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A Structural Equation Model on Teacher's Self-Efficacy in Education for Sustainable Development in Higher Education

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Abstract. In the academic milieu, several persistent problems often challenge the teachers' self-efficacy in optimizing education for sustainable development (ESD). This empirical pursuit aims to scrutinize a comprehensive best-fit model that explains the complex relationship between the transformational leadership style of school heads, teachers' attitudes, teachers' participation in professional development, and teachers' self-efficacy in education for sustainable development. SPSS v.26 and AMOS software were used to evaluate 400 valid cases in a quantitative descriptive-correlational predictive research design utilizing structural equation modeling. After stratification of the hypothesized models based on the analysis and theoretical relevancy, Model 3 was the best-fit model to divulge the predictive link among transformational leadership of school heads, teachers' attitude, and teachers' self-efficacy in ESD, which affirms the theory of Social Cognitive Theory. The result suggests transformative leadership and fostering positive attitudes are crucial in enhancing teachers' self-efficacy in the ESD context in promoting advancement to prioritize the accessibility and equitability of quality education while bolstering lifelong learning opportunities, as conveyed in SDG (Sustainable Development Goal) 4.

Keywords: Self-efficacy; Transformational leadership; Teachers' attitudes; Education for Sustainable Development (ESD); Structural Equation Modeling (SEM).

1.0 Introduction

In the academic milieu in the context of education for sustainable development, several persistent problems often weaken the teacher's self-efficacy. The core foundations of high-quality learning among students from varying academic levels are that teachers in higher education are significantly pressed to cope with ESD demands (Durrani et al., 2019; Kang, 2021). Amidst their demanding roles, transformative growth in diverse aspects has been progressively required, and among those expected adjustments is centered on their self-efficacy (Hussain & Khan, 2022). Despite its steady gaining prominence in academic settings, the factors shaping the teachers' self-efficacy in ESD in higher education on its consequential nature in this area are less investigated both in the local and international arenas (Tang & Zhu, 2024; Vare, 2023; Palomino, 2022). Alongside this notion, the scarcity of theory-driven modeling to curate positive changes in ESD self-efficacy among teachers exacerbates the need to augment support on related empirical endeavors (Handtke et al., 2022; Choi & Kang, 2021).

In the global setting, urged by these fast-evolving global expectations, researchers from different countries have been increasingly committed to assessing and enhancing teachers' self-efficacy in ESD (Lyu, 2023; Mokski et al., 2023). Substantiating this, in Greece, 267 educators who partook in pertinent ESD training or implemented ESD projects at their institutions to probe their Self-Efficacy Scale for ESD (Malandrakis et al., 2019). In Pakistan, Nousheen et al. (2024) unveiled the ESD teaching efficacy of 419 teaching interns regarding pedagogical knowledge parameters. Aligned with this, in Korea, Choi and Kang (2021) constructed a structural equation modeling to indicate how teachers' self-efficacy, stances toward ESD, and collaborative career advancement are indirectly impacted by transformational leadership (TL). Encapsulating the latter research attempts, it is still notable for clarifying that Higher Education Institutions (HEIs) worldwide are actively pressed to cope with the fast-evolving expectations to prioritize the enhancement of teachers' self-efficacy in ESD (Berchin et al., 2021).

In the Philippines, almost no research explores teachers' self-efficacy in ESD in higher education. Although HEIs in the country have joined the fray in discussing ESD, most published studies revolve around documentary analysis of national and international laws that strengthen the implementation of ESD. However, when scrutiny is diverted to the limited local studies, teachers' self-efficacy is also vastly credited to transformational leadership influences (Duran & Mariñas, 2024; O'beid, 2023). Exemplifying this, Nicdao (2019) inferred from their qualitative findings that university presidents who adhered to the best transformational leadership practices had spurred motivation in their administration, as reflected among the sampled renowned state universities in the country.

