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Secondary School Students' Self-Assessment of Design Process: A Study on Scale Development and Prediction by Various Variables

Research Article

Munise SECKIN KAPUCU[1], Kubra KARAKAYA OZYER[2]

[1] *Osmangazi University, Faculty of Education, Eskisehir, Turkey*, ORCID: 0000-0002-9202-2703

[2] *Osmangazi University, Faculty of Education, Eskisehir, Turkey*, ORCID: 0000-0002-0208-7870

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ABSTRACT

In the study, self-assessment scale of design process was developed for secondary school students. In addition, the relationship between perception for problem solving skills and decision-making attitudes, which are considered important in the design process, were examined. This study was based on the relational screening model and purposive sampling method was preferred. The research was carried out in two stages, in the fall and spring term of the 2018-2019 academic year. In the first stage, the scale was developed and in the second stage, the relationship between the scale and other variables was examined. The first stage of the study was conducted with 530 students from 7th and 8th grades, whereas 447 students participated in the second stage. In this study, Self-Assessment Scale of Design Process, Perception Scale for Problem Solving Skills and Decision-Making Scale in Adolescents were used. Descriptive statistics, Exploratory and Confirmatory Factor Analysis, Pearson Correlation Coefficient, and Multiple Regression analyzes were used in data analysis. As a result of the research, a valid and reliable measurement tool that can be used for self- assessment of design process has been developed. Moreover, it was concluded that problem solving perception and cautious-selective decision-making style have significant contribution on the self-assessment of the design process.

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Keywords:[1]

Design process, problem solving skills, decision making attitudes, secondary school students, scale development

Introduction

The problems we face in daily life change day by day and many disciplines such as science, technology, engineering and mathematics need to be integrated with each other to be able to solve the problems we face (Moore, Stohlmann, Wang, Tank, & Roehrig, 2014). The basis of the interdisciplinary approach is the

[1] Corresponding author's address: Eskişehir Osmangazi University, Faculty of Education, Turkey
Telephone: +90222 239 3750
e-mail: muniseseckin@hotmail.com
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innovative educational movement that John Dewey proposed in the early 1900s, to associate school learning with real life (Ellis and Fouts, 2001). The integration of disciplines is defined as an approach or teaching strategy that integrates knowledge, skills and values from different subject areas in order to teach concepts in a more meaningful way (Wang, 2012). Lederman and Niess (1997) likened the integration of disciplines to a chemical compound composed of different components. In chemical compounds, the components lose their properties, and the resulting compound has its own properties. Similarly, the combination of science, technology, engineering and mathematics disciplines has different characteristics than each discipline it covers. In many countries, especially in the United States, the integration of science, technology, engineering and mathematics disciplines is considered important in improving the literacy level of societies (Roehrig, Wang, Moore, & Park, 2012). The integration of the disciplines Science, Technology, Engineering and Mathematics is called STEM. STEM was first used by Judith A. Ramaley in the 1990s (Breiner, Harkness, Johnson and Koehler, 2012; Sanders, 2009). STEM is translated into Turkish as FeTeMM, which is the abbreviation for Science, Technology, Engineering and Mathematics words in Turkish (Çorlu, Capraro, & Capraro, 2014). This education is included in the agendas of the countries aiming to raise an innovative society that closely follows technology (Bybee, 2010). However, different understanding of STEM all over the world has created diversity in practices (Akgündüz & Ertepınar, 2015). Due to the low performance that the students in Turkey exhibited in international tests such as PISA and TIMSS, a tendency towards STEM education has begun (Herdem and Unal, 2018). In this context, STEM education was included in the curriculums in Turkey. Science Curriculum is one of these curriculums that includes STEM applications (MEB, 2018a).

