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EXAMINING THE RELATION BETWEEN PROBLEM SOLVING AND CREATIVITY SCALES BY CANONICAL CORRELATION ANALYSIS

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ABSTRACT
Canonical correlation analysis, is one of the multi-variate statistics methods used for determining the relationship between two variate data sets. Although there is no obligation, in this analysis technique; one of the variate sets can be seen as dependent, and the other one being independent variate set. In the analysis process, for both of the sets, new variants from the linear combinations of the sets are obtained and the correlation between these new variants is sought to be maximum. In this study, the data for problem solving and creativity scale, gathered from 146 students studying in the department of Physical Education and Training in Yüzüncü Yıl University. After determining the basic factor for the scales using factor analysis, canonical correlation analysis is used in order to examine the relationship between two scales. According to the results obtained, the fact that coefficient of canonical correlation is positive and meaningful points out that there is positive directional relationship between problem solving and creativity. Aim of this study is to present the interaction between problem, solving and creativity of the students who study in the department of Physical Education and Training. When the results obtained from canonical correlation analysis are assessed, it is seen that for problem abilities thinking, evaluation, self-trust and planned approaches stand out and have a positive effect.

Keywords : Correlation, canonical correlation, problem solving, creativity

INTRODUCTION

Correlation analysis between sets (canonical analysis) is a statistical method used to reveal the relationships between two data sets (X and Y) consisting p>1 and q>1 number of variables (Özdamar, 2010).

The first method that comes to mind when determining the linear relationship between variables, is taking these variables two by two and calculating the coefficient of Pearson correlation between them. This coefficient is a widely used scale in determining the direction and the degree of the linear relationships between the continuous variables, when some assumptions or pre-conditions are fulfilled. If assumptions and pre-conditions are not fulfilled, one of the non-parametrical methods, Spearman rank correlation or Kendal Tau correlation can be used (Keskin and Özsoy, 2004). In some cases, the direction and the degree of the relationship can be affected by another variable or variables related to one or both of the variables. In such cases, calculating the partial coefficient of correlation related to the elimination of the affects of the variable or variables affecting the relationship between the two variables are more appropriate. In the case that there are both dependent and independent variables are more than one, meaning, in determining the relationship between two variable sets, none of the coefficients stated can be used. Instead, the correlation between sets based on finding the relationship between these variables is used by converting the variable sets into canonical variables that are made up of the linear components in these sets (Gürbüz, 1989). Simple correlation analysis is a method that states the relationship between two variables such as, Xi and Yi (i=1,..., n) and that evaluates the relationship using rxy correlation coefficient. Multiple correlation analysis is a method that evaluating the relationships between a dependent variable (Y1) and two or more independent variables (X1, X2, ..., Xp). Correlation analysis between sets is a statistical method evaluating the linear relationship between two sets including two or more variables (X1, X2, ..., Xp; Y1, Y2, ..., Yp), with the help of linear components (Özdamar,2010).

Correlation analysis between sets, which is one of the multi-variable statistical analysis methods, requires the stages of complex analysis (Tatlıdil, 1996). Because correlation analysis between sets examines the complex structure of relationships between variable sets, difficulties in the interpretation of the results, pushes aside the usage of this method. Whereas, examining the relationship structure between the

variables emphasized on with correlation analysis between sets without breaking the relationship structure, instead of simple coefficients of relationship, will provide the researchers with more information (Kesin and friends, 2005).

In the study, the aim is to determine the structure of the relationship between the features of problem solving and creativity of students, in the department of Physical Education and Training in Yüzüncü Yıl University, using canonical correlation analysis.

MATERIAL AND METHOD

Participants

A total of 146 students made up of 87 men (59.6%) and 59 women (40.4%), from the department of Physical Education and Training in Yüzüncü Yıl University, have participated in the study.

Data gathering tools

In order to reveal the students' problem solving abilities, the Problem Solving Inventory and How Creative Are You(Creativity) scales have been used in the study. Scales have been used simultaneously in class and without any limitation of time.

Made up of 35 points and prepared as a 6-point Likert type scale, Problem Solving Inventory, which includes the individual's perceptions, approach of solving and the evaluation of a problem, has been developed by Heppner and Peterson in 1982, and translated into Turkish by Şahin and his friends in 1993.

