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VALIDITY AND RELIABILITY ANALYSES FOR CHEMISTRY SELF-CONCEPT INVENTORY

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Abstract. *Self-concept, one of affective introductory behaviours, is one of the most frequently studied issues especially in social sciences. Since it is a strong mental structure which psychologists and social psychologists say to be related with learning, this research aims to adapt Chemistry Self-Concept Inventory developed by Bauer (2005) so as to evaluate students' self-concept into Turkish, and analyse its psychometric properties. The data were collected by applying the inventory to 530 prospective teachers attending the chemistry education, primary school education and science education departments of three different Universities. Following the translation work, Turkish form of the inventory was given the final shape. The construct validity of the inventory was tested by confirmatory factor analysis. McDonald's Omega (ω) and Cronbach Alpha (α) coefficients were calculated for the reliability study of the inventory. Fit indices were found to be lower in the first confirmatory factor analysis conducted than the ones expected, and 11 items with the fewest factor loads and with the highest modification indices were removed from the inventory. The sub-dimensions apart from creativity were found to have ω and α coefficients above 0.70.*

Key words: *academic enjoyment self-concept, academic self-concept, chemistry self-concept, creativity self-concept, mathematics self-concept*

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Introduction

A variable, which is one of the affective introductory behaviours and is questioned in terms of its influences in learning, is self-concept. Marsh (2007) points out that self-concept is one of the most important, the most controversial and the most extensively researched topics in social sciences. It is a strong mental structure which psychologists and social psychologists say to be related with learning (Bauer, 2005). A literature review makes it clear that there are diverse definitions of self-concept. Self-concept is the way individuals perceive themselves in relation to a general or specific domain of knowledge, and their beliefs (Bauer, 2005; Marsh & Yeung, 1997; Nieswandt, 2007). It is the cognitive evaluation of individuals' ability in a field by themselves (Pintrich & Schunk, 1996). Things that individuals are aware in relation to themselves are their abilities, and the things that they can do are their limits (Yandı & Köse, 2013). According to Gecas and Mortimer, on the other hand, self-concept contains individuals' attitudes, beliefs, values, experiences, the effects of all these on individuals, and the evaluations made by individuals. For instance, the statement "I have problems in understanding something about chemistry" is a statement of self-concept (Bauer, 2005).

Self-concept, which is regarded as an important reflection of individuals' affective behaviours, is important in influencing individuals' relations with their environment, and their behaviours (Yıldız & Fer, 2008). The first psychologist to be systematically engaged in self-concept was William James in the 1880s. According to James, there are three aspects of self-concept:

1. Material self-concept: Everything that an individual has,
2. Social self-concept: An individual's behaviour compatible with many masks that he/she wears,
3. Spiritual self-concept: It is subjective, and it shows how an individual evaluates and perceives himself/herself (Ulusoy, 2014).

Self-concept develops through individuals' experiences in different learning environments and it expresses a general evaluation (Bong & Skaalvik,

2003). Peer groups and relations with parents, social expectations, and the experiences that individuals undergo contribute significantly to the development of self-concept (Yandı & Köse, 2013). Self-concept plays an important role in students' performance even if the factors related to teaching content are controlled (Chan & Bauer, 2015). Research demonstrates that self-concept is an important predictor of future performance (Fryer, 2015). Research conducted by Helmke and van Aken (1995); Lewis, Shaw, Webster, and Heitz (2009); Marsh and Yeung (1997) exhibited that students with high level of self-concept displayed better performance in general chemistry course.