The reports published by NRC (2012) aimed to support science education with other disciplines (engineering and technology) (Cited by, Pratt, 2012). In this approach, the integration of STEM disciplines was based on engineering design problems (Roth, 2001; Strong, 2013; Wendell, 2008). This approach, which is based on the use of engineering design problems in science education, is mentioned in the literature as design-based science education (Kolodner et al., 2003; Mehalik, Doppelt, & Schunn, 2008; Wendell, 2008). Daugherty (2012) stated that in this approach, science teaching is carried out through engineering design process. The inclusion of engineering design activities into the science courses leads students to science and reveals the relationship between science and daily life (Leonard, 2004). Therefore, it is important to focus on engineering design steps to understand engineering design activities performed in science courses. However, the steps of the engineering design process may also vary in the literature. For example, the engineering design process described by Cunningham (2009) has five stages, which are asking for solutions to an engineering problem, imagining, planning, creating and developing. Jamerson's design process has four stages: planning, designing, controlling and sharing (Barger, Gilbert, Poth, & Little, 2005). According to Mentzer (2011), the steps of the design process include defining the problem, producing solutions to the problem, making use of the models related to the solution, testing, decision making and group work. Regarding all these definitions, problem solving and decision making seem to be important steps in the design process, where the problem is defined, research is conducted, requirements are set, solutions are evaluated through brainstorming, prototype is developed, solution is tested, the meeting of the requirements is tested, and the results are shared (Wells, 2016). In design activities students develop various solution suggestions for real life problems, decide about the most appropriate solution among these suggestions, test their decisions about solutions in appropriate ways, evaluate their results and determine the necessary improvements as a result of these evaluations. In this process, students participate in engineering design activities personally (NAE & NRC, 2009; NRC, 2012).

Engineering is described as "the design process of the man-made world" (NAEP, 2014; NAE & NRC, 2009). In addition, design is shown as the most important dimension of engineering (NAE & NRC, 2009). Design is defined as a cyclical decision-making process or targeted problem-solving activity in order to make the best use of human resources (Smith, 1988). Design is also seen as a tool in which scientific knowledge and real-world problem-solving skills can be developed (Fortus, Dershimer, Krajcik, Marx, & Mamlok-Naaman, 2004). Regarding these definitions, it can be said that the design includes problem solving and decision-making skills.

Engineering design skills are included in the field-specific skills of the Science Curriculum (MEB, 2018a). Innovative thinking is emphasized in engineering design skills. Innovative thinking leads students to invent something or make a difference in an existing product. Engineering design skills support students to address problems with an interdisciplinary approach, create products using research and design skills, and advertise and promote their products (MEB, 2018a).

Science Curriculum includes discovering, questioning, creating arguments as well as product design (MEB, 2018a). In the program, students are expected to produce products by using the stages of engineering design process within the scope of Science, Engineering and Entrepreneurship Practices. Within this scope, it is seen that Science Curriculum includes 57 gains, distributed as 9 gains in the 4th grade, 12 in the 5th grade, 12 in the 6th grade and 12 in the 8th grade (MEB, 2018a). In 7th grade, the subject area of Physical Phenomena of the Force and Energy unit includes the following gain: "Designs a tool to reduce the impact of air or water resistance". In the 8th grade, a gain in the Physical Events subject area of the Simple Machines unit is: "Designs a mechanism that provides ease of work in daily life by using simple machines". It is seen that these gains are associated with the design process. Thus, it can be said that the 2018 Science and Technology Curriculum in Turkey has integrated the design process into the science topics.

In all stages of engineering design, which has been defined by ITEA (2007) as a repetitive decision-making process, students have to make various decisions (Cited by Denson, 2011). Purzer and Chen (2010) concluded that the most common method used in the development of decision-making skills in engineering education was focusing on decision-making skills in design projects. Decision-making skills are among the competences that students are expected to develop in science programs (MEB, 2018a).

Students experience the practices of engineering design process in science and technology and design courses. Students with engineering and design skills can produce solutions to complex real-life problems (Fortus, et al., 2004; Fortus, Krajcik, Dershimer, Marx, & Mamlok-Naaman, 2005). In addition, engineering design-based science education is considered to be very important for the development of students' decision-making skills (Denson, 2011; ITEA, 2007; Jonansen, 2011). Denson (2011) stated that decision-making skills should be emphasized in the education conducted with engineering design approach. Moreover, studies show that students' problem-solving skills (Fortus, et al., 2004; 2005) and decision-making skills (Denson, 2011; ITEA, 2007; Jonansen, 2011) are important in the design process.

Regarding the studies conducted with the students about the design process, it is seen that they were generally involved in increasing students' academic achievement (Doppelt, et al., 2008; Ercan and Şahin, 2015; Fortus, et al., 2004). However, there are also experimental studies that examined the effect of engineering design process on problem solving skills (Fortus, et al., 2005) and decision-making skills (Denson, 2011). There are studies in which students experienced the design process and developed products as a result of these experiences (Roth, 2001; Tal, Krajcik and Bluemenfeld, 2006). There are no studies in the literature showing the relationship between engineering design process and problem-solving and decision-making skills. Regarding the students who take science and technology and design courses, it is thought that their perceptions of problem-solving skills and decision-making attitudes may be effective in their self-assessment of design process. The literature review showed that there is no scale development study aiming to evaluate design processes of secondary school students. For this reason, in this study, firstly, a scale has been developed to evaluate the design processes of secondary school students. In addition, this study aimed to examine the perceptions of secondary school students about problem solving skills and the role of decision-making attitudes in predicting the assessment of the design process. For this purpose, the following questions were addressed:

1. "Self-assessment scale of design process" developed for secondary school students, is it a valid and reliable scale?