Another scale, used in the study, is the How Creative Are You (Creativity) scale which has been developed by Raudsepp in 1979 and is made up of 27 points.

Statistical Analysis

Problem solving inventory, used to evaluate the individual's problem solving abilities, is made up of 6 factors; "hasty approach", "thinking approach", "self trust approach", "planned approach", "thinking approach" and "evaluating approach". In order to determine the validity of the scale in the sample it's applied to, the coefficient of reliability has been calculated. For the canonical correlation analysis, the factors of the problem solving inventory has been used as they are. In order to determine the validity of the one factor creativity scale (Zeytun, 2010), coefficient of reliability has been calculated and factor analysis has been applied so that this scale could be used as a variable in canonical correlation analysis (Bektaş and Tayyar, 2009).

Given that $p>1$ and $q>1$, if there are p number of variables in the first variable set, and q number of variables in the second variable set, canonical correlation analysis takes the combinations between these two variable sets and calculates the correlation between them. Correlations, calculated this way are called canonical correlations; the new variables created by variables' linear combinations are called canonical variables. The canonical correlations between these canonical variables are calculated separately from each other (Johnson and Wichern, 2002). For the analysis of canonical correlations to be made, some assumptions have to be provided. These assumptions can be summarized as, features showing multivariate normal distribution, non-existence of multicollinearity between variables and the width of the sample being at least 5 times of the number of variables (Keskin and friends, 2005). When X set of variables is

expressed as; X1=[X1, X2, ..., Xp] and Y set of variables is expressed as ; Y1=[Y1, Y2, ..., Yp], the average vector, calculated from the sample belonging to these variable sets, is;

$$\overline{X} = \begin{bmatrix} \overline{x}_1 \\ \overline{x}_2 \end{bmatrix}$$

And the matrix of covariance is;

$$S = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

The correlation between U = a′X linear combination of X variable set and V = b′Y linear combination of Y variable set can be calculated.

$$\sigma_U^2 = aS_{11}a \quad E(U) = E(a'X) = a'E(X) = 0$$
$$\sigma_V^2 = bS_{22}b \quad E(V) = E(b'Y) = b'E(Y) = 0$$

When these transformations are carried out, U and V canonical correlation between the canonical variants is found;

$$r_{UV} = a'S_{12}b'$$

According to the conditions afore mentioned, this statement should be adjusted to maximum.

Significance Tests of Canonical Correlation Coefficients

As canonical correlation analysis can be also used for dimension reduction, about the correlation between the original variant sets, it should be known; of how many of the new variant pairs can it be explained with in a large extend, and in other words, how many of those among p number of canonical correlation are statistically important. For this reason, we calculate the χ^2 statistics, with this equation:

$$\chi^2 = \left[n - 0.5(V1 + V2 + 1)\right]\left[\log(\Lambda)\right]$$

In this equation, n; number of observation, V1; number of variants in the first set (independent variable set) and V2; number of variants in the second set (dependent variant set). And Λ is calculated using;

$$\Lambda = \left(1 - R_{k1}^2\right)\left(1 - R_{k2}^2\right)...\left(1 - R_{kp}^2\right)$$

calculated χ^2 statistics is compared with pxq degrees of freedom χ^2 table value (Özçomak ve Demirci, 2010).

Redundancy index

As it is stated before, the inter-set correlation analysis maximizes the correlation between the linear variants of X and Y variant sets. Therefore it does not explain the variation in one of the variant sets that is explained by the other one. For this, redundancy index is calculated. Redundancy index generally is calculated for the first canonical correlation to be taken into consideration. Redundancy index (RI_{UiVi})

which belongs to i. canonical correlation which is calculated between the U_i and V_i canonical variant sets, is measured in two stages. First stage; the part of the variation of Y variate set which can be averagely explained by i. canonical variant (V_i). This value is calculated with this equation:

$$OV(Y|V_i) = \frac{\sum_{j=1}^{p} LY_{ij}^2}{p}$$

Here, $OV(Y|V_i)$, is the mean variance that is explained by i. canonical variant of Y variate set, LY_{ij}, is structural correlation between i. canonical variant and j. variant of the Y variate set (j. loading of variant) and q is the number of variants belonging to the Y variate set. In the second stage, redundancy index is calculated with this equation (Sharma, 1996);

