Effects of transformational leadership on teachers' self-efficacy in education for sustainable development: A serial mediation analysis

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ABSTRACT

Based on empirical evidence, this study aimed to analyze the effect of transformational leadership on teachers' self-efficacy in ESD and test mediation effects in the relationship between transformational leadership and teachers' self-efficacy in ESD. To this end, researchers constructed nine hypotheses, predicting direct effects among variables, each single mediation effect of two mediators, and serial multiple mediation effect. The participants of the research consisted of 193 Korean in-service teachers. Data analysis was conducted using descriptive statistics, the Pearson correlation coefficient, and multiple regression analysis. In addition, researchers applied serial mediation procedures with PROCESS Macro for SPSS to test specific mediate effects based on the bootstrap method. The the research, there were identified mechanisms through which the influence of the principal's transformational leadership on teachers' efficacy occurs in the context of ESD. The findings of the study were discussed in the light of relevant literature, and some suggestions were made for the future.

Keywords

Education for Sustainable Development (ESD); Transformational leadership; Teachers' self-efficacy in ESD; Teachers' attitude toward PD; Professional development; Serial Mediation Analysis

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1. Introduction

Education for Sustainable Development (ESD) emphasizes holistic, interdisciplinary, and learner-centered teaching that engages students in critical inquiries into fundamental issues of ecological preservation, social justice, and economic prosperity. Thus, ESD challenges the discipline-based dominant curriculum and teacher-centered pedagogical practices. If these challenges are to be confronted in schools, setting direction for school organizations related to ESD is needed. Principals' transformational leadership practice has been identified as critical in creating successful school organizations (Leithwood, Jantzi & Steinbach, 1998; Youngs & King, 2002). Furthermore, transformational leadership has been reported to play a significant role in forming shared vision, creating cross-curricular structures, and motivating ESD because ESD requires innovation on curriculum change and gradual transformation (Henderson & Tilbury, 2004).

Plenty of empirical research studies support that transformational leadership can positively affect teachers' commitment, create school structures that foster participation in professional development ((Leithwood, Jantzi & Steinbach, 1998; Youngs & King, 2002; Meister, 2010; Postholm, 2011) and raise teacher efficacy significantly (Demir, 2008; Hipp, 1997; Peagler, 2003; Ross & Gray, 2006; Sharma & Singh, 2017; Ninković, S. & Knežević, 2018). Prior research (Torff & Sessions, 2008; Torff & Sessions, 2009) investigates the relationship between teachers' attitudes toward PD and their participation in professional development (PD) or the relationship between teachers' attitudes and their self-efficacy, showing that teachers' mastery orientations predict teachers' enthusiasm. A strand of research (Yoo, 2016; Edwards et al., 1998; Fritz, Miller-Heyl, Kreutxer & MacPhee, 1995; Howard, 2003; Licklider, 1995; Ross & Bruce, 2007) reported that PD, including workshops, mentoring, and professional learning communities (PLC), can help teachers enhance their self-efficacy. The effect of instructional leadership on teachers' self-efficacy mediated through participation in PD (Cadungog, 2015). Furthermore, there is a significantly positive relationship between teachers' attitudes and self-efficacy (Fang, Chung & Yun, 2021), and teachers' self-efficacy is a significant predictor of positive attitudes (Shin, 2013).

Purpose of study

Taking together related literature, transformational leadership can positively influence teachers' self-efficacy in ESD, and there can be mediators in the relationships between transformational leadership and teachers' self-efficacy. More specifically, both teachers' attitudes and participation in PD likely mediate the relationship between transformational leadership and teachers' self-efficacy in ESD. In addition, transformational leadership is likely to cause teachers' attitudes toward PD, which, in turn, causes participation in PD, influencing teachers' self-efficacy in ESD as an outcome. However, despite the fact that there is likely to be a relationship among these factors, to our knowledge, little or no studies have been conducted to test relationships among the variables in the ESD field. There is, therefore, a need to search for a deeper understanding of the relationship between transformational leadership and teachers' attitude toward PD, participation in PD, and teachers' self-efficacy in ESD as a strategy to achieve high-quality ESD. Regarding this necessity, these authors explored the following research questions.