2. Is there a significant relationship between the sub-dimensions of Perception Scale for Problem Solving Skills, Decision-Making Attitudes Scale and Self-assessment of Design Process?

3. Do the sub-dimensions of Perception Scale for Problem Solving Skills and sub-dimensions of Decision-Making Attitudes Scale predict Self-Assessment of Design Process?

Methodology

Research Model

This study was conducted in two different time periods. The first time period is 2018-2019 fall term and the second time period is 2018-2019 spring term. In the first period, data were collected from 530 7th and 8th grade students in a public school in Eskişehir, to develop the Self-Assessment Scale of Design Process. In the second period, a public and private school again in Eskişehir were included and a total of 469 students in these schools were asked to complete the scales. In this study, correlational survey model was used (Karasar, 2016).

Study Group

During the development of the "Self-Assessment Scale of Design Process", 530 students attending a public school in Eskişehir have participated in the study in the fall semester of 2018-2019. 48.7% of these students were 7th grade and 51.3% were 8th grade students.

469 students attending 7th and 8th grades in a public and a private secondary school in Eskişehir participated in the second phase of the study. However, the data of the students who did not complete the scale completely was omitted from the data set. In addition, 10 data containing outliers have also been deleted. The analysis was conducted on the data of 447 students. Criterion sampling from the purposive sampling methods was used to determine the study group. In this study, taking technology and design course was determined as the main criterion. Demographic information of 447 participants is shown in Table 1.

Table 1. Demographic information of secondary school students

Variables		*f*	%
Gender	Female	215	48,1
	Male	230	51,5
Grade	7th grade	245	54,8
	8th grade	202	45,2
School Type	Public	344	77,0
	Private	103	23,0
Attending Science Application Course	Attending	265	59,3
	Not attending	166	37,1
Mother's education level	Primary school	32	7,2
	Secondary school	61	13,6
	High school	158	35,3
	University	148	33,1
	Postgraduate	38	8,5
Father's education level	Primary school	12	2,7
	Secondary school	50	11,2
	High school	145	32,4
	University	176	39,4
	Postgraduate	49	11,0
	Total	447	100,0

48.1% of the participants were female and 51.5% were male students. In addition, 54.8% of the students participating in the study were in 7th grade and 45.2% were in 8th grade. 77.0% of the participants were from public schools and 23.0% were from private schools. 59.3% of the students participating in the study were taking science applications elective course, while 37.1% were not taking this elective course. Mother education level of the students participating in the study was 7.2% primary school, 13.6% middle school, 35.3% high school, 33.1% university, 8.5% postgraduate education, whereas father education level was 2.7% primary school, 11.2% secondary school, 32.4% high school, 39.4% university, 11.0% postgraduate education

Data Collection Tools

Self-assessment scale of design process. In this study, "Self-Assessment Scale of Design Process" was developed first. In this process, the scale development steps proposed by DeVellis (2016) were taken into consideration. In the first stage of the scale development, the literature review was conducted. The stages of the design process were examined, and the conceptual framework was determined. Thus, the statements that can be used in the scale were drafted. Considering the conceptual framework, a pool of 33 items was initially created. The 33-item trial form was then submitted to the opinion of a science teacher, two technology design teachers, a psychologist, a measurement and assessment expert, and a Turkish language expert. After the expert opinions, the items that were not thought to measure the design process were removed from the form and 25-item trial form was finalized. Participants were expected to evaluate their own design processes on a 5-point Likert-type scale, where (5) indicates "Completely correct", (4) "Mostly correct" (3) "Somehow correct", (2) "Not correct" and (1) "Not at all correct"

In order to search for clues about the construct validity of the Self-Assessment Scale of Design Process, exploratory factor analysis was performed on the data. Factor extraction was performed by principal component analysis method and then varimax rotation method was applied. Factors' eigenvalues were checked, the scree plot was examined and as a result of these examinations it was found that the scale consisted of two factors. The variance explained by the first factor of the scale was 38.39%, while the variance explained by the second factor was 7.11%. As a result of the analyzes conducted on the data collected for the scale development study, the internal consistency reliability coefficient of the scale was calculated as .78 for the first factor and .88 for the second factor. In addition, Cronbach's alpha value of the whole scale was .90. In the light of the literature, the first factor was named as "Design development and evaluation" and the second factor was "Idea creation and planning".