Numerous pieces of research evidence worldwide reinforce the notion that the high level of teachers' self-efficacy, if not addressed, will incapacitate them from embracing innovative teaching methods, setting ambitious goals, demonstrating improved organizational skills, concentrating their efforts on addressing academic challenges, and excel in collaborating with other stakeholders (Yang & Du, 2024; Ho, 2021; Lazarides & Warner, 2020; Wu et al., 2019). As the education system continually remains abreast with technological innovations, designing reliable models that seek to authenticate mechanisms in which transformational leadership and other salient determinants in addressing teachers' self-efficacy in ESD contexts become imperative (Akin & Calik, 2023). A crucial gap among research endeavors that elucidates the predictive link between teachers' self-efficacy in facilitating ESD in higher education remains predominant in the Philippines. Driven by these facts and circumstances, the researcher promptly perceives the requisite nature to undertake this study. Eyeing to cater to research-oriented perspectives and guidance, this empirical attempt is centered on intensifying initiatives toward enhancing the adoption of ESD and higher education teachers' efficacy in this domain through a structural equation model.

2.0 Methodology

2.1 Research Design

This quantitative descriptive–correlational predictive study utilized a structural equation modeling approach. Complementing its research design, the quantitative approach investigates an idea by creating precise hypotheses and collecting data to either validate or disprove the hypothesis (Creswell, 2021). Employing Structural Equation Modeling (SEM) in predictive research design provides a versatile and advanced method for examining intricate correlations among variables. Structural Equation Modeling (SEM) enables examining causal relationships among variables. It improves predicted accuracy via its measurement and structural model framework and facilitates a thorough analysis of inter-variable connections while accommodating measurement error and offering robust predictive modeling methodologies.

Moreover, this study applied descriptive methods to quantitatively assess variables such as the level of transformational leadership, teachers' ESD-inclined attitudes, self-efficacy, and professional development participation. Enriching these statistical resonances, correlational analysis corroborated the critical connection between two or more variables. Upon estimating and evaluating the effects, the interrelationship between transformational leadership (TL), teachers' attitudes (TA), participation in professional development (PPD), and self-efficacy (SD) in ESD contexts. The researcher also employed multiple regression analysis to examine the structural relationship among observed variables and underlying constructs (Hair et al., 2019).

2.2 Research Locale

The geographical context focused on in this research endeavor is Region XI. This spatial boundary is ideal as this region is home to several State Universities and Colleges (SUCs) offering various programs and degrees. Adding

to its credence, the target higher institutions mirror their reliability and prominence through competitive academic standards, highly trained educators, and inclusive learning environments. Regarding ESD, they had substantial efforts reflecting their commitment to providing their teachers with knowledge on sustainable development to give students the best education for success. The study respondents were sourced from various state universities and colleges in Region XI, which consented to permit the researcher to survey within their institutions to support the continuous commitment to excellence.

2.3 Research Participants

The selected respondents to this empirical endeavor were teachers from the different State Universities and Colleges (SUCs) in Region XI with at least one year of experience in teaching, regardless of whether they are regular or part-time teachers. The total number of respondents was obtained using the Quota sampling technique. In operational understanding, this non-probability selection framework deliberately identifies respondents gleaned from predetermined qualities to ensure that they accurately represent specified attributes in proportion to their occurrence throughout the population (McLeod, 2019). The quota for the respondents of this study was 400 college instructors. The study involved participants from various State Universities and Colleges (SUCs) in Region XI, with 400 college instructors distributed across 5 SUCs. The respondents were evenly distributed across these institutions to ensure equal representation and a comprehensive analysis of teachers' self-efficacy in education for sustainable development.