Developing students' self-concept and their interests while supporting their success is an important component of formal education, and is located inside other components (Fryer, 2015). Academic self-concept is one of the elements constituting affective introduction behaviours, and it signals individuals' perceptions of efficacy related to their academic achievement status (Wigfield & Kapathian, 1991). It is individuals' evaluation of their general abilities in a field made by themselves (Marsh & Martin, 2011). According to Parker, Marsh, Ciarrochi, Marshall, and Abduljabbar, (2014) it is the subjective evaluation of one's achievement by oneself. It is the general beliefs of a student in school and in learning, and those beliefs influence his or her learning (Yıldız & Fer, 2008). For instance, when students respond to the item "I am better at science studies", their interpretation of 'better' changes according to their standards and references. Therefore, differing comparison processes using different references are among the most important sources of self-concept (Möller & Marsh, 2013). The sources of academic self-concept are as in the following:

1. Social comparisons: Students compare their performance with their friends' performance in the same field (Festinger, 1954; Marsh, 1987; Seaton, Marsh, & Craven, 2009).
2. Temporal comparisons: Students compare their performance in a field with their previous performance in the same field (Albert, 1977; Möller, 2005).
3. Dimensional comparisons: Students compare their performance in a field with their performance in another field, and thus they develop a perception of their strengths and weaknesses (Marsh, 1986; Marsh et al., 2015, Möller & Marsh, 2013).

Taking the statements above into consideration, the importance of measuring self-concept becomes clear. Bauer (2005) lists the reasons for measuring self-concept as in the following:

1. Students taking introductory courses have differing interests, backgrounds and learning approaches in relation to the courses. Educators, on the other hand, have an awareness of the classroom atmosphere based on their interactions with a few students. The data collected before and after the application provide a more certain understanding about all students.
2. Educators can apply a new teaching approach and can want to know whether the new approach has influenced students' self-concepts about the previous approach. The previous approach can be applied in the previous year or in the same year.
3. Good educators are interested in students' intellectual and emotional development. Examination results can provide information only on one aspect of students. Chemistry Self-concept Inventory, however, exhibits different ways of recognising students individually and socially, and it helps educators to enable their students to develop accordingly.

Research Focus

The fact that self-concept is an important part of learning process and that it is influential in learning forms, the basis of the interest in self-concept (Yıldız & Fer, 2008). Based on this point, the importance of measuring self-concept once again becomes apparent. Therefore, this research aims to adapt Chemistry Self-concept Inventory developed by Bauer (2005) so as to evaluate prospective teachers' self-concept into Turkish, and analyse its psychometric properties. Since this inventory measures students' self-concept in relation to specific chemistry, it was chosen.

Methodology of Research

General Background of Research

The survey model was used in this research. Survey model is a research approach aiming to describe a state which existed in the past or which currently exists as it is (Fraenkel & Wallen, 2000; Karasar, 2014). Also the research was conducted in the fall and spring semesters in the 2014-2015 academic year.

Sample of Research

A total of 530 prospective teachers that enrolled in general chemistry course and attending the chemistry education, primary school education and science education departments of Hacettepe, Bülent Ecevit and Cumhuriyet Universities were included in this research. The prospective teachers included in the research were in the 18-21 age range, and they were very similar in terms of socio-economic levels. Purposeful sampling method was employed in the selection of the sample. Purposeful sampling is an approach of non-random sampling which enables one to research in-depth the states rich in information in accordance with the purpose of research (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2013; Fraenkel & Wallen, 2000).

Instrument and Procedures

Chemistry Self-Concept Inventory (CSCI): The inventory was developed by Bauer (2005) in order to evaluate students' self-concept. It consists of two parts. Demographic information and questions concerning students' gender, age, and their department are included in the first part. The second part is composed of 40 items of 7-pointed Likert type, and 5 sub-dimensions. Following the exploratory factor analysis performed by Bauer (2005), items 3 and 15 were removed from the inventory since they did not have any strong association with the other factors (loading between 0.01 and 0.37). Table 1 shows the sub-dimensions of the scale. Students respond to statements that are (1) "very inaccurate of me" to (7) "very accurate of me" regarding descriptive statements.

Table 1. The sub-dimensions of the CSCI.