Cronbach's alpha reliability coefficient of the study calculated for the data collected within the scope of the correlational survey design was found to be .74 for the first factor and .82 for the second factor. In this study, the Cronbach's alpha reliability coefficient calculated for the whole scale was .87.

Perception scale for problem solving skills. In this study, "Perception Scale for Problem Solving Skills" developed by Ekici and Balım (2013) was used to determine students' perception of problem-solving skills. This scale was designed as a five-point Likert type scale (always, often, sometimes, rarely, never). There are 22 items in the scale; 15 of them are positive and 7 are negative. As a result of the analyzes, it was found that the scale consists of two factors (Ekici and Balım, 2013). The Cronbach's alpha reliability coefficient of the scale was calculated as .88 for the first factor, .78 for the second factor, and .88 for the whole scale. The first factor was named as "Students' problem-solving perception" and the second factor as "Students' perception of willingness and determination towards problem solving". In this study, Cronbach's alpha reliability coefficient was found to be .90 for the first factor and .88 for the second factor, and the Cronbach's alpha reliability coefficient calculated for the whole scale was .88. According to the Cronbach's alpha values calculated both in this study and by Ekici and Balım (2013), it can be said that the scale results are reliable and valid.

Decision-making scale in adolescents (DMSA). In the current study, Decision-Making Scale in Adolescents developed by Mann, Harmoni and Power (1989) was also used. This scale was adapted to Turkish by Çolakkadıoğlu and Güçray (2007). It consists of two parts, which are Self-esteem in Decision Making and Handling Styles in Decision Making. Self-esteem in decision-making includes the first six items, which includes "I trust my decision-making ability" and "The decisions I make result positively". Items 2, 4 and 6 were designed as negative. Handling Styles in Decision Making part consists of 4 sub-dimensions, which are named as cautious-selective, panic, avoidance of responsibility and indifference (Çolakkadıoğlu and Güçray, 2007). The scale was prepared as four-point Likert type, scoring between zero and three. Zero point was given to the category "Never valid for me", one point for "sometimes valid for me", two points for "often valid for me" category and three points for "always valid for me" category. The highest score of each subscale was 18, whereas the lowest was zero. The Cronbach alpha coefficient of the scale was found to be .61. In addition, Cronbach's alpha coefficient was calculated as .79, .78, .77, .65 and .73 for self-esteem, cautious-selective, panic, avoidance of responsibility and indifference sub-dimensions (Çolakkadıoğlu and Güçray, 2007). In the current study, Cronbach's alpha coefficients were calculated as .71, .58, .82, .73 and .73 for self-esteem, cautious-selective, panic, avoidance of responsibility, and indifference subdimensions. Based on the current data, Cronbach's alpha coefficient of the whole scale was calculated as .68. Based on these findings, it can be said that the decision-making scale in adolescents is appropriate to be used in the research for psychometric properties.

Data Analysis

The data obtained from 530 students who participated in the study were examined for scale development purposes. In the scope of the research, the suitability of the sample size was checked first and the study group was found to be sufficient (Tabachnick & Fidell, 2001). Exploratory factor analysis (EFA) was used to determine the construct validity of the Self-Assessment Scale of Design Process. The principal components analysis with varimax rotation was used to determine the factors. In the analysis, factor loadings were set to be at least .30 (Büyüköztürk, 2018). Cronbach's alpha coefficient was used to determine the reliability of the scale. In addition, Confirmatory Factor Analysis (CFA) was applied to the data to test the accuracy of the revealed factor structure. SPSS 21 and LISREL 8.51 programs were used to perform all these analysis (Büyüköztürk, 2018; Çokluk, Şekercioğlu, & Büyüköztürk, 2018).

For the second and third sub-problems of the study, Pearson correlation coefficient and multiple linear regression analyzes were used. In order to use these analysis methods, some assumptions were checked first. Since the scales were prepared in Likert type, they should fulfill the condition of being continuous (Büyüköztürk, 2018). The skewness and kurtosis coefficients and histogram curves were examined to determine whether the normal distribution condition required for the analyses was satisfied. Skewness and kurtosis values were observed to be between -1 and +1. As a result of these analysis, these variables were found to show a distribution close to the normal distribution (Field, 2009). In multiple regression analysis, the relationship among independent variables should not be too strong (Büyüköztürk, 2018; Field, 2009). If the relationship between independent variables is .90 and above, "multicollinearity problem" arises (Alpar, 2013). To detect multicollinearity problems, variance inflation factor (VIF), which should be less than 5, should be checked (Güriş & Astar, 2015). In addition, to demonstrate that there is no multicollinearity problem, the tolerance value, which should be above .20, should also be checked (Field, 2009). For this purpose, VIF and tolerance values were checked to confirm that there is no multicollinearity problem. Another assumption was that there should be no auto-correlation between error terms, and the Durbin-Watson test was used to test this assumption. Durbin-Watson value is expected to be between Dlow and Dhigh in the Durbin-Watson table (Özdamar, 2013). The Durbin-Watson value was found as .86 in this study which is in the acceptable limits. In addition, the normal distribution of the errors was demonstrated using the histogram graph of standardized residuals. All these values show that the assumptions of multiple regression analysis were met.