RQ1: Does transformational leadership positively influence teachers' self-efficacy in ESD directly or indirectly?

RQ2: Do teachers' attitudes toward professional development mediate the relationship between transformational leadership and teachers' self-efficacy?

RQ3: Do participation in professional development mediate the relationship between transformational leadership and teachers' self-efficacy?

RQ4: Do teachers' attitudes toward professional development and participation in professional development mediate the relationship between transformational leadership and teachers' self-efficacy in serial?

Thus, the research aims to analyze the total effect of transformational leadership on teachers' self-efficacy in ESD and test specific mediate effects in the relationship between transformational leadership and teachers' self-efficacy.

2. Literature Review

Transformational leadership and Teachers' self-efficacy

Bass (1990) has argued that transformational leadership is universal across organizations, suggesting that this leadership theory should transition nicely into education. Leithwood et al., (1998) followed principles of transformational leadership in the school context with a few modifications and conceptualized transformational leadership along with eight dimensions which are: (1) building school vision (developing a widely shared vision); (2) establishing school goals; (3) providing intellectual stimulation; (4) offering individualized support; (5) modeling best practices and essential organizational values; (6) demonstrating high-performance expectations; (7) creating a productive school culture; (8) developing structures to foster participation in school decisions. Eight dimensions can be grouped into three broad categories: setting directions, developing people, redesigning the organization. Later, Leithwood and colleagues (Leithwood et al., 2006) added the dimension of managing the instructional program to their conceptualization of transformational leadership. In this study, the authors apply Leithwood and colleagues' dimensions as a framework of transformational leadership and approached transformational leadership as a construct that includes setting directions, developing people, redesigning the organization, and managing the instructional program. Therefore, in ESD, transformational principals are expected to set a vision on ESD, stimulate motivation to implement ESD, coordinate ESD-centered school curricula, and encourage teachers to participate in PD.

Regarding the significance of transformational leadership in the educational setting, prior researchers have analyzed relations among transformational leadership, teachers' efficacy, teachers' attitudes, and teachers' participation in PD (Torff & Sessions, 2009). Transformational leadership has significantly positive effects on teachers' self-efficacy (Sharma & Singh, 2017; Ninković & Knežević, 2018), which refers to a person's confidence in performing a behavior successfully (Bandura, 1993). Bandura (1977) identified four sources of self-efficacy: mastery experiences, physiological and emotional state, vicarious experiences, and social persuasion. Transformational principals can provide teachers with mastery experiences or vicarious experiences by facilitating teacher professional development. In the process, teachers can enhance their self-efficacy and increase perceptions of their current success and expectations for the future.

Transformational principals can also influence teachers' efficacy through social persuasion by giving inspirational messages to teachers (Ross & Gray, 2006) and motivating teachers' desire by demonstrating high-performance expectations for ESD.   In summary, the transformational principal can influence teachers' self-efficacy by four sources of efficacy (Sharma & Singh, 2017; Ninković & Knežević, 2018). Therefore, considering this evidence, it is likely that transformational leadership will impact teachers' self-efficacy in ESD either directly or indirectly. Thus, the following hypothesis one (H1) was established.

H1: Transformational leadership will affect teachers' self-efficacy in ESD, either directly or indirectly.

Transformational leadership, Teachers' attitude, and Teachers' self-efficacy

Principal leadership affects teachers' attitudes (Leithwood, Jantzi & Steinbach, 1998; Youngs & King, 2002; Ross & Gray, 2006) and can stimulate teachers' desire for professional development by encouraging individual efforts, giving direction, and motivating teachers to implement the shared vision (Barnett, K. & McCormick, 2003). For example, Israeli elementary schools teachers who perceived their principal as having transformative leadership, which encouraged renovations and collaboration, tended to express more positive attitudes towards inclusion

(Weisel & Dror, 2006).