Sub-dimensions	Item no	Number of items
Mathematics self-concept	1. 5*. 9. 13*. 17. 19*. 21*. 25. 29*. 33. 37*	11
Chemistry self-concept	4*. 8. 12. 16. 20*. 24. 28*. 32*. 36. 40*	10
Academic self-concept	7. 18. 23. 26. 34. 39	6
Academic enjoyment self-concept	2. 6*. 10. 14. 22*. 30*. 38*	7
Creativity self-concept	11*. 27*. 31. 35*	4

**Negative items*

Cronbach Alpha coefficients for the sub-dimension of the inventory were found as 0.91 for mathematics self-concept, 0.90 for chemistry self-concept, 0.77 for academic self-concept, 0.77 for academic enjoyment self-concept, and 0.62 for creativity self-concept in Bauer (2005)'s research. Cronbach Alpha coefficients were calculated in order to check the internal consistency of the sub-dimensions of the inventory in Chan and Bauer (2015). The Cronbach Alpha coefficients calculated for the sub-dimensions were above 0.8 for all apart from creativity sub-dimension (0.71 pre-test; 0.66 post-test).

Process

The desire to adapt Chemistry Self-Concept Inventory developed by Bauer (2005) into Turkish was explained to the author, and the permission was received. Then, the inventory -which was in English - was translated into Turkish by two experts one of whom was competent in both English and Turkish languages, and the other of whom was an expert in chemistry education. By taking into consideration the common points in both translations, the Turkish form of the inventory was shaped. The Turkish form was translated back into English again by the language expert. Having made the necessary corrections, the final shape was given to the Turkish form by field experts. The Turkish form was later applied to a group of 25 prospective teachers. After the form was tested in terms of content and intelligibility, it was given the final shape. Afterwards, the forms in the original language and in Turkish were applied to 20 prospective teachers who had good command of both languages at intervals of one week, and medium level positive correlations were found between the sub-dimensions of both the inventories.

Data Analysis

Prior to the analyses, Kaiser-Meyer-Olkin and Bartlett's Sphericity Tests were performed so as to determine the adequacy of the sample and to check whether or not the data fitted for factor analysis. Kaiser-Meyer-Olkin compares the magnitude of observed correlation coefficients with the magnitude of partial correlation coefficients. Kaiser-Meyer-Olkin ratio should be above 0.5. The highness of the ratio indicates the fit of the data set for factor analysis. Table 2 shows the results for Kaiser-Meyer-Olkin test and for Bartlett's Test of Sphericity.

As is clear from Table 2, the KMO value of 0.907 shows that the data set fits factor analysis. The result of Bartlett's Sphericity Test with 0.05 significance level indicates that a high level of correlation is available between variables, and that the data set fits factor analysis.

After that confirmatory factor analysis was employed for analyzing of the data. Confirmatory factor analysis is an analysis performed so as to test the pre-determined relations between items and components (Akbulut, 2010).

Table 2. KMO and Bartlett's sphericity test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	Bartlett's Sphericity Test		
,907	Approx. Chi-Square	df	Sig.
	8951,211	780	.000

Results of Research

The findings concerning the validity and reliability analyses of Chemistry Self-Concept Inventory are presented in this part of the research. The construct validity of the inventory was tested by means of confirmatory factor analysis. In the first confirmatory factor analysis conducted, the fit indices were found to be below the ones expected, and 11 items with the fewest factor loads and with the highest modification indices were removed from the scale. Having made the modification, the fit indices were found to be at the expected level. The values are shown in Table 3. In the final form of the inventory the sub-dimension of mathematics self-concept had 8 items, the sub-dimension of chemistry self-concept had 7 items, the sub-dimension of academic self-concept had 6 items, the sub-dimension of academic enjoyment self-concept had 5 items, and the sub-dimension of creativity self-concept had 3 items.

Table 3. Model-Data fit values for the data of chemistry self-concept inventory.

