	36	0.97	18	0.918	0.913
1st dimension (1-18) SPS.K	18	0.96	9	0.862	0.867
2nd dimension (19-36) SPS.A	18	0.97	9	0.878	0.801
Measurement and Evaluation	39	0.98	19	0.848	0.903
1st dimension (1-8) ME.K	8	0.92	5	0.692	0.695
2nd dimension (9-19) ME.A	11	0.94	4	0.678	0.674
3rd dimension (20-39) ME. B	20	0.97	10	0.834	0.833

On examining Table 7, it becomes clear that Cronbach's alpha coefficients calculated for components of items emerging as a result of EFA range between 0.92 and 0.98 indicating that they designate high levels of internal consistency. It is also evident that Cronbach's alpha coefficients for the factor structures of the sub-scales of PCBT scale whose number of items was reduced to 67 range between 0.68 and 0.92, and that McDonalds omega coefficients range between 0.67 and 0.92. As the estimate of the reliability of the PCBT scale with four sub-scales, stratified alpha was calculated. Stratified alpha coefficient is an alternative to Cronbach's alpha coefficient when the components of a scale can be grouped into subscales (Osburn, 2000). The stratified alpha coefficient for PCBT scale was estimated to be approximately 0.95. Those coefficients indicate sufficient level of internal consistency.

Discussion and Conclusions

An instrument to facilitate the measurement of competency in biology teaching through prospective teachers' perceptions was developed in this study. The fact that each dimension used for the scale was complicated within itself caused us to use sub-scales. In tandem with the classifications relating to the knowledge of teaching profession in the literature, the scale considered four basic dimensions—namely, biology content knowledge, implementing

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the curriculum, scientific process skills, and measurement and evaluation. Yet, each dimension has a great deal of content. Therefore, data were collected from two different study groups and the structures of the sub-scales were examined first. The item pools of the sub-scales had 5-point Likert scales, and a group of experts wrote the items, decided on the appropriateness of the items and made the necessary revisions. The 118-item measurement tool, which had four sub-scales (with 39 items at maximum) was transformed into a 67-item measurement tool that had four sub-scales with one having 19 items at maximum. Of the sub-scales, biology content knowledge (BCK) had one-dimensional structure, whereas the other sub-scales had multi-dimensional structures. Those dimensions are consistent with the ones predicted at the item-writing stage. Implementing the curriculum (IC) consisted of items related with teachers' knowledge of the curriculum (IC.K), planning the teaching process (IC.P), applying it (IC.A), and items related to evaluation efficacies predicted in the curriculum (IC.E). As a result of the analyses, these sub-dimensions emerged. Scientific process skills (SPS) contained items related to being able to use scientific study methods (SPS.K) and being able to prepare the process of teaching (SPS.A). The items presented under the premise of those items indicated a two-dimensional structure. Measurement and evaluation (ME), on the other hand, was written on the basis of being able to use fundamental measurement techniques and being able to measure the gains in the curriculum (ME. B). Fundamental measurement techniques included traditional measurement techniques (ME.K) and alternative measurement techniques (ME.A), and had a three-dimensional structure.

When examining the values of correlations between those sub-scales, it was found that those dimensions could be added up. First-order CFA results, which were found by calculating the total scores for the sub-scales, confirmed the factorial validity of the sub-scale. The AVE values and the square roots of the AVE values found with this analysis provided the evidence that the scale achieved discriminant and convergent validity. Second-order CFA results for the PCBT scale showed that the scale predicted the determined sub-scales. The internal consistency of the items obtained through EFA and CFA results indicated high levels of internal consistency in both study groups. According to these results, it was shown that PCBT was a valid and reliable tool of measurement measuring teachers' perceptions of belief in competency in biology teaching. The scale items, which can be applied to teachers and pre-service teachers, were graded between "I definitely disagree" and "I definitely agree," and are scored between 0 and 4. Thus, a total score can be produced from the whole of PCBT scale.

Reducing the number of items in the PCBT scale to 67 enhanced the application in terms of time. The items in the scale were original and clear self-efficacy statements measuring the basic skills forming the knowledge of teaching profession. The statements were constructed with expert opinions and were chosen statistically. In the relevant literature, statements constructed for different purposes are usually preferred (Ergun, Yurdatapan & Sürmeli, 2013; Şeker, Deniz & Görgen, 2004). Didactic requirements were considered in the operational description of the PCBT scale. Scientific process skills, which were considered in this framework, are an important dimension that is taken into consideration in the process of teaching. With the SPS sub-scale, PCBT measures both prospective teachers' knowledge of scientific study methods and the perceptions of competency in performing teaching by using those methods. The other dimensions of the scale contain dimensions described in relation to biology teachers' efficacies. In studies that are adapted as biology teachers' self-efficacy scales, the scales are reported to have 2 or 3 dimensions (Ekici, 2005; Savran & Çakıroğlu, 2001). Those scales are composed of dimensions such as students' participation, teaching techniques, classroom management, external factors, individual factors, biological methods, generalisations on biology and other science courses, analyses of information, biological concepts, and implementing the skills.

The main contribution of this study is to develop a scale, which is aimed to measure PCK competencies in teaching of biology, for pre-service teachers. Perceptions of competency in PCK were formed on the idea that changing knowledge should be researched on a multidimensional basis, as can be understood from relevant literature. The scale developed is a valid and reliable instrument containing all dimensions related to teaching biology as a discipline. It assesses teaching competencies or who is effective as an educator based on their PCK. Thus, PCK is a significant component of pre-service teachers' knowledge base. Researchers are encouraged to consider designing professional development in pre-service programs that is related to the various PCK orientations of teacher candidates in order to reach meaningful professional competencies. The PCBT is a scale containing all dimensions of teaching profession efficacies and measuring prospective teachers' perceptions of self-efficacy in biology teaching. Rozenszajn and Yarden (2013) emphasise that knowledge and belief are the two components of teaching knowledge. According to the researchers, beliefs are acquired through theoretical knowledge and experiences, they are formed on the basis of knowledge, and are more difficult to change than knowledge. Therefore, measuring the perceptions of competency in PCK is as important as measuring the levels of knowledge.

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