Regarding the effect of attitude on self-efficacy, the pre-service kindergarten teachers' attitude toward music directly affects their teaching self-efficacy (Shin, 2013). Previous studies reported that teacher attitude toward inclusion is strongly linked with teachers' self-efficacy in inclusive instruction. Teachers' self-efficacy is a significant predictor of positive attitudes regarding inclusive education (Evriani & Kumalasari, 2019; Weisel & Dror, 2006; Alnahdi & Schwab, 2021). Another study reported that teachers' self-efficacy mainly comes from experience, education, and interest (Nordlöf, Hallström & Höst, 2019). Taking together evidence, it is likely that transformational leadership can affect teachers' attitudes toward PD related to ESD, and teachers' attitudes toward PD can affect teachers' self-efficacy. Also, considering hypothesis one (H1), it is highly likely that transformational leadership will indirectly affect teachers' self-efficacy through teachers' attitudes toward PD. Therefore, the authors established the following hypotheses.

H2: Transformational leadership will affect teachers' attitudes toward PD.

H3: Teachers' attitudes toward PD will have influence teachers' self-efficacy in ESD.

H4: Teachers' attitude toward PD will mediate the relationship between transformational leadership and teachers' self-efficacy in ESD.

Transformational leadership, Teachers' participation in PD, and Teachers' self-efficacy

Broadly, PD can be defined as activities that encompass formally planned and naturally occurring activities that teachers may engage in collaboratively or independently to acquire and develop ideas, knowledge, skills, attitudes, and practices that bring about change in their work (OECD, 2014). Hence, PD can occur in informal contexts such as collegial dialogues, peer observations, personal readings, and a formal program utilizing workshops and in-services training (Mizell, 2010). In this study, the authors approached PD as a broader framework. The past research findings have shown that in-service training, workshops, conferences, or professional learning community give teachers time to collaborate with other teachers and allows meaningful learning. In addition, PD is an avenue for teachers to increase their competency since PD allows teachers' insights into their competency and instructional practices to deepen (Payne, & Wolfson, 2000).

The principal is a crucial predictor which influences teachers' participation in PD activities [. Payne and Wolfson (2000) have identified principals' five roles in teachers' participation in PD: a role model, the leader, the motivator, the provider of resources, and the facilitator. In addition, empirical evidence has been reported that transformational leadership significantly affects teachers' participation in PD (Louis & Marks, 1998).

Furthermore, teachers' professional development positively affects teachers' self-efficacy (Yoo, 2016; Edwards et al., 1988; Fritz et al., 1995; Howard, 2003; Licklider, 1995; Ross & Bruce, 2007). Taking together evidence, it is likely that transformational leadership will indirectly affect teachers' self-efficacy in ESD through teachers' participation in PD. The following hypotheses were established based on transformative leadership, teachers' participation in PD, and teachers' self-efficacy.

H5: Transformational leadership will affect teachers' participation in PD related to ESD..

H6: Teachers' participation in PD related to ESD will influence teachers' self-efficacy in ESD.

H7: Teachers' participation in PD related to ESD will mediate the relationship between transformational leadership and teachers' self-efficacy in ESD.

Transformational leadership, Teachers' attitude toward PD, Teachers' participation in PD, and

Teachers' self-efficacy

Teachers' attitudes toward PD are a vital predictor of their participation in PD and affect their successful professional development (Torff & Sessions, 2008; Torff & Sessions, 2009) . Therefore, considering theoretical evidence and the above hypotheses conjointly, it is highly probable that transformational leadership influences teachers' attitude toward PD (M1), which, in turn, affects teachers' participation in PD (M2), concluding with teachers' self-efficacy in ESD as an outcome. Therefore, based on the empirical data, the following hypotheses were established.

H8: Teachers' attitude toward PD will affect teachers' participation in PD

H9: Transformational leadership will indirectly affect teachers' self-efficacy in ESD through teachers' attitudes toward PD and teachers' participation in PD in serial.