	Model-data fit indices (acceptable fit values)								
N	χ2/df (<3,0)	RMSEA (<0,08)	SRMR (<0,1)	CFI (>0,95)	GFI (>0,90)	AGFI (>0,85)	NFI (>0,90)	NNFI (>0,95)	IFI (>0,90)
530	2,98	0,061	0,063	0,94	0,88	0,85	0,92	0,94	0,94

According to Table 3, the indices of model fit (χ^2/df=2.98, RMSEA=0.063, SRMR=0.063, CFI=0.94, GFI=0.88, AGFI=0.85, NFI=0.92, NNFI=0.94, IFI=0.94) were regarded to meet the goodness of fit indices for university students (Çelik & Yılmaz, 2013; Schermelleh-Engel, Moosbrugger, & Müller, 2003). Garver and Mentzer (1999) suggest that the NNFI, CFI and RMSEA values could be taken into consideration for acceptable fit indices. Therefore, commonly used fit indices are NNFI and CFI (>0.90 indicates good fit), RMSEA (<0.08 indicates acceptable fit), and the χ^2 statistics (it is desired that the χ^2/df proportion be smaller than 3) (Hoe, 2008). If comparative fit index is bigger than 0.95 according to Hu and Bentler (1999), and if it is bigger than 0.90 according to Cheng and Chan (2003) and if the standardized root-mean-squared residual (SRMR) is smaller than 0.08; a model is said to have good fit with the data. Thus, because the NNFI, CFI, RMSEA, SRMR and the χ^2/df proportion had acceptable values in this research; the inventory was considered to attain construct validity. Table 4 shows the confirmatory factor analysis results.

Table 4. The λ_x, δ, t, R^2, α and ω values obtained through confirmatory factor analysis.

Sub-dimensions	Item no	λx	δ	t	R2	α	ω
Mathematics self-concept	1	0,43	0,82	9,55	0,18	0.823	0.829
	5	0,59	0,65	13,98	0,35		
	13	0,73	0,47	18,35	0,53		
	19	0,52	0,73	12,00	0,27		
	21	0,75	0,44	18,99	0,56		
	29	0,74	0,45	18,74	0,55		
	33	0,50	0,75	11,33	0,25		
	37	0,62	0,61	14,84	0,38		
Chemistry self-concept	4	0,59	0,66	13,78	0,35	0.810	0.816
	8	0,44	0,81	9,87	0,19		
	12	0,43	0,81	9,74	0,18		
	20	0,72	0,48	18,04	0,52		
	28	0,70	0,51	17,19	0,49		
	32	0,73	0,47	18,28	0,53		
	40	0,72	0,49	17,79	0,52		
Academic self-concept	7	0,40	0,84	8,65	0,16	0.702	0.720
	18	0,72	0,48	17,10	0,52		
	23	0,33	0,89	7,02	0,11		
	26	0,78	0,38	19,07	0,61		
	34	0,65	0,57	15,25	0,42		
	39	0,34	0,88	7,27	0,12		
Academic enjoyment self-concept	6	0,63	0,60	14,93	0,40	0.763	0.772
	14	0,60	0,64	13,99	0,36		
	22	0,68	0,54	16,37	0,46		
	30	0,75	0,44	18,46	0,56		
	38	0,51	0,74	11,50	0,26		
Creativity self-concept	27	0,69	0,52	14,11	0,48	0.607	0.621
	31	0,57	0,68	11,68	0,32		
	35	0,52	0,73	10,57	0,27		

Table 4 shows factor loadings (λ_x), error variance (δ), t values, and explained variance for each item. Accordingly, it is clear that the t values are significant, and that factor loads are between 0.33 and 0.78. McDonald's ω coefficient which is recommended for congeneric measurements (when factors loadings are not equal) in addition to Cronbach α values- which is the internal consistency coefficient- was calculated for the reliability research of the scale (McDonald, 1985, as cited in Yurdugül, 2006; Yurdugül, 2006; Zinbarg, Revelle, Yovel, & Li, 2005). It is clear that both α and ω coefficients are above 0.70 for all sub-dimensions except for creativity sub-dimension. The α and the ω coefficients above 0.70 for four factors indicate that measurement results are reliable (Nunnally & Bernstein, 1994, as cited in Yurdugül & Alsancak Sırakaya, 2013). In Bauer (2005) also, the internal consistency coefficient was found to be α=0.62 for the sub-dimension of creativity. Hence, the α value for this factor was considered to be acceptable.

