



THE EFFECT OF MATHEMATICS TEACHER CANDIDATES' LOCUS OF CONTROL ON MATH ANXIETY: STRUCTURAL EQUATION MODELING

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Abstract:

In this study, the effect of mathematics teacher candidates' locus of control on math anxiety was tested, along with the effects of gender, achievement and class level moderators. The study was carried out according to a causal design in which locus of control was taken as an independent variable, while math anxiety was taken as the dependent variable, and gender, achievement and class levels were considered as moderator variables. The participants were 402 students from three different state universities in Turkey who were selected using a combination of convenience and purposive sampling. Data were collected from the participants using the Locus of Control Scale (LCS) and the Math Anxiety Rating Scale-Short Version (MARS-SV). A path analysis was then used to provide a combination of measurement error in both latent and observed variables. The results of the path analysis revealed that the participants' locus of control positively affected math anxiety. Furthermore, the moderator analysis showed that this effect was higher in males and in groups with lower achievement scores. Finally, a significant positive correlation was found between the external locus of control and the total and sub-scale scores of math anxiety.

Keywords: math anxiety, locus of control, external control, internal control, structural equation modelling, mathematics education

1. Introduction

The theory of 'locus of control' was defined by Rotter (1966) as a concept that expresses the beliefs of individuals about whom and what they hold responsible for their experiences. In this sense, individuals may see themselves as accountable for the reasons behind their experiences, but they may also hold external factors responsible. According to this theory, internal locus of control-oriented individuals believe that their

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will play a decisive role in the emergence and development of the events they experience; while on the contrary, external locus of control-oriented individuals believe that what they experience is created by the influence of forces other than themselves (such as chance, misfortune, fate or other people). In terms of control orientation, individuals may be located at either end point or anywhere between these two points. The theory also holds that the perceptions of individuals with different orientations also tend to differentiate their behaviors (Lefcourt, 1982; Rotter, 1966; Rotter, Chance & Phares, 1972).

The locus of control theory, which has an impact in various fields, particularly the research findings of Gilbert and Levinson (1957), attracted the attention of Willower, Eidell, and Hoy (1967) with respect to the field of education, wherein researchers have observed similar findings to those of Gilbert and Levinson (1957). In this respect, Willower, Eidell, and Hoy (1967) believed that teachers, like the mental hospital workers in Gilbert and Levinson's study, had different orientations for student control and approached their students as individuals who need to be controlled. Their research served as a starting point for further locus of control studies, which have subsequently been carried out for many years in the field of education. In addition, Rotter's (1966) 'Locus of Control' and Bandura's (1977, 1986) 'Social Learning' theories triggered the emergence of the concept of effectiveness with respect to teachers.

With respect to the development of the concept of locus of control, Moretz (1997) points out that many researchers have attempted to establish relationships between locus of control and other variables. For instance, Lefcourt (1982) and Spector (1982) revealed a relationship between locus of control and other characteristics of teachers; while Kremer and Lifmann (1982) showed that teachers' locus of control differed according to age groups. Parkay, Olejnik, and Proller (1986), on the other hand, examined the relationship between locus of control and stress; whereas Czubaj (1996) found that locus of control was a basic motivational structure and that the internal locus of control was a factor in decreasing teacher stress, hence increasing their motivation. Moreover, Cheng (1994) found that locus of control was a strong indicator of job attitude and organizational perception in teachers. Similarly, Alderman (1990) stated that internal locus of control-oriented teachers had a high sense of effectiveness, whereas Radford, Cashion, and Latchford (1993) showed that locus of control influenced teachers' job perceptions, job satisfaction, relationships with students, and their ability to motivate and even to teach. Unsurprisingly, drawing a parallel from a person's external locus of control to his or her internal locus of control, Moretz (1997) demonstrated that this aspect was also associated with the success of a teacher candidate in their training program.

Furthermore, numerous studies have established that internal locus of control-oriented individuals had less difficulty in expressing their emotions; that they were more confident and needed less approval from others; and that they cared more about their psychological-physical health compared to external locus of control-oriented individuals. On the other hand, external locus of control-oriented individuals experienced more anxiety, stress and depression than internal locus of control-oriented

individuals due to their belief that they lacked the ability to prevent negative events from occurring (Ashby, Kottman, & Draper, 2002). In general, it can be stated that internal locus of control-oriented individuals are active, entrepreneurial, combative, compatible, emotionally healthy and balanced (Pandey & Tewary, 1979; Phares, 1976; Stricland, 1978), whereas external locus of control-oriented individuals have low levels of competence and expectations in certain subjects, as well as high levels of anxiety, and low levels of acceptance for life events (Lefcourt, 1976).