3. Methods and Materials

Data Collecting

The data was collected through an online survey, and the convenience sampling method was preferred in the present study. Two hundred eleven teachers from various teaching fields responded to the survey. The rate of response is 84.4 %. The researcher used 193 valid cases for analysis. The demographics of teachers are displayed in Table 1.

Table 1 *Teacher Demographics*

Characteristics		Respondents	
Gender	Male	61	31.6
	Female	132	68.4
Age	20s	31	16.1
	30s	76	39.4
	40s	44	22.8
	50s	38	19.7
	60s	4	2.1
Year of teaching experience	5 years or less	58	30.1
	6~10 years	36	18.7
	10~15 years	30	15.5
	16~20 years	24	12.4
	More than 20 years	45	23.3
Highest educational level	Bachelor	145	75.1
	Master	46	23.8
	Doctor	2	1.1

Measurement Instrument

The research instruments were a questionnaire consisted of two parts. The first part consists of items asking gender, age, year of teaching experience, highest educational level, school size, and school location. The second part contains teachers' perceptions of principals' transformational leadership, teachers' attitude toward PD, participation in PD, and teachers' self-efficacy in ESD. Measurement items are shown in Table 2.

Table 2 : *Variables and Measurement items*

Variables	Questionnaire Items
Teachers' self-efficacy in ESD	To what extent can you do the following in the context of ESD?
	I can integrate content related to ESD into the subject matter.
	I have the content knowledge to implement ESD.
	I can effectively implement instructional strategies suitable for ESD.
	I can accurately evaluate student activities related to ESD, using a variety of assessment strategies.
	I can motivate even students who show low interest in learning for implementing ESD.
	I can be responsive to the learning needs of students in ESD class.
	I can stimulate my students to participate in ESD-related activities.
Participation in PD	How often do you do the following activities for the last 12 months?
	School-based in-service training courses.
	Teach jointly as a team in the same class
	Observe other teachers' classes and provide feedback
	Engage in joint activities across various groups
	Exchange teaching materials with colleagues
	Attend conferences or workshop
	Take part in a professional learning community
Teachers' attitude toward PD	How strongly do you agree with the following statements?
	In-service training courses related to ESD are necessary for teachers.
	Professional development activities help teachers to develop their ESD competency.
	Teachers need to participate in professional development for ESD.
Transformational leadership	How strongly do you agree with the following statements about the principal in this school?
	Principal(s) in this school...
	Set a widely shared vision on ESD
	Demonstrate high-performance expectations for ESD
	Express enthusiastically about ESD
	Encourage teachers' collaboration for ESD.
	Provide teachers with in-service training for ESD.
	Engage in joint activities related to ESD
	Encourage teacher's classes observation and providing feedback.
	Encourage teachers to apply new teaching strategies.
	Give individual support to help you improve teaching practices.
	Provide teachers with resources to improve their instruction
	Have curriculum competency
	Share decision-making authority with teachers
	Empower teachers to perform autonomous tasks.
	Frequently discusses educational issues with the teacher.
	Develop structures to participate in school decisions.
	Behave in a manner thoughtful of personal needs.
	Encourage teachers to consider new teaching ideas

Note: All items were measured using a four-point Likert scale

Survey items used in this investigation were adapted from a portion of this original questionnaire of prior research (Ford, 1992; Louis & Marks, 1998; Butler, 2007; Ryan, 2007; OECD, 2014).

To establish the construct validity of measurement tools, authors carried out factor analysis using principal axis factoring technique with varimax rotation, retaining all factors with eigenvalues greater than 1. Items with communality less than 0.50 were removed, and items with a loading less than 0.50 on component were removed. The authors run Kaiser-Meyer-Olkin (KMO) test to measure sampling adequacy and conducted Bartlett's Test of Sphericity to test the presence of correlations among variables. Before carrying out factor analysis, the authors analyzed the values of the bivariate correlation coefficients. None of the pair of variables with bivariate correlation scores was greater than 0.8. Transformational leadership practice was assessed using 20 items. Factor analysis on teachers' perceptions of transformational leadership practice initially yielded two items with communalities less than 0.50 and one with loading less than 0.50 on a component. Next, four items were removed and were leaved seventeen items. This produced a solution comprising four factors, as shown in Table 3.