In the second sub-problem, the linear relationship between the sub-dimensions of the variables involved in the research was investigated and Pearson correlation matrix was obtained to reveal these relationships. For the third sub-problem, self-assessment of design process variable was set as the dependent variable, and the sub-dimensions of the perception of problem-solving skills (perception of problem solving and willingness and determination to solve problems) and sub-dimensions of decision-making scale (self-esteem, cautious-selective, panic, avoidance of responsibility and indifference) were taken as independent variables and they were added to the multiple linear regression model by enter method. (Body text starts here)

Findings

This section includes the findings about the validity and reliability of the Self-Assessment Scale of Design Process, the relationships between the scales and the findings of the multiple regression analysis.

Scale Development Findings

After establishing the item pool, the scale was applied to 530 students and the data were collected. Exploratory factor analysis (EFA) was performed to reveal the structure formed by these data, in other word to determine the construct validity. First of all, Kaiser-Meyer-Olkin (KMO) coefficient and Barlett Sphericity test results were checked to determine whether the data was factorizable. KMO value was 0.95 ($p < .01$). In addition, Bartlett Sphericity test (chi-square: 4787.916, $p < .01$) showed statistical significance (George and Mallery, 2001). Both results showed that the data set was suitable for EFA (Alpar, 2013; Kalaycı, 2016).

Principal component analysis technique, which is one of the factor extraction methods, was used in exploratory factor analysis. In addition, varimax rotation method was applied to simplify factor loadings. As a result of EFA, the eigenvalues and the scree plot of the factors were examined, and it was seen that the scale was grouped under 2 factors. 7 items with factor loadings below .30 were excluded from the analysis. Then, the data of 18-item scale were re-analyzed through exploratory factor analysis. According the results of the new KMO and Bartlett test, it was found that the data of 18-item were suitable for factor analysis (KMO = 0.94 and Bartlett: 3228.41, $p < .01$). Factor loadings of all items were .40 and above. In addition, the difference between the items loaded on both factors was .10 and above (Büyüköztürk, 2018). Factor analysis was performed with the final 18 items and the total variance explained by these 2 factors was found to be 45.50%. The results of the EFA performed using varimax rotation technique are shown in Table 2.

Table 2. EFA Results of Self-Assessment Scale of Design Process (N=530)

	Factors	
Items	T1	T2
M18	.704	
M22	.681	
M25	.663	
M24	.647	
M17	.642	
M20	.641	
M16	.618	
M12	.607	
M14	.578	
M21	.576	
M11	.518	
M19	.485	
M3		.736

M2		.712
M1		.700
M4		.585
M6		.566
M5		.471
Cronbach's Alpha	.88	.78
Percentage of explained variance	38.39	7.11
Cumulative explained variance	38.39	45.50

Regarding Table 3, there were 12 items in the first dimension and the factor loadings of these items were between .49 and .70. In the second dimension, there were 6 items and their factor loadings varied between .47 and .74. The total variance explained by these two factors was found to be 45.50%. The first factor, which explained 38.39% of the total variance, consisted of the statements reflecting the initial stage of the design process and it was called "Idea Creation and Planning". The variance explained by the second factor was 7.11%. This factor was called as "Design Development and Evaluation" and consisted of statements reflecting the development and evaluation phase of the design process. The results of exploratory factor analysis showed that the results were in accordance with the theoretical structure formed at the beginning of the research.

In addition, the relationship between the sub-dimensions of the self-assessment scale of design process was also examined. Table 3 shows the correlation coefficients between "idea creation and planning" and "design development and evaluation" dimensions. Correlation coefficients indicated a moderate and positive relationship between the two sub-dimensions.