2.4 Research Instrument

In aggregating quantitative data to substantiate the objectives of this study, a four-part survey questionnaire was constructed and administered among the quota-sampled respondents. For Part I of the data gathering tool, school heads' transformational leadership (TL) became the focus of the assessment. Concurrently, Part II of the survey instrument delved into evaluating teachers' attitudes toward ESD, and Part III concentrated on weighing their PPD and self-efficacy related to ESD. Diverging into a reliable reference for data collection, the researcher adapted a survey questionnaire from Sunaengsih et al. (2021) to gather data for the independent variable, transformational leadership. Elaborating on the data gathering for the first mediating variable, teachers' attitudes toward ESD, the researcher contextually captured salient parts of the survey tool by Peedikayil et al. (2023). With this, the coherent adoption of the Likert Scale is central to examining this variable. Denoting the metrics to assess the second mediating variable, a structured questionnaire originally by OECD (Organization for Economic Cooperation and Development) (2014) has capacitated a detailed examination of the teacher's participation in professional development (PPD) in ESD. Cohesive with the previous usage, this variable also used a similar evaluation grid as a five-point Likert Scale at which one (1) remains the lowest and five (5) is maintained as the highest. For the dependent variable, the survey questionnaire reflected and applied in the research venture by Tschannen–Moran & Hoy (2001) has efficiently navigated an objective analysis of the teachers' self-efficacy in ESD. Collectively, the researcher's instrument entails 45 Items. Each part embodies the comprehensive variable being studied. For instance, Part I is anchored in the structured data collection about the independent variable, the school heads' TL, as discerned by teacher-respondents. It is stretched from a survey questionnaire by Sunaengsih et al. (2021), comprising twelve (12) items, with questions for diverse indicators, namely idealized influence, individualized consideration, inspirational motivation, and intellectual stimulation.

Expounding teachers' attitudes towards ESD, a survey instrument stemming from the empirical pursuit by Peedikayil et al. (2023), has enabled crucial evidence accumulation for the first mediating variable. Contextually, it consists of nineteen (19) items, with questions in each indicator for implementation, limitations, and adequacy. Supplementing a holistic accent, the focal interest in teachers' participation in professional development in ESD was met in Part III of the survey, which used the six (6) item questionnaires with indicators of engagement and collaboration adapted from OECD (2014). Following this data gathering for the second mediating variable, the last section, Part was immersed in the extensive data acquisition regarding the dependent variable. Employing the eight-item questionnaire with indicators of teaching and student involvement referenced from Tschannen–Moran & Hoy (2001), the objectives inputs showcasing teachers' self-efficacy in ESD within the established research locale were efficiently gathered. Culminating the quantitative nature of this research, a five-point Likert Scale application was deemed valuable in assessing each variable. Ergo, distinctive interpretations in defining the teachers' perceived extent of TL, attitudes, PPD, and self-efficacy in ESD were concisely established among all data collection tools.

On account of validity and reliability, the consultant reviewed the questionnaires that had undergone validation by specialists. Reliability result demonstrates a rule that follows the recommended threshold typically suggested by researchers (Asif et al., 2022). Meanwhile, composite reliability (CR) and average variance extracted (AVE) indices confirmed its construct validity for each variable under investigation. As deduced from empirical assertions, the CR is considered appropriate when it exceeds 0.7, and the AVE is deemed acceptable above 0.5 (Qing et al., 2020). Further heightening uniformity, Cronbach's alpha was utilized to evaluate and solidify the internal homogeneity of the research instrument. A 0.70 or above Cronbach's alpha coefficient is satisfactory in the generic threshold.

2.5 Data Gathering Procedure

Distributing the Informed Consent Forms before disseminating the survey instrument to the respondents allowed them to ask all the questions they had in mind related to the research. With the absence of additional queries and areas demanding clarifications, the Informed Consent Form was processed for due signing to guarantee their willing approval. After this, proper scheduling was arranged, and survey forms were carefully distributed among the respondents. The researcher thoroughly explained how to answer the questionnaires given to college instructors working in different state tertiary institutions with the approval and full support of the school heads. The questionnaires are distributed to respondents via Google Forms. Although some participants did not provide their e-signatures, their engagement and responses demonstrate their voluntary participation in the survey. After the respondents had provided the relevant data and answered the Google form honestly, the researcher extracted all completed questionnaires. After the survey questions had been successfully administered and retrieved online, the results were gathered and tallied. Data was collected using appropriate statistical methods to interpret the result and further analysis.

2.6 Ethical Considerations

Upholding ethical standards in research is essential in fostering honesty, safeguarding participants, and bolstering the credibility of scientific progress (Bhandari, 2021). The researcher adhered to and implemented specific ethical standards and concerns set by the HCDC–SMILE. Respondents were given informed consent forms to ensure their willingness to participate, essential for safeguarding participants, preserving research integrity, and cultivating trust among the scientific community and society. There was no potential harm to the respondents. To meet the quota per State Universities and Colleges (SUCs) while ensuring anonymity, the researcher assigned code names to each SUC. This allowed the researcher to track the distribution of respondents without compromising their confidentiality. The researcher's dedication to ethical principles strengthens the basis of responsible research, facilitating the quest for knowledge while honoring human rights and dignity.