Discussion

In this research- aiming to adapt Chemistry Self-Concept Inventory developed by Bauer (2005) so as to evaluate students' self-concept into Turkish, and to analyse its psychometric properties- the data obtained from the inventory were analysed through confirmatory factor analysis. Prior to the analysis, the inventory was translated into Turkish by two experts one of whom was competent in both English and Turkish languages, and the other of whom was an expert in chemistry education. By taking into consideration the common points in both translations, the Turkish form of the inventory was shaped. The Turkish form was translated back into English again by the language expert. Having made the necessary corrections, the final shape was given to the Turkish form by field experts. The Turkish form was later applied to a group of 25 prospective teachers. After the form was tested in terms of content and intelligibility, it was given the final shape.

After that Kaiser-Meyer-Olkin and Bartlett's Sphericity Tests were performed so as to determine the adequacy of the sample and to check whether or not the data fitted for factor analysis. The KMO value of 0.907 showed that the data set fits factor analysis. The result of Bartlett's Sphericity Test with 0.05 significance level indicated that a high level of correlation is available between variables, and that the data set fits factor analysis. Then the construct validity of the inventory was tested by means of confirmatory factor analysis. In the first confirmatory factor analysis conducted, the fit indices were found to be below the ones expected, and 11 items with the fewest factor loads and with the highest modification indices were removed from the scale. Having made the modification, the fit indices were found to be at the expected level. The factors derived as a result of the confirmatory factor analysis supported the original factor structure of the inventory. In the final form of the inventory, the sub-dimension of mathematics self-concept had 8 items, the sub-dimension of chemistry self-concept had 7 items, the sub-dimension of academic self-concept had 6 items, the sub-dimension of academic enjoyment self-concept had 5 items, and the sub-dimension of creativity self-concept had 3 items.

Calculated the indices of model fit (χ^2/df=2.98, RMSEA=0.063, SRMR=0.063, CFI=0.94, GFI=0.88, AGFI=0.85, NFI=0.92, NNFI=0.94, IFI=0.94) were regarded to meet the goodness of fit indices for university students (Çelik & Yılmaz, 2013; Schermelleh-Engel, Moosbrugger, & Müller, 2003). According to the obtained NNFI, CFI, RMSEA, SRMR, and the χ2/df values the inventory was considered to attain construct validity. Factor loadings (λ_x), error variance (δ), t values, and explained variance for each item were calculated. The t values were found significant, and factor loads were found between 0.33 and 0.78. After that McDonald's ω coefficient in addition to Cronbach α values, which was the internal consistency coefficient, was calculated for the reliability research of the scale. The α and the ω coefficients above 0.70 for all sub-dimensions except for creativity sub-dimension showed that the measurement results were reliable. The internal consistency coefficient for creativity sub-dimension was calculated as α=0.62. Based on these results, it may be concluded that the Turkish form of Chemistry Self-Concept Inventory is a valid and reliable tool of measurement.

Conclusions

Chemistry Self-Concept Inventory, which is used in evaluating prospective teachers' self-concept and which was developed by Bauer (2005) based on the importance of the effects of self-concept – one of affective introductory behaviours – on students' learning, was adapted into Turkish in this research and the psychometric properties of the inventory were determined. Measuring students' self-concept through this inventory is important in that it provides educators and teachers with opportunities to detect the behaviours that students bring to the learning environment and thus to obtain information about students. Positiveness of students' belief in learning may be a factor influential in the increase of their achievement because self-concept is a variable predicting students' achievement and thus contributing to achievement in a positive way. Therefore, the correlations between prospective teachers' self-concept determined through Chemistry Self-Concept Inventory and their chemistry achievement could be analysed in later research studies to be performed. Besides, since developing students' self-concept is a part of education, students should be provided with opportunities to have experiences in various learning environments which will contribute to improve their self-concept.

Researchers can use the sub-dimensions included in Chemistry Self-Concept Inventory independently of each other, and they can also analyse the correlations of these dimensions with other variables in accordance with their research purposes or with the affective variables they analyse.

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