Table 3. Correlations of Self-Assessment Scale of Design Process Factors

	Idea Creation and Planning	Design Development and Evaluation
Idea Creation and Planning	1	.67**
Design Development and Evaluation	.67**	1

*n=530, **p<.01*

Based on the results of exploratory factor analysis, the two-factor structure was tested by Confirmatory Factor Analysis. The CFA results confirmed two-factor structure. The model obtained by CFA is illustrated in Figure 1.

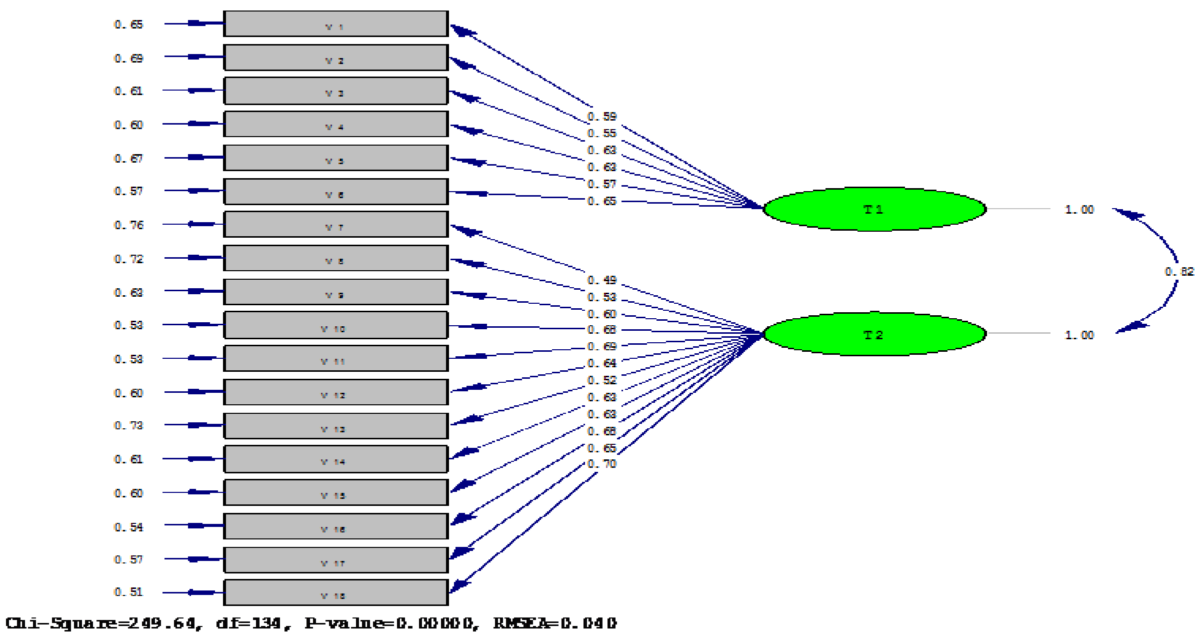

Figure 1. Confirmatory Factor Analysis

Confirmatory factor analysis, factor loadings and goodness of fit values of Self-Assessment Scale of Design Process are given in Figure 1. The review of Figure 1 showed that the chi-square value of the two-dimensional scale gave significant results (chi-square: 249.64, sd: 134, p <.01). For the compliance of CFA, chi-square value should not be significant (Özdamar, 2013). However, chi-square, which is affected by the sample, is sensitive to small deviations. Therefore, to determine the goodness of fit, the value obtained by dividing chi-square value to the degree of freedom was taken into consideration (Özdamar, 2013). The result of the division of the chi-square value to the degree of freedom (249.64/134) was 1.86, which was found to be acceptable (Çokluk, Şekercioğlu & Büyüköztürk, 2018). Goodness of fit values of the confirmatory factor analysis of Self-Assessment Scale of Design Process were: CFI: 0.99, NFI: 0.97, NNFI: 0.99, SRMR: 0.04; RMSEA: 0.040. These results were found to be acceptable (Kline, 2015; Schermelleh-Engel, Moosbrugger and Müller, 2003). Accordingly, it was confirmed that the Self-Assessment Scale of Design Process has a two-factor structure.

Since the first-level CFA results were found to be acceptable, the two-factor structure formed by exploratory factor analysis was confirmed.

Findings of Correlation Analysis

Descriptive statistics of variables were checked before examining the relationships among variables and these values are given in Table 4.