3.0 Results and Discussion

3.1 Descriptive Analysis

As shown in Table 1, school heads' overall transformational leadership style obtained 4.25, a mean value of a "very high level." It signifies that the transformational leadership style of school heads is always observed. Among all the four indicators, Intellectual Stimulation yielded a 4.38 mean score or a "very high level," showcasing school heads always provide references in self-development to educators/staff, provide opportunities for them to also improve training and overall education, involve them in policy development and assessment for higher education, solve problems innovatively, and offers beneficial solutions for stakeholders. Contrarily, the individualized considerations have the lowest mean, 4.14, or a "high descriptive level," implying that the school head frequently praises faculty and staff achievements, invites recommendations for improvement, and provides support and training to individuals facing challenges. They usually advise reviewing evaluation outcomes to address deficiencies and understand the needs of lecturers regarding classroom teaching and learning activities while also attending to the grievances of lecturers and staff for collective well-being.

Diverting into the teacher's attitude towards ESD, the 4.25 composite mean value or "very high" denotes that the teacher's attitudes toward ESD always manifest, indicating a positive and consistent attitude towards ESD. Adequacy attains the highest of the three indicators at a 4.47 mean score or a "very high descriptive level." As gleaned from the figure, a conclusion is that teachers consistently exhibit a positive attitude towards ESD, believe that ESD effectively enhances students' awareness of sustainability, find it adequately integrated into the

curriculum, and consider themselves sufficiently knowledgeable about ESD. Also evidenced from the findings, the 3.82 mean value or a "high descriptive level" for Limitations implies that teachers' attitudes towards ESD are frequently manifested. Likewise, they regard ESD as a contentious pillar that must be pedagogically articulated in higher education. It is a realistic approach and easy to integrate into their teaching pedagogy, which may increase students' motivation and ability to understand.

Table 1. *Level of transformational leadership style of school heads, teachers' attitude towards ESD, teacher's participation in professional development in ESD, and teacher's self-efficacy in ESD*

Variables	Mean	Descriptive Level
Transformational Leadership of School Heads		
1. Idealized Influence	4.24	Very High
2. Individualized Considerations	4.14	High
3. Inspirational Motivation	4.24	Very High
4. Intellectual Simulation	4.38	Very High
Overall Result	4.25	*Very High*
Teacher's Attitude Towards ESD		
1. Implementations	4.44	Very High
2. Limitations	3.82	High
3. Adequacy	4.47	Very High
Overall Result	4.24	*Very High*
Teacher's Participation in Professional Development in ESD		
1. Engagement	4.35	Very High
2. Collaboration	4.44	Very High
Overall Result	4.39	*Very High*
Teacher's Self-Efficacy in ESD		
1. Teaching	4.63	Very High
2. Student Involvement	4.45	Very High
Overall Result	4.54	*Very High*

Drawing upon the teachers' participation in professional development in ESD, the garnered 4.39 mean score or "very high level" reflects that the teachers' involvement in professional development is always manifested. This reveals the teacher's commitment to professional development and personal growth in the ESD context. Between the two indicators, Collaboration with a mean score of 4.44 or "very high level" resonated with teachers' proactive Collaboration with their colleagues. On the other hand, Engagement's 4.35 mean score or "very high level" supports the personal active Engagement of the teachers in training, joint activities, and professional learning communities in pursuit of professional development in ESD.

Lastly, the teacher's self-efficacy in ESD 4.54 mean value or a "very high level" distinguishes the frequent manifestation of teacher's self-efficacy in ESD. With this, it can be inferred that their confidence and competence in Teaching and integrating ESD context positively and consistently demonstrate their efficacy. Contrasting the two indicators, Teaching has a mean score of 4.63 or "very high level", suggesting that the teacher's teaching efficacy in integrating ESD in their pedagogy is highly demonstrated. On another note, Student Involvement with a mean score of 4.45 or "very high level". Mirroring how teachers can integrate ESD lessons in the teaching and learning process into their classrooms while actively involving their students.