Table 3: *Factors loadings from Principal Axis Factoring technique with varimax rotation*

	Redesigning school	Setting direction	Developing people	Managing instruction
Principal in this school....				
Share decision-making authority with teachers	**0.80**	0.11	0.26	0.26
Empower teachers to perform autonomous tasks.	**0.79**	0.05	0.25	0.21
Frequently discusses educational issues with teacher	**0.79**	0.08	0.27	0.33
Develop structures to participate in school decisions.	**0.79**	0.07	0.21	0.34
Behave in a manner thoughtful of personal needs.	**0.74**	0.12	0.10	0.03
Encourage teachers to consider new teaching ideas	**0.70**	0.17	0.34	0.33
Set a widely shared vision on ESD	0.16	**0.84**	0.02	-0.05
Demonstrate high performance expectations for ESD	0.07	**0.83**	0.12	0.19
Express enthusiastically about ESD	0.22	**0.82**	0.14	-0.06
Encourage teachers collaboration for ESD	-0.06	**0.82**	0.13	0.17
Provide teachers with in-service training for ESD.	0.13	0.02	**0.84**	0.15
Engage in joint activities related to ESD	0.34	0.17	**0.70**	0.18
Encourage teachers'classes observation and providing feedback	0.28	0.21	**0.67**	0.31
Encourage teachers to apply new teaching strategies	0.32	0.14	**0.56**	0.15
Give individual support to help you improve teaching practices.	0.28	0.13	0.14	**0.84**
Provide teachers with resources to improve their instruction	0.29	-0.03	0.27	**0.76**
Have curriculum competency	0.34	0.13	0.29	**0.74**
Eigenvalue	4.22	2.94	2.56	2.51
Percentage of variance explained	24.83	17.29	15.04	14.79
Cronbach's α	0.92	0.86	0.79	0.85
KMO coefficient 0.90		Bartlett's test of sphericity 0.000		

As shown in Table 3, Kaiser-Mayer-Olkin Measure of Sampling Adequacy was 0.92, which indicates the sampling is adequate. Bartlett's Test of Sphericity was significant by 0.000. As shown in Table 3, a total of four constructs were extracted with eigenvalues exceeding 1.0, each having factor loadings greater than 0.50 on at least three items. The Four extracted factors collectively accounted for 71.95% of the total variance in the data, thus suggesting the instrument exhibited satisfactory construct validity. Four components of transformational leadership practice contain redesigning the school, setting direction, developing people, and managing instruction, which adapted four dimensions presented within the questionnaire designed by Leithwood et al., (2006).

Reliability analysis was undertaken for each scale. As shown in Table 3, all constructs exhibited Cronbach's α reliability coefficient values greater than 0.70. Thus, the internal consistency of each construct indicates high internal consistency reliability.

Teachers' attitude toward PD was measured with three items. First, the authors carry out a Factor Analysis using the data collected from the responses on a commitment to ESD competency. One item initially had communalities less than 0.5, which was removed. Final Factor analysis yielded a stable solution with three items, and Cronbach's α reliability coefficient value is 0.84.

Participation in PD was created using seven items. Authors conceptualized professional development as encompassing planned and naturally occurring activities that teachers may engage in acquiring and developing ideas, knowledge, skills, attitudes, and practices that bring about change in their work. PD includes peer observations, team teaching, joining in projects across teachers, and a formal program utilizing conference, workshops, and in-service training in this study. Initial Factor Analysis yielded one item with communalities less than 0.50, which was removed. EFA yielded a stable solution with six items, and Cronbach's α reliability coefficient value is 0.81.