$$RI_{UiVi} = OV(Y|V_i)C_i^2$$

Findings and Discussion

Reliability coefficient (Cronbach a) measured for problem solving inventory is found to be 0.80, this value is measured 0.89 for creativity scale. In order to find the variants of the creativity scale set, that will be used in canonical correlation analysis, we have used factor analysis. After assessing the results of KMO measure (0.843) of sampling adequacy tests and Bartlett's global test (χ^2=2334.13; p=0.000), it is assured that creativity scale is suitable for factor analysis. In the end of analysis, 6 factors have been found. These factors correspond to the 55.22% of the total variance. The first factor to be found includes these items; *I believe that I can make original and useful things for the humanity* (1), *I rely on my intuitions and my sense of truth/false when I am close to solving a problem* (4), *I can easily change my approach if it is no good for solving a particular problem* (7), *I often care to work on a problem that I cannot understand thoroughly or failed to explain yet* (9), *the mysteries of life appeals to me* (10), *I believe that progressing step by step, through logical stages is the best method* (12), *the second method; I think self respect is more important than the respect shown by other people* (5), *I try to assure that I'm following the right steps solving a problem* (11), *it's more important to do what I feel it is right than trying to have other people's approval* (13), *I like people who prefer work over fun more* (20), *keeping everything in its right place and in order is important to me* (21) and *I am a reliable person with a sense of responsibility* (25), third factor; *I generally provide very quick solutions to problems* (8), *I might work on solving a difficult situation for a while* (14), *I like having new thoughts even if they don't always lead to the right answer* (22), *I often try to eliminate difficulties rather than ignoring them* (26) and *I prefer applied subjects rather theoretical subjects* (27), fourth factor; *I might be engrossed in my study if it is necessary* (3), *I like those works that show me impressive* (6), *most of the time, best of my ideas come to my mind when I'm not busy with something else* (15) and *I think asking the wrong question is often the reason why the problem cannot be solved* (23), fifth factor; *I get along better with people from the same social class or who work in an alike job* (18), *I try to avoid subjects that I feel inadequate* (19) and *being accepted as a good member of the group is important to me* (24), and lastly sixth factor includes; *while solving a problem I work faster analysis stage but work more slowly at the synthesis stage* (16), and *entering a world of imagination is effective in creating many of my projects* (17). Illustrative statistics measured for the variants used in this study are shown in Table 1.

Table 1. Introductory statistics

Y variable set (Problem solving)		X variable set (Creativity)	
Variants	$\overline{x} \pm s$	**Variants**	$\overline{x} \pm s$
Impatient (AC)	3.045 ± 0.751	1.factor (F_1)	3.899 ± 0.677
Thinking (DU)	4.357 ± 0.756	2.factor (F_2)	3.948 ± 0.733
Avoiding (KA)	3.048 ± 0.719	3.factor (F_3)	4.006 ± 0.665
Evaluating (DE)	4.204 ± 0.892	4.factor (F_4)	3.731 ± 0.705
Self trust (KG)	3.964 ± 0.687	5.factor (F_5)	3.588 ± 0.771
Planned (PL)	4.266 ± 0.891	6.factor (F_6)	3.539 ± 0.888

In this study, we are researching to see if creativity has any impact on individual's problem solving abilities. Problem solving and creativity scales are compromised of 6 factors. Therefore, the mean value of items in each factor is calculated and for each factor a different variant is produced. The correlation coefficients calculated between the variants from both of the variable sets are given in Table 2.

Table 2. Correlations between the factors

	Impatient (AC)	**Thinking (DU)**	**Avoiding (KA)**	**Evaluating (DE)**	**Self trust (KG)**	**Planned (PL)**	**Factor 1 (F_1)**	**Factor 2 (F_2)**	**Factor 3 (F_3)**	**Factor4 (F_4)**	**Factor5 (F_5)**
Impatient	1										
Thinking	-0.22**	1									
Avoiding	0.38**	-0.01	1								
Evaluating	-0.07	0.56**	0.12	1							
Self trust	-0.06	0.61**	0.05	0.53**	1						
Planned	-0.12	0.68**	0.09	0.64**	0.67**	1					
Factor 1	-0.07	0.41**	0.02	0.43**	0.40**	0.42**	1				
Factor 2	0.01	0.35**	0.02	0.36**	0.32**	0.37**	0.65**	1			
Factor 3	0.02	0.33**	0.04	0.35**	0.42**	0.37**	0.61**	0.65**	1		
Factor 4	0.15*	0.12	0.03	0.20**	0.17*	0.19**	0.50**	0.50**	0.46**	1	
Factor 5	0.18**	0.04	0.14*	0.13	0.18**	0.17**	0.36**	0.47**	0.48**	0.40**	1
Factor 6	0.18**	0.13	0.14*	0.16*	0.16*	0.19**	0.34**	0.36**	0.40**	0.34**	0.27**