Table 4. Descriptive statistics of all variables

Variables	n	$\bar{X}$	S
Self-assessment of design process	447	70.96	11.02
Problem-solving perception	447	59.43	9.60
Perception of willingness and determination towards problem solving	447	24.85	6.87
Self-esteem	447	11.78	3.44
Cautious-selective	447	13.00	2.90
Panic	447	7.81	4.59
Avoidance of responsibility	447	5.06	3.55
Indifference	447	4.53	3.47

Regarding Table 4, secondary school students' average perception level of problem-solving skills was 59.43 and the average perception of willingness and determination towards problem solving was 24.85. Regarding the sub-dimensions of the decision-making scale, the mean of self-esteem dimension was 11.78, cautious-selective attitude dimension was 13.00, panic dimension was 7.81, avoidance of responsibility was 5.06 and indifference was 4.53.

Correlations between secondary school students' self-assessment of design process and sub-dimensions of perception of problem-solving skills (problem-solving perception and willingness and determination to solve problems) and sub-dimensions of decision-making scale (self-esteem, cautious-selective, panic, avoidance of responsibility and indifference) are given in the table. In the correlation results, values less than .30 were interpreted as low level, values between .30-.70 as medium level, whereas values greater than .70 were interpreted as high-level relationship (Büyüköztürk, Çokluk & Köklü, 2017).

Table 5. Correlation coefficients between students' self-assessment of design process and perception of problem-solving skills and their attitudes towards decision making

Variables	1	2	3	4	5	6	7	8
1.Design	1.00	.71**	.25**	.27**	.44**	-.15**	-.19**	-.21**
2. Problem-solving perception		1.00	.23**	.34**	.45**	-.14**	-.21**	-.18**
3. Perception of willingness and determination towards problem solving			1.00	.42**	.28**	-.47**	-.51**	-.49**
4. Self-esteem				1.00	.42**	-.50**	-.54**	-.36**
5. Cautious-selective					1.00	-.20**	-.27**	-.21**
6. Panic						1.00	.60**	-54**
7. Avoidance of responsibility							1.00	.67**
8. Indifference								1.00

** p < .01

A high positive correlation was found between self-assessment of design process and perception of problem solving (r = .71, p <.01). In line with these results, the students who have high perception of problem solving have high self-assessment of design process. Similarly, a moderate and positive relationship was found between cautious-selective attitude and self-assessment of design process variables (r = .44, p <.01). It was observed that students' perceptions of willingness and determination towards problem solving and self-esteem variables had a low and positive relationship with self-assessment of the design process (r = .25, r = .27 respectively). On the other hand, the sub-dimensions of decision-making styles such as panic, avoidance of responsibility and indifference variables were found to have a low and negative relationship with self-assessment of design process (r = - .15, r = -.19, r = - .21, respectively).

Findings of Multiple Linear Regression Analysis

Multiple regression analysis was conducted in order to see how secondary school students' perception of problem-solving skills (problem-solving perception and perception of willingness and determination towards problem solving) and sub-dimensions of decision-making scale (self-esteem, cautious-selective, panic, avoidance of responsibility and indifference) predict self-assessment of design process. Table 6 shows the results of multiple regression analysis involving the prediction of the self-assessment of design process by these dimensions.

Table 6. The results of multiple regression analysis on the prediction of self-assessment of design process

Variables	B	SH_B	*β*	*t*	*p*	Zero-order r	Partial r	Toleran ce	VIF
Constant	20.57	3.29		6.25	.00				
Problem-solving perception	.73	.04	.64	16.96	.00	.71	.63	.76	1.31
Perception of willingness and determination towards problem solving	.09	.07	.06	1.37	.17	.25	.07	.64	1.56
Self-esteem	-.15	.14	-.05	-1.06	.29	.27	-.05	.55	1.81
Cautious-selective	.55	.15	.14	3.69	.00	.44	.17	.71	1.41
Panic	-.06	.11	-.03	-.57	.57	-.16	-.03	.54	1.84
Avoidance of responsibility	.14	.16	.05	.91	.36	-.19	.04	.42	2.41
Indifference	-.23	.15	-.07	-1.52	.13	-.21	-.07	.50	2.00

n=447, *R*=.73, R^2=.53, *F*=69.47, *sd*= 446, *p*<.01

First of all, it should be noted that the regression model was significant (F = 69.473, sd = 446, p <.01). According to this model, seven independent variables explains 53% of the total variance of the dependent variable, which is self-assessment of design process (R = .73, R2 = .53). Then, the contribution of each variable to the model was examined through the coefficients table. It can be seen that the perception of problem solving, and cautious-selective variables significantly predicted the dependent variable, namely self-assessment of design process (t = 16.96, p <.01; t = 3.69, p <.01, respectively).

Regarding the partial correlations between independent and dependent variables, there was a high positive correlation between self-assessment of design process and problem-solving perception (r = .63). Similarly, there was a low positive correlation between cautious-selective attitude and self-assessment of design process (r = .17).