As seen in the related literature, both locus of control and teachers' effectiveness studies that were based on locus of control may have an effect on educational practices. In particular, research has determined that there are significant relationships between locus of control and anxiety. With respect to mathematics teaching specifically, recent studies have revealed that emotional, as well as cognitive factors have a significant effect (Cargnelutti & Passolunghi, 2017; García et al., 2016; Gunderson et al. 2018; Ramirez et al., 2016). As one of the emotional factors, when math anxiety is considered, it can be argued that it will be affected by the locus of control.

However, in the existing literature, math anxiety and math achievement are generally discussed in relation to mathematical concepts (mathematics achievement, attitude, teacher competence, motivation); there have been few studies that have explained the relationships between math anxiety and locus of control in mathematics teacher candidates. Because the theoretical framework of the concepts implies that locus of control may be associated with math anxiety; and within the scope of the existing needs and expectations, the following assumptions were made by the researcher in designing the present study:

- There is a significant positive relationship between locus of control and math anxiety [H1];
- A locus of control sub-scale will significantly predict the mathematics total score [H2];
- A theoretical model may be constructed concerning the effect of locus of control on math anxiety [H3];
- Locus of control has a significant positive effect on math anxiety [H4];
- Locus of control has a greater effect on the behavior of math anxiety in males [H5a];
- Locus of control has a greater effect on the behavior of math anxiety in groups with low math achievement [H5b];
- Locus of control has a greater effect on the behavior of math anxiety in 2nd-year students in mathematics courses [H5c].

2. Material and Methods

2.1. Research Design

In this study, a *causal design* was employed to examine the cause-effect relationship between the variables in the theoretical model. The locus of control variable in the model was considered as the cause; the math anxiety variable was considered as the

effect; and gender, achievement and grade level were considered as moderator variables.

2.2. Sample

The participants consisted of 402 students from three different state universities in Turkey; they were selected using a combination of convenience and purposive sampling. Among these participants, a total of 313 (77.9%) were female, and 89 (21.1%) were male, with an average age of 21.1 (SD= 1.07). Moreover, a total of 219 participants were in their 2nd year of study (54.5%), while 183 were in their 4th year (45.5%). For the purposes of this investigation, mathematics achievement was determined as a moderator variable. Third-year students were excluded from the study due to the fact that 1st-year students (who did not have a math achievement score when the study data was collected) and the moderator variables were binary. The mathematical achievement levels of the participants were calculated in consideration of their average achievement in the mathematics courses they had taken in their undergraduate studies. Based on their scores, the participants were classified into two groups, above 3 and below 3, with a maximum score of 4.

2.3. Instruments

2.3.1. Locus of Control Scale (LCS)

The Locus of Control Scale (LCS) consisted of 47 Likert-type items under five subscales (Personal Control, Belief in Chance, Meaninglessness of Effortfulness, Belief in Fate, Belief in an Unjust World) (Dağ, 2002). The items were rated on a 5-point scale, ranging from 'Completely Appropriate' to 'Not Appropriate at All'. The scale was generally compatible with the external locus of control sub-scale of Rotter's Internal-External Locus of Control Scale. The internal consistency of the LCS data in the current study ranged from .75 to .81 (see Table 1).

2.3.2. Math Anxiety Rating Scale-Short Version (MARS-SV)

The Math Anxiety Rating Scale-Short Version (MARS-SV) was derived from the 98-item Math Anxiety Rating Scale (MARS) that was adopted by Suinn and Winston (2003). The short version of MARS is a revision of the original instrument, which is lengthy and time-consuming and consists of numerous dimensions. The resulting MARS-SV includes 30 Likert-type items under five subscales (i.e., Test Anxiety, Course Anxiety, Application Anxiety, Computation Anxiety and Social Anxiety). The scale was adapted into Turkish by Baloğlu (2010). The internal consistency of the MARS-SV data in the current study ranged from .72 to .81 (see Table 1).

2.4. Procedure

After permission to use the LCS and MARS-SV was obtained, a research package that included demographic questions and the questionnaire items from the LCS and MARS-SV was assembled. The students were contacted during their classes and given

information about the study, and the selected participants signed consent forms, which took approximately 25-30 minutes.

The study was tested using the structural equation model of hypotheses, which is designed to test whether the data obtained for an independent theoretical model are appropriate (Karadağ, 2009). In the theoretical model of the current study, the following were assumed:

- That locus of control affects math anxiety;
- That *gender*, *achievement* and *grade level* have a moderator role on this effect.

Since the model consisted of observed variables, the variables were represented by rectangles, and the effects of the variables on the other variables were represented by one-way lines (see Figure 1). After the theoretical model of the study was built, acceptable models were obtained in terms of statistical compliance where the relationships between the variables were defined. First of all, the goodness of fit indexes were estimated based on the model that was accepted as correct. The goodness of fit indexes used in the study was as follows: GFI, AGFI, RMSEA, χ^2 , df and χ^2/df ratio and t coefficient. In addition, the variables were correlated with statistically determined structures. Thus, the relationships between the variables and the structures in the model were confirmed.

3. Findings

Before testing the theoretical model, correlation and multiple regression analyses were performed to determine the relationships between the variables. Afterward, the coherence of the models and the effects of the variables were determined by calculating the goodness of fit indexes for the theoretical models.

3.1. Correlation Analysis Findings for Theoretical Model

The participants' loci of control and their math anxiety levels are described in Table 1. The sub-scale of locus of control with the highest average was found to be 'Belief in Fate' ($M=3.65$, $SD=0.87$), and the sub-scale with the lowest average was found to be 'Belief in an Unjust World' ($M=2.46$, $SD=0.81$). Furthermore, the participants experienced 'Mathematics Exam Anxiety' ($M=3.52$, $SD=0.60$) and 'Mathematics Course Anxiety' ($M=2.99$, $SD=0.88$) to a greater extent, while the least-reported types of math anxiety were 'Calculation Anxiety' ($M=1.36$, $SD=0.64$) and 'Social Anxiety' ($M=1.58$, $SD=0.77$).

The relationships between the LCS and MARS-SV sub-scales were analyzed for Pearson-moment Correlation (see Table 1). The results showed a significant positive correlation between LCS total and the sub-scale scores and between the MARS-SV total and sub-scale scores - except for certain sub-scales. However, no significant relationship was found between the following scores:

- The PK sub-scale scores of LCS and the total and whole sub-scale scores of the MARS-SV;
- The BC sub-scale scores of LCS and the SA sub-scale scores of the MARS-SV,

- The BF sub-scale scores of LCS and the SA and ComA sub-scale scores of the MARS-SV.

Therefore, Hypothesis 1 was supported, with the exception of these insignificant relationships.

Table 1: LCS and MARS-SV Correlation Matrix

Sub-scales	α	M	SD	1	2	3	4	5	6	7	8	9	10	11	12
Locus of Control Scale (LCS)															
1. LCS total	.88	2.74	0.40	-											
2. PK	.82	2.57	0.57	.58**	-										
3. BC	.80	3.02	0.57	.13**	-.06*	-									
4. ME	.79	2.47	0.79	.65**	-.03	.17**	-								
5. BF	.77	3.65	0.87	.19**	-.25**	.08**	.11**	-							
6. BUW	.76	2.46	0.81	.65**	-.03	.51**	.73**	.11*	-						
Math Anxiety Rating Scale-Short Version (MARS-SV)															
7. MARS-SV total	.91	2.54	0.60	.26**	-.06	.68**	.24**	.16**	.24**	-					
8. TA	.77	3.52	0.83	.33**	.02	.24**	.44**	.12*	.14**	.20**	-				
9. CA	.74	2.99	0.88	.20**	-.09	.26**	.30**	.17**	.27**	.33*	.78**	-			
10. AA	.80	2.02	0.82	.10*	-.04	.70**	.11**	.10*	.11*	.71**	.26**	.29**	-		
11. SA	.75	1.58	0.77	.13**	-.06	.06	.25**	.08	.17**	.13**	.24**	.23**	.70**	-	
12. ComA	.79	1.36	0.64	.25**	.01	.67**	.29**	.02	.29**	.56**	.19**	.32**	.46**	.67**	.46**

PC: Personal Control; BC: Belief in Chance; ME: meaninglessness of the effortfulness; BF: Belief in Fate; BUW: Belief in an Unjust World; TA: Test anxiety; CA: Course anxiety; AA: Application anxiety; SA: Social anxiety; ComA: Computation anxiety;

$n=401$; * $p<.05$; ** $p<.01$

3.2. Multiple Regression Analysis Findings for the Theoretical Model

The LCS's predictive levels for the sub-scales of the MARS-SV were examined by multiple regression coefficients (Table 2). The results showed that the subscales of the LCS significantly predicted the MARS-SV total score and that the sub-scales of the LCS could explain 18% of the MARS-SV total score change [$R=.740$, $R=.43$, $R^2=.18$, $F=17.92$, $p<.01$]. Regarding whether the regression coefficient was significant, only PC, ME and BUW were significant predictors of the total score of MARS-SV among the sub-scales of the LCS. Therefore, Hypothesis 2 was supported.

Table 2: Multivariate regression matrix between variables

Math Anxiety	B	SH_B	β	t	p
Constant	1.85	.22		8.28	.00
1. Personal Control	-.11	.05	-.10	-2.19	.02
2. Belief in Chance	.04	.05	.03	.68	.49
3. Meaninglessness of the Effortfulness	.42	.06	.50	6.84	.00
4. Belief in Fate	.00	.03	.01	.27	.78
5. Belief in an Unjust World	-.11	.05	-.15	-2.18	.03

$n=402$, $R=.43$, $R^2=.18$, $F=17.92$, $p<.01$

3.3. Parameter Estimates and Goodness of Fit Indexes

After the creation of the theoretical model, parameter estimations for an acceptable, independent structural equation model reflecting the relationship between locus of control and math anxiety were examined (Figure 1).

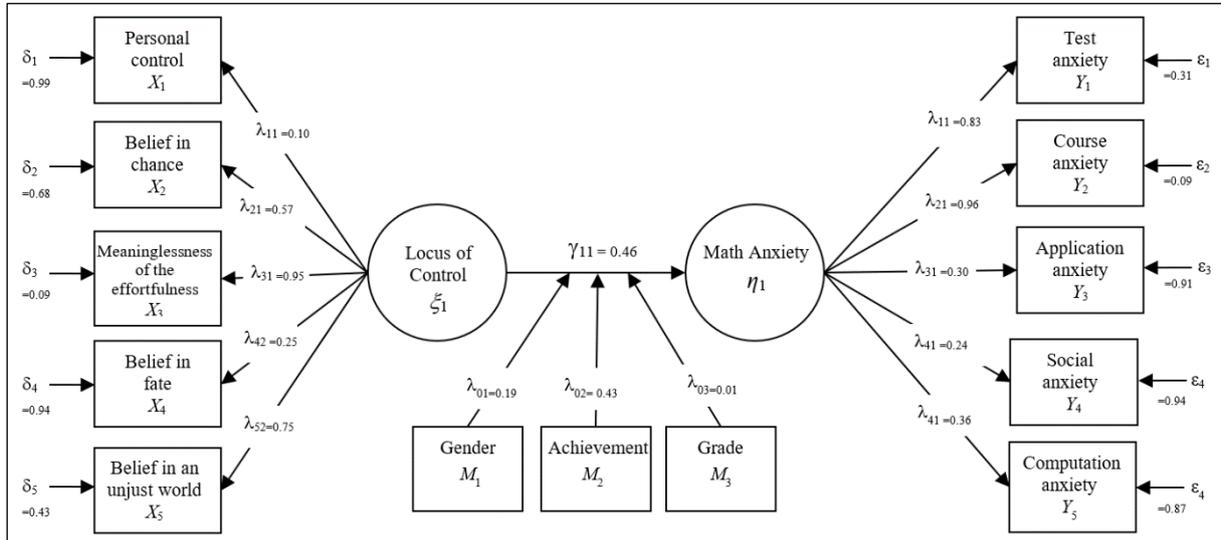


Figure 1: Structural equation diagram model and coefficients of the study

The simultaneous contribution of the theoretical model to the total model of each observed and latent variable was examined for goodness of fit (see Table 3). The theoretical model's goodness of fit was determined to be RMSEA, CFI, GFI, AGFI, χ^2 and χ^2/df . The RMSEA coefficient was determined as .06, the CFI coefficient was .88, the GFI coefficient was .91, the AGFI coefficient was .87, and the χ^2/df ratio was 1.43. The coefficients show that the theoretical model is suitable for the data obtained (Hair, Ringle, & Sarstedt, 2011; Kline, 1994; Jöreskog & Sörbom, 1993); therefore, Hypothesis 3 was supported.