3.2 Correlational Analysis

Table 2 shows the inferential analysis of the correlation among all variables.

Table 2. *Test of significance on the relationship between transformational leadership of school heads, teacher's attitude towards ESD, teacher's participation in ESD, and teacher's self-efficacy in ESD*

	Teacher's Self-Efficacy in Education for Sustainable Development			
	r – Value	**p – Value**	**Decision on Ho**	**Interpretation**
Transformational Leadership of School Heads	.371	.000	Reject	Significant
Teacher's Attitude Towards ESD	.494	.000	Reject	Significant
Teacher's Participation in Professional Development in ESD	.763	.000	Reject	Significant

Transformational leadership of school heads is correlated with ESD teacher self-efficacy with an r-value of .371 and a p-value of .000. This shows a significant low positive correlation between the variables. Additionally, teachers' attitude toward ESD and self-efficacy in ESD have a correlation r of .494 with a p-value of .000. This

suggests a substantial positive correlation between these variables. Teacher participation in professional development and ESD self-efficacy have a correlational r value of .763 and a p-value of .000. This indicates a strong positive relationship between variables. So, the first null hypothesis is rejected.

3.3 Regression Analysis

The inferential analysis of all variable regression is shown in Table 3.

Table 3. *Test of significance on the influence of transformational leadership style of school heads, teachers' attitude towards ESD, teachers' participation in professional development in ESD on teachers' self-efficacy in ESD*

	Unstandardized Coefficients		Standardized Coefficients			Decision	Interpretation
	B	Std. Error	Beta	t	Sig.		
Constant	1.84	.119		15.4	.000		
Transformational Leadership of School Heads	.173	.033	.264	5.23	.000	Reject	Significant
Teacher's Attitude Towards ES	.149	.040	.188	3.67	.000	Reject	Significant
Teacher's Participation in Professional Development in ESD	.639	.033	.805	19.2	.000	Reject	Significant

$R = .781; R^2 = .610; F - value = 206.104; p - value = .000$

A multiple linear regression was done to examine how transformational leadership of school head, teacher's attitude towards ESD, and teacher's participation in professional development in ESD predict teacher's self-efficacy in ESD. The relationship between transformational leadership of school head, teacher's attitude towards ESD, teacher's participation in professional development in ESD, and teacher's self-efficacy in ESD was positive and linear and did not reveal any bivariate outliers. The table shows that all the variables significantly influence teacher's self-efficacy in ESD, with a p-value of .000, .000 and .000, respectively. With an R-value of .781 and an F – value of 206.104, p =.000, which shows that there is a significantly strong predictive relationship between the predictors and the outcome variable, saying that the model works and with an R^2– value of .610 accounting for 61% of the variability in teachers' self-efficacy was predictable from the level of transformational leadership of school heads, teachers' attitude towards ESD, and teachers' participation in professional development in ESD. The slope confidence interval to predict teacher's self-efficacy from transformational leadership of school heads, teacher's attitude towards ESD, and teacher's participation in professional development in ESD was a 95% confidence level with a Beta of .173, .149 and .639 respectively. Hence, the second null hypothesis is rejected.

3.4 Structural Equation Modeling Analysis

Establishing the best model is important in research involving Structural Equation Modeling. The last objective for this research is to identify the optimal model that elucidates the influence of transformational leadership of school heads, teachers' attitudes towards, and teachers' participation in professional development on teachers' self-efficacy in ESD. This paper section examines the interconnections among the research study's variables. Five proposed models were evaluated to identify the optimal model for teachers' self-efficacy in ESD. One is a model that quantifies the load on each factor about their latent constructs. The structural model delineates the relationships among latent variables. Evaluating each model's suitability determines whether to accept or reject it. In establishing the best-fit model, the researcher sought to demonstrate a causal relationship among latent variables. A correlation between exogenous and endogenous variables was also discovered. The structural model achieved an adequate fit that satisfied the stipulated criteria, indicating the consistency of empirical connections among the variables. Table 4 shows the fit indices for measurement models for each construct.