The relative order of significance of the independent variables on the self-assessment of design process was determined through standardized regression coefficients. These beta values were found to be problem-solving perception (β = .64) and cautious-selective attitude (β = .14). The regression equation for the prediction of the self-assessment design process was developed using the results of the regression analysis and shown below:

Self-assessment of design process = 20.57 +0.73 problem-solving perception + 0.55 cautious-selective attitude

Conclusions

In this study, a scale was developed first for the self-assessment of design process. An item pool was created considering the scale development stages, as a result of expert opinion and item analysis, the self-assessment scale of design process consisting of 18 items and two sub-dimensions was developed. Dimensions of the scale were named as; "Idea Creation and Planning" and "Design Development and Evaluation". As a result of the analyses, it was found that the scale gives valid and reliable results. Consequently, it can be said that this scale can be used in studies related to the design process for secondary school students.

Pearson correlation coefficients were checked to see whether there is a significant relationship between the sub-dimensions of perception scale for problem-solving skills, sub-dimensions of decision-making scale and self-assessment of design process. All relationships between self-assessment of design process and sub-dimensions of perception scale for problem solving skills and sub-dimensions of decision-making scale in adolescents were found to be statistically significant. However, only the relationship between self-assessment of design process and problem-solving perception was high. In addition, a moderate relationship was found between cautious-selective attitude, one of the sub-dimensions of the decision-making scale in adolescents and self-assessment of design process. The relations of all other sub-dimensions with the self-assessment of design process were found to be low.

While evaluating high school students' experiences in design process, higher problem-solving perceptions can be considered as an indicator that they act more consciously in design process. At the same time, it can be said that secondary school students, who are more selective and careful in making decisions, experience their design process in a more meaningful and adopting way. In this respect, there are many studies in the literature showing that problem solving, and decision-making skills are important for the design process (Denson, 2011; Fortus, et al., 2004; 2005; ITEA, 2007; Jonansen, 2011; Purzer and Chen, 2010).

The prediction power of the sub-dimensions of the perceptions scale for problem solving skills and the sub-dimensions of the decision-making scale on the self-assessment of design process was investigated. As a result of multiple regression analysis, only problem-solving perception and casual-selective attitude sub-dimensions were found to significantly predict the self-assessment of design process. The contribution of other sub-dimensions to the model could not be determined. According to these results, high school students' problem-solving perception and their selective behaviors while making decisions help them to better understand and experience design processes. Considering that these two variables explain the self-assessment of design process by more than 50%, further efforts can be put to increase students' perceptions about problem solving and their selectivity in decision making before starting the design process. In particular, experimental studies investigating problem solving and decision-making variables that are thought to affect the design process can be designed.

As a result of the research, a relationship was found between self-assessment of design process and perception and decision-making attitudes for problem solving skills. It is seen that engineering design process is included in the 2018 Science Curriculum, Science Applications Course Curriculum and Technology and Design Curriculum (MEB, 2018a, MEB, 2018b, MEB, 2018c). The program also includes gains for the design process. In this context, students are expected to experience the steps of the design process and produce products. However, there are no courses involving STEM or engineering design process in teachers' undergraduate programs, thus the competence of teachers in this context should also be questioned. It should be noted that the competence of teachers in this context will affect the performance of students on these issues. For this reason, the re-evaluation of the teacher competencies of the program gains and to overcome the deficiencies in the forthcoming processes will play an important role on the results of the design studies. Schools, curricula, teachers and students are all effective in the successful implementation of STEM. It was stated in the literature that the schools, the gains of the curriculums, the activities and the assessment approaches should be evaluated in terms of STEM applications (Bybee, 2010; NRC, 2012). It was observed that studies on STEM education have been increased in recent years, but there is no consensus on what STEM is, its place in curriculum and how it can be applied in classrooms (Çepni, 2018).

The prediction power of the sub-dimensions of the perceptions scale for problem solving skills and the sub-dimensions of the decision-making scale on the self-assessment of design process was investigated. As a result of multiple regression analysis, only problem-solving perception and casual-selective attitude sub-dimensions were found to significantly predict the self-assessment of design process. The contribution of other sub-dimensions to the model could not be determined. According to these results, high school students' problem-solving perception and their selective behaviors while making decisions help them to better understand and experience design processes. This study is limited to the data collection tools used and the variables included in the model. There is a 47% portion of self-assessment of design process variable that could not be explained by other variables. For this reason, further research can be conducted to reveal the effect of different variables on self-assessment of design process.

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