Teachers' self-efficacy in ESD was assessed using eight items, which measured the extent to which a teacher performing a given activity believes themselves capable of doing it effectively in the context of ESD. These items were adapted from those suggested by Tschannen-Moran, and Woolfolk (2001). The teachers' self-efficacy in ESD yields one dimension, and Cronbach's α reliability coefficient value is 0.87, indicating high internal consistency reliability.

Analysis Method

The authors conducted descriptive analysis and inferential analysis. Descriptive statistics were carried out to examine the distribution for single variables. Descriptive statistics were used to analyze the research data, and the relationships between research variables were examined using the Pearson correlation coefficient. The authors checked if the data satisfied the assumptions of linear regression before proceeding with the inferential analysis. Authors analyzed descriptive analysis, the Pearson correlation, and assumptions of linear regression using IBM SPSS Statistics, version 25.0

Separate mediation effects were analyzed with PROCESS Macro for SPSS. PROCESS Macro, which is based on the bootstrap method, is considered more powerful for detecting indirect effects in smaller samples. The indirect effect always becomes non-normal data when related to the product indicator and product effect, even if the data was initially normally distributed. Bias corrected and accelerated confidence interval (BCaCI) minimize problems that can arise from non-normal sampling (Hayes, 2013) and is the most trustworthy approach to testing the mediating effects when an indirect effect exists (Hayes, 2014; Hayes & Scharkow, 2013; Shrout & Bolger, 2002). In addition, through a contrast test conducted with the software developed by Hayes (2013), specific indirect effects of the variables were determined and the variable with a more powerful mediation for the model was selected upon a comparison of mediating variable pairs. To test the hypotheses, the authors run with the Serial-Multiple Mediation Model 6, a logical, causal sequence with two mediators.

This procedure allows the study of direct and indirect effects of X on Y while modeling a process in which X causes M1, which, in turn, causes M2, concluding with Y as an outcome. This model allows the control of the indirect effect of individual mediators while controlling for other variables and provides regression coefficients for the causal steps of the specific indirect effects. Bias-corrected bootstrapped point estimates for the indirect effects of the independent variable on the dependent were calculated, together with standard errors and 95% confidence intervals. Hayes (2013) recommended 10,000 bootstrap samples to be used for mediation analyses in the test from Serial-Multiple Mediation Model 6. Thus, data obtained from 10,000 bootstrap samples were used in the current study. The significance level of the current study was set as 0.05.

4. Results

Distribution to teachers' response and Correlations of values

The authors conducted a descriptive analysis to examine the distribution of teachers' responses and carried out a Pearson correlation analysis to determine the relationships between research variables. Table 4 includes the descriptive statistics and Pearson correlation coefficient values.

Table 4: *Descriptive Statistics and Pearson Correlation Coefficient Values*

.	Mean	SD	Skewness	Kurtosis	AT	PD	TSE
Transformational leadership (TL)	44.33	7.97	-0.30	1.03	.22**	.33**	.28**
Teachers' attitude toward PD (AT)	9.02	1.66	0.04	0.02	1	.37**	.35**
Teachers'participation in professional development (PD)	10.80	2.48	1.16	1.69	.34**	1	.64**
Teachers' self-efficacy in ESD (TSE)	19.44	5.00	0.03	0.56	.35**	.64**	1

Note. N = 193, **$p < 0.01$.

The correlation matrix in Table 4 shows that teachers' self-efficacy in ESD correlated with transformational leadership, teachers' attitudes toward PD, and teachers' participation in PD. Thus, table 4 indicates significantly positive relationships between transformational leadership and teachers' self-efficacy in ESD, between transformational leadership and teachers' attitude toward PD, and between transformational leadership and teachers' participation in PD.

Effect of transformative leadership on teachers' self-efficacy in ESD

To determine the serial multiple mediations of teachers' attitudes toward PD and their participation in PD in the relationship between transformational leadership and teachers' self-efficacy in ESD, the authors conducted Model 6 for SPSS. PROCESS Macro.

Before the serial multiple mediation analysis, the authors analyzed whether the linear regression model's assumptions satisfied to validate regression model validation. The authors checked P-P plots and scatter plots. Despite minor deviations, P-P plots fell approximately on a straight line, implying that the data fit reasonably well. Therefore, this research satisfies the assumption that regression model residuals are independent and normally distributed. Durbin Watson statistic, Tolerance, and Variance inflation factors (VIF) are included in Table 5. To sum, the data was considered to satisfy the assumptions for the use of multiple regression. Findings obtained through the serial mediation analysis of teachers' attitudes toward PD and their participation in PD in the relationship between transformational leadership and teachers' self-efficacy in ESD are presented in Table 5.

Table 5 : *Path Coefficients*

DV	ADV	B	SE	t	p	LLCI	ULCI	Tolerance	VIF	Hypothesis	Decision
AT	C	7.03	0.66	10.60	0.000	5.724	8.342				
	TL	0.04	0.02	3.04	0.003	0.016	0.074			H2	Support
	R^2: 0.046, F(1, 191): 9.265, p < 0.01, Durbin-Watson: 1.899										
PD	C	3.39	1.16	2.92	0.004	1.095	5.676				
	TL	0.08	0.02	3.94	0.000	0.041	0.124	0.954	1.049	H5	Support
	AT	0.42	0.10	4.14	0.000	0.218	0.615	0.954	1.049	H8	Support
	R^2:0.180,F(1,190):20.828,p<0.001Durbin-Watson 2.013										
TSE	C	1.30	1.99	0.65	0.516	-2.635	5.229				
	TL(T)	0.19	0.04	4.07	0.000	0.091	0.263			H1	Support
	TL(D)	0.04	0.04	1.14	0.256	-0.031	0.114	0.882	1.134		

AT	0.43	0.18	2.44	0.016	0.083	0.778	0.875	1.143	H3	Support
PD	1.15	0.12	9.43	0.000	0.909	1.390	0.820	1.219	H6	Support
R^2 : 0.434, F(3, 189): 48.215 p < 0.001, Durbin-Watson: 2.043										

TL: transformational leadership, TL(T): total effect of TL TL(D): direct effect of TL, AT: teachers' attitude toward PD, PD: teachers' participation in professional development, TSE: teachers' self-efficacy in ESD

As can be seen in Table 5, the model is at a significant level (F (3, 189) = 48.215, p < 0.001) and explained 43% of the total variance in teachers' self-efficacy in ESD.

When transformational leadership and all other mediating variables were simultaneously entered into the equation, the direct effect of transformational leadership on teachers' self-efficacy in ESD was not at a significant level (B: 0.04, p > .05). However, the total effect of transformational leadership on teachers' self-efficacy in ESD (B: 0.19, p < .001) was at a significant level, implying that Hypothesis one (H1) is confirmed.

In addition, direct effects of transformational leadership on teachers' attitude toward PD (B: 0.04, p < 0.01) and participation in PD (B: 0.08, p < 0.001) were at significant levels. The direct effect of teachers' attitude toward PD on their participation in PD (B: 0.42, p < .001) is on a significant level. A review of the direct effects of mediating variables (M1, M2) on teachers' self-efficacy in ESD showed that the effects of teachers' attitude toward PD (B: 0.43, p < 0.05) and participation in PD (B: 1.15, p < 0.001) were at significant levels, respectively.

Test of Mediation effects and Comparison between mediating effects

Each of the indirect effects and the comparison of each indirect effect of transformational leadership on teachers' self-efficacy in ESD through teachers' attitude toward PD and participation in PD is included in Table 6. As seen in Table 6, the total indirect effect of transformational leadership through both teachers' attitude toward PD and their participation in PD on teachers' self-efficacy in ESD is statistically significant (point estimate = 0.1357; 95% BCaCI [0.0604, 0.2040]). Contrasting findings presented in pairs were included in the current research to determine whether specific indirect effects of mediating variables were more substantial than others.

Current research analysis results showed three contrasting pairs were obtained. Within the tested model, when considering the mediating variables separately and together in relation to the mediating indirect effects of transformational leadership on teachers' self-efficacy in ESD, single mediation of teachers' attitude toward PD (point estimate = 0.0193; 95% BCaCI [0.0002, 0.0494]), serial-multiple mediation of teachers' attitude toward PD and PD (point estimate= 0.0215; 95% BCaCI [0.0052, 0.0419]), and single mediation of PD (point estimate = 0.0949; BCaCI [0.0339, 0.1532]) were found statistically significant. Therefore, hypotheses related to the mediation effect were not rejected.

Table 6 : *Comparison of the Indirect Effects of Transformational Leadership on Teacherśself-efficacy in ESD*

	Product of Coefficients		Bootstrapping	95% confidence level	Test of Hypothesis
Effects	Point Estimate	SE	Lower	Upper	
TOTAL Indirect Effects	0.1357	0.0357	0.0604	0.2040	
TL -> AT -> TSE (Model 1)	0.0193	0.0129	0.0002	0.0494	H4 Support
TL -> PD -> TSE (Model 2)	0.0949	0.0300	0.0339	0.1532	H7 Support
TL -> AT -> PD -> TSE (Model 3)	0.0215	0.0093	0.0052	0.0419	H9 Support
Contrasts					
Model 1 minus Model 2	-0.0756	0.0331	-0.1408	-0.0088	
Model 1 minus Model 3	-0.0022	0.0121	-0.0261	0.0243	

Model 2 minus Model 3	0.0735	0.0305	0.0103	0.1334

Note. N = 193, k = 10,000, TL: transformational leadership, AT: teachers΄ attitude toward PD, PD: teachers΄

participation in professional development, TSE: teachers΄ self-efficacy in ESD

In comparing the specific mediating effects of model 1(the single mediation effect of teachers' attitude toward PD) and model 2 (the single mediation effect of teachers' participation in PD), the participation in PD was observed to have more vital mediation than teachers' attitude toward PD. In the comparison of model 1 with model 3, there was a zero-point estimate interval within the 95% BCaCI, which indicates that mediating power was not statistically different from each other. In comparison between model 2 and model 3, there was not a zero-point estimate interval within the 95% BCaCI. Therefore, the comparison was found to be statistically different from each other with mediating power. The participation in PD was observed to have more strong mediation than teachers' attitude toward PD and the participation in PD in serial.

5. Conclusion

Based on empirical evidence, this study aimed to analyze the effect of transformational leadership on teachers' self-efficacy in ESD and to test mediation effects in the relationship between transformational leadership and teachers' self-efficacy in ESD. To this end, researchers constructed nine hypotheses, predicting direct effects among variables, single mediation effect of two mediators, and serial multiple mediation effect. Results findings confirmed the support of all hypotheses.

These research findings make some noteworthy contributions to the existing literature. First, this study extends current research on transformational leadership by examining mediate effects in the relationship between transformative leadership and teachers' self-efficacy in ESD. Furthermore, this study identified the mechanisms through which transformational leadership influences teachers' self-efficacy in ESD. Thus, these findings help clarify the nature of the influence of transformational leadership on teachers' self-efficacy in ESDs and facilitate a better understanding of their relationship. Third, results contribute to principals using data for their reflective purposes, whereas education officials may use it when designing programs for recruiting principals and in-service training.

Although research findings contribute to our understanding mechanism of transformational leadership on teachers' self-efficacy in ESD, limitations must be considered. First of all, non-probability convenience sampling was chosen as the sampling method in this study. Therefore, the results of this study might not be generalized to the whole of Korean secondary teachers. The authors suggest future studies attempt to replicate these results with probability sampling methods. In addition to limitations, we recommend that future researchers reexamine the relationships between leadership and teacher attitude by elaborating the constructs. Such research will allow investigators to explore the source of the principal's influence on teacher attitude toward PD.

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