Table 3: Goodness of Fit Parameters

Fit Parameter	Coefficient
RMSEA	0.06
CFI	0.88
GFI	0.91
AGFI	0.87
<i>df</i>	34
χ^2	48.9
χ^2/df	1.43

3.4. Multiple Correlation and Stability Coefficients for Measurement Models

In the context of this study, multiple correlation and stability coefficients of the measurement models within the theoretical model were examined (Table 4). The multiple correlation coefficients between the components of the theoretical model were generally between .32 and .98. This implies that none of the observed variables in the

theoretical model were latent. In addition, the stability coefficients of the measurement component were found to be at a reliable level of .81 and .86.

The first measurement model for the study was the Locus of Control Scale. In this context, the multiple correlation coefficients for the observed variables were between .32 and .97 for the sub-scales. Among the five observed variables, the 'Meaninglessness of Effortfulness' sub-scale was the most important and most reliable variable in determining the locus of control. Moreover, the total coefficient of stability for the theoretical model was at a reliable level of .81.

The second measurement model was the *Math Anxiety Rating Scale-Short Version*. Here, the multiple correlation coefficients for the observed variables were between .49 and .98 for the sub-scales. Of the five observed variables, the 'Course Anxiety' sub-scale was the most important and the most reliable in determining math anxiety. Moreover, the total coefficient of stability for the theoretical model was at a reliable level of .86.

Table 4: Multiple Correlation and Stability Coefficients of the Model

Fit Parameter	Coefficient
Locus of Control Scale (LCS)	
X ₁ Personal Control	.32
X ₂ Belief in Chance	.75
X ₃ Meaninglessness of the Effortfulness	.97
X ₄ Belief in Fate	.49
X ₅ Belief in an Unjust World	.87
X _s Kararlılık Düzeyi	.81
Math Anxiety Rating Scale-Short Version (MARS-SV)	
Y ₁ Test Anxiety	.91
Y ₂ Course Anxiety	.98
Y ₃ Application Anxiety	.55
Y ₄ Social Anxiety	.49
Y ₅ Computation Anxiety	.60
Y _s Kararlılık Düzeyi	.86

3.5. Relationship between Locus of Control and Math Anxiety

In this study, standardized regression coefficients related to locus of control and math anxiety and gender, achievement and grade level moderation were examined (see Figure 1 and Table 5). In the third part of the study model, the results indicated that locus of control positively affects math anxiety ($\gamma_{11} = .46$); therefore, Hypothesis 4 was supported.

However, the locus of control had a greater effect on math anxiety in males with low mathematics achievement. Therefore, Hypotheses 5_a and 5_b were accepted, and Hypothesis 5_c, which includes the moderation of grade level, was rejected.

Table 5: Standardized Regression Matrix

Variables	Math Anxiety
Locus of Control	.46*

*p<.01

4. Discussion and Theoretical and Practical Implications

In this study, the hypotheses that 'the locus of control will have a positive effect on math anxiety; and gender, mathematics achievement and grade level are moderators of this effect' were tested. In the theoretical models constructed on the bases of these hypotheses, the locus of control was independent; math anxiety was dependent; and gender, mathematics achievement and class level were considered as moderator variables.

The findings illustrate that the goodness of fit indexes of the model were at an adequate level. This demonstrates that interaction models of locus of control and math anxiety can be constructed. As a result of the study, all other hypotheses except for Hypothesis 5_c were accepted. Although there are no direct studies with which to compare the current results, the findings in the literature (e.g., Smith, 1997; Sari, 2007) suggesting that locus of control is one of the important determinants of anxiety support the finding that the model obtained in this study can be constructed.

The theoretical model consisted of three parts: two measurement components and one structural equation component. The findings related to the measurement models can be summarized as follows:

- The locus of control, which was the external variable in the study, consists of five observed variables [Personal Control, Belief in Chance, Meaninglessness of Effortfulness, Belief in Fate and Belief in an Unjust World]. The first measurement model of the study provided some clues about locus of control; for instance, the 'Meaninglessness of Effortfulness' sub-scale was the most important and reliable variable in determining locus of control.
- Math anxiety, which was the internal variable in the study, consists of five observed variables [Test Anxiety, Course Anxiety, Application Anxiety, Social Anxiety and Computation Anxiety]. The first measurement model provided some clues about locus of control, in that the 'Course Anxiety' sub-scale was the most important and most reliable variable in determining locus of control.
- In addition, the total coefficient of stability for the theoretical model in both measurement models was at a reliable level.

The structural equation component of the study was as follows: (i) the direct effect of the locus of control on math anxiety and (ii) the effect of gender, achievement and class level moderators. The significant findings related to the structural equation component can be summarized as follows:

- Locus of control has a positive effect on math anxiety.
- The effect of locus of control on math anxiety is higher in males.
- The effect of locus of control on math anxiety is higher in those with lower achievement in mathematics.

The findings demonstrated that locus of control was a high predictor of math anxiety. Similarly, Baloğlu and Türkoğlu (2007) studied the relationship between levels of math anxiety and locus of control with 120 university students and found that those with an external locus of control ($M= 85.94$, $SD= 44.29$) had significantly higher levels of

math anxiety statistically than the students with an internal locus of control ($M=127.00$, $SD=72.42$). Likewise, they found that the relationship between math anxiety scores and locus of control scores was significant ($r=.19$). After evaluating the results, it is possible to state that teacher candidates' locus of control is positively related to math anxiety. In this regard, Lefcourt (1982) demonstrated that individuals with an internal locus of control had more of the characteristics of successful teachers and were described as bright, intelligent and successful; whereas individuals who exhibited external locus of control were seen as dull, inadequate and prone to failure.

Moreover, both Lefcourt (1982) and Spektor (1982) put forward that locus of control may be a significant personality variable with respect to understanding teachers and their role in the classroom. Furthermore, Czubaj (1996) identified locus of control as a basic motivational structure and argued that internal locus of control is a factor that reduces teacher stress and hence increases motivation. With this in mind, and taking all of the data into account, it can be stated that locus of control is a significant competence for teachers and teacher candidates; and that this characteristic is a basis for math anxiety of mathematics teachers, as well as teacher candidates, whose basic function is to teach mathematics.

Additionally, the findings showed that males' locus of control had a higher effect on their math anxiety than females'; and similarly, the locus of control of the groups with low mathematics achievement also affected their math anxiety. This result is supported by other studies that have illustrated that men are not only external locus of control-oriented, but also have higher math anxiety in comparison with women. (Bieg, et al., 2015; Hill, et al., 2016; Karkoulian, Srour, & Sinan, 2016; McPherson & Martin, 2017; Van Mier, 2018). On the other hand, Maayan (2000) and Pinger (2010) argued that individuals with higher achievement levels are more internal locus of control-oriented, while individuals with low achievement levels tend to seek the cause of their failures in external variables and consequently have higher anxiety (Maayan, 2000; Pinger 2010). Therefore, the results obtained in this study are consistent with both theoretical and empirical literature.

5. Limitations and Directions for Future Research

In this study, it was found that there were significant relationships between locus of control and math anxiety. With this in mind, suggestions for both theoretical and practical areas of advanced research are as follows:

- In future studies, the theoretical model constructed within the scope of this study may be retested using a larger sample.
- Qualitative research with both women and men may help to convert details that may be ignored through quantitative research into data and reveal the reasons that locus of control increases math anxiety in males.
- Forty-six percent of math anxiety has been explained in the research. In this context, it should be kept in mind that unexplained variance may be caused by different variables.

- The cross-sectional nature of the research design may have hampered deeper understanding of the relationship between coping with mathematics and math anxiety and achievement. Therefore, it may be useful to conduct a longitudinal study using mixed-method approaches for addressing the research problem more comprehensively.

The most important limitation of this study was the research sample, as it was conducted with teacher candidates from three faculties. In addition, data were collected from a single faculty and evaluated. In this respect, the generalizability of the findings is limited. Furthermore, the data were collected through self-reporting, which may have caused common method bias, and thus, an artificial increase in the observed correlations.

Although this limitation cannot be completely eliminated, errors can be reduced to minimum levels. Accordingly, necessary measures were taken during the data collection stage of the study through recommended practices. Namely, the validity and reliability of the scale used in the data collection phase of the study were tested, and the participants were told during the face-to-face interviews that their responses would be kept in full confidentiality and would not be disclosed. In addition, the questionnaire that was applied with the participants was arranged in such a manner that the items related to the independent variables were presented before the items related to the dependent variables.

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