Table 4. *Test of Best–Fit Model on teachers' self-efficacy in ESD*

Index	CMIN/ DF	p-value	NFI	TLI	CFI	GFI	RMSEA	p-close
Criterion	< 5	> 0.05	> 0.95	> 0.95	> 0.95	> 0.95	< 0.05	> 0.05
Model 3	.352	.881	.999	1.008	1.000	.999	.000	.983

The best-fit SEM model does not incorporate all possible connections. Instead, the model balances goodness of fit with parsimony, accurately representing the data with the fewest necessary parameters. After stratification of the models based on theoretical relevancy, the following table proves how the null hypothesis is rejected as Model 3 was the best-fit model to elucidate the direct influence of transformational leadership of school heads and teacher's

attitudes on the teachers' self–efficacy in ESD. Also, model 3 explains the interrelationships between transformational leadership of school heads and teacher's attitude towards ESD.

According to modeling fitting requirements, Model 3 has the best goodness-of-fit model indices, as shown in Table 4. The model has values of indices Chi-Square/Degrees of Freedom (CMIN-DF) of .352 which implies a adequate fit index of the model, Probability Value (P-VALUE) of .881 indicating the statistical significance of the tested model, Normed Fit Index (NFI) of .999 which implies the goodness-of-fit of the model, Tucker Lewis Index (TLI) of 1.008 which shows the evaluation of the fit model accounting to the models complexity, Comparative Fit Index (CFI) 1.000 which shows the model fitting of the observed data in comparison to the null model which provides insights to the relative improvement of the model fit, Goodness of Fit Index (GFI) .999 indicating that the model aligns with the observed data which shows the assess fraction of the variance elucidated by the model, Root Mean Square of Error Approximation (RMSEA) of .000 which describes how well the model approximates the true underlying data structure and Probability Close (P-CLOSE) of .983 indicating that the model's likelihood is associated with the parameters which conforms the robustness of the hypothesized model in which the result of the analysis conforms to the standard criterion used in identifying the best fit model.

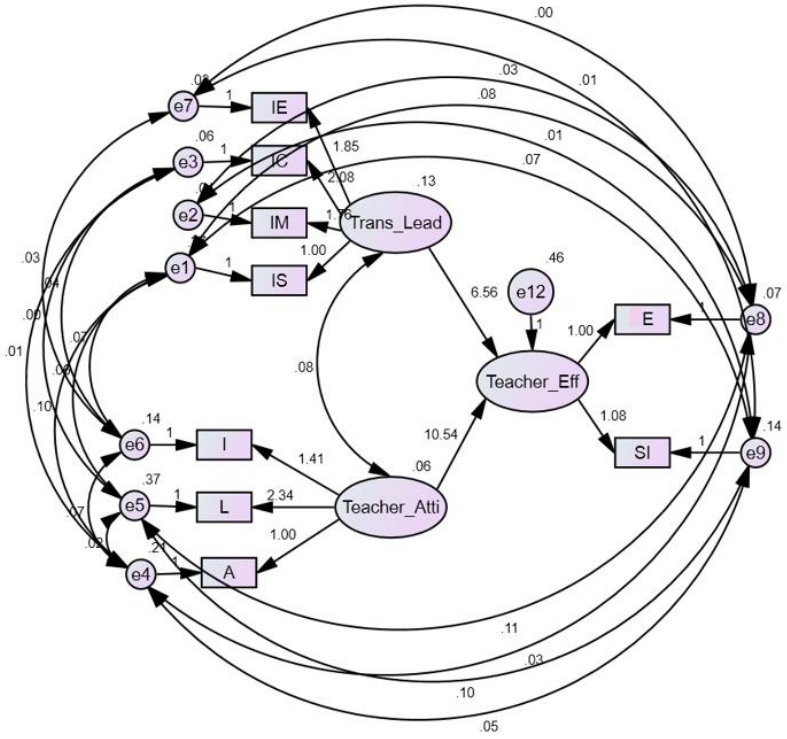

Figure 