* p<0.05; ** p<0.01

When the correlation coefficients in the Table 2 are examined; among the coefficients of the inter-set correlation; except for the coefficients of correlation between the impatient and avoiding approaches; and evaluating, self trust and planned approaches, it can be seen that the coefficients of the correlation are statistically more important.

The factors in the problem solving inventory in Canonical correlation analysis are as dependent and the factors that are used in creativity scale are considered as independent variants. As the number of variants for both sets is six, the maximum canonical correlation number to obtain is also six. In order to decide which one(s) of these canonical correlations will be used, we need to take look at their statistical meaningfulness and redundancy indexes. Canonical correlations that are calculated between the canonical variate pairs are shown in Table 3.

Table 3. Canonical correlation coefficients

Canonical Variate	Canonical correlation	p value	Wilk's Lambda
U_1V_1	0.549	0.000	0.578
U_2V_2	0.344	0.029	0.828
U_3V_3	0.195	0.649	0.939
U_4V_4	0.132	0.823	0.976
U_5V_5	0.074	0.838	0.993
U_6V_6	0.035	0.608	0.999

When the values shown in the Table 3 are examined; it can be seen that the canonical correlation (0.549; $p<0.01$ and 0.344; $p<0.05$) which is calculated between the first canonical and the second canonical correlation pairs, is statistically important. Redundancy measures for the variate sets are given in Table 4.

Table 4. Redundancy indexes

Explained variance ratio (Creativity)	Redundancy index (Creativity)	Explained variance ratio (Problem solving)	Redundancy index (Problem solving)
U1: 0.363	V1: 0.109	V1: 0.470	U1: 0.141
U2: 0.281	V2: 0.033	V2: 0.191	U2: 0.022

As it is shown in Table 4, redundancy measures that are calculated for the first canonical correlation are 0.109 for creativity and 0.141 for problem solving. For this reason, first canonical correlation is of reasonable quality. For the second function, redundancy measures are 0.033 for creativity and 0.022 for problem solving. As these values are very small, although the coefficient of the second canonical correlation has a statistical meaning, it will not be included in the assessment because its explanatory power for the variant is very small. The fact that the coefficient of the first canonical correlation is positive and meaningful shows that there is a unidirectional relationship between creativity and problem solving abilities. Standardized canonical coefficients belonging to the first canonical variate pair, canonical and cross loadings are given in Table 5.

Table5. Standardized canonical and cross loadings belonging to the first canonical variate pair

	Standardized Canonical Coefficients	Canonical Loadings	Cross Loadings
Problem solving (x)			
Impatient	-0.073	-0.238	-0.131
Thinking	0.352	0.859	0.472
Avoiding	-0.072	-0.027	-0.015
Evaluating	0.396	0.829	0.456
Self trust	0.316	0.819	0.450
Planned	0.112	0.817	0.449
Creativity (y)			
1st factor	0.686	0.896	0.493
2nd factor	0.268	0.737	0.405
3rd factor	0.436	0.773	0.425
4th factor	-0.225	0.329	0.181
5th factor	-0.253	0.218	0.120
6th factor	-0.075	0.283	0.156

In Table 5, standardized canonical coefficients, canonical and cross loadings are shown. Standardized canonical correlation coefficients show the amount of change in the canonical variate in terms of standard deviation, in response to 1 standard deviation increase of the original variate. In other words, these coefficients are, when the canonical variate is developing in a set, the coefficients that show the impact

value of original variates of that set. Using this table, equations belonging to the canonical variates of U_1 and V_1 can be written in this way:

$U_1 = –0.073AC + 0.352DU – 0.072KA + 0.396DE + 0.316KG + 0.112PL$
$V_1 = 0.686F_1 + 0.268\ F_2 + 0.436F_3 – 0.225F_4 – 0.253F_5 – 0.075F_6$

When the equalities are examined, the biggest contribution to the formation of U_1 canonical variate, belongs to the evaluating approach with 0.396, following that there are thinking (0.352) and self trust (0.316) approaches, whereas it is observed that impatient (-0.073) and avoiding (-0.072) approaches have negative contributions. Similarly, first factor (0.686) has the biggest contribution to the formation of V_1 canonical variate for the Y variable set, following that; third factor has 0.436 with the impact of standard deviation, and then the second factor has0.268 with the impact of standard deviation. The rest; 4^{th}, 5^{th} and 6^{th} factors are observed to have negative effects.

When the sample width is small and there is a multi collinearity suspicion on data set, it is expressed that using correlation coefficient between the canonical variate and the original variate of that set, would be more suitable (Sharma, 1996). These coefficients are named canonical loading or structural correlations. In Table 5, when the canonical loading of variants of the X variable set, with the first canonical variate (U_1), the highest value belongs to the thinking approach (0.859) and the lowest value belongs to the impatient approach with -0.238. As in standardized coefficients, thinking, evaluating, self-trust and planned approach coefficients have positive effects, whereas impatient and avoiding approaches have negative effect. When the canonical loadings of coefficients of the Y variable set, with the V1 canonical variate are examined; the highest loading corresponds to the first factor (0.896) and after that in respective order, there is third factor (0.773), second factor (0.727), fourth factor (0.329), sixth factor (0.283) and fifth factor (0.218).

When the canonical cross loadings of the problem solving skills are examined, these are the items that forms 1^{st} factor (0.493) which makes the largest contribution to the canonical variate of creativity;

- I believe that I can make original and useful things for the humanity (1),
- I rely on my intuitions and my sense of truth/false when I am close to solving a problem (4),
- I can easily change my approach if it is no good for solving a particular problem (7),
- I often care to work on a problem that I cannot understand thoroughly or failed to explain yet (9),
- The mysteries of life appeals to me (10),
- I believe that progressing step by step, through logical stages is the best method (12)

When the canonical cross loadings of the creativity variant are examined, the largest contribution is compromised of these items;

- Before making a decision, I compare the options and evaluate the each result by comparing and contrasting,
- I try to guess the consequence of a specific behavior,
- The first thing I do, when I encounter a problem, is to gather information and to overview the situation,
- After I make a decision, usually the result complies with the one I expect,
- When I notice a problem, one of the first things I do is to try to gain a clear understanding of the situation,

all of which make up the thinking approach variant (0.472).

CONCLUSION

Canonic correlation analysis is not widely preferred by researchers because of the difficulties encountered while interpreting the results and the calculations, along with the long process time. However; revealing the structure of the correlations between two sets of variables without disrupting the data acquired, and enabling more information to be collected are the fundamental elements that brings out the significance of this method.

In our study which examines problem solving abilities and creativity of individuals, 146 scale forms that are suitable for a healthy evaluation are taken into consideration in the process of evaluation. It is found that there is a unidirectional and middle-level relationship between problem solving abilities and creativity as a result of the canonical analysis applied to the data. This result of the study shows parallelism to the results obtained from Zaytun's study (2010). When the results of canonical correlation analysis are examined, it is seen that thinking, evaluating, self-trust and planned approaches stand out and have positive effects problem solving abilities. Schullteiss and Steid (2004), stated that planned approach is essential in the development process of individual, regarding the effective problem solving and decision making skills. Arslan, in his study in 2005, states that self-trust approach is highly affiliated with the self perceived degree of problem solving ability, and that the more self confident the individual is, the more successful they will be. When the effects of creativity variance on problem solving abilities are looked further into, especially the first factor is distinguished form others. In addition to this, the effects of third and second factor are undeniably high. Thinking of a creative person as an individual who creates new products and proposes different solutions, we might expect them to have the ability to solve the problems encountered in the discovery stage. The higher the problem skills are, the more likely they will be to solve the problems during the discovery stage (Kiremitçi, 2011). And this might help the problem solving and the creation proves to continue in a healthier and desired route. The individual reaches their goal by solving the problems they encounter and realizes their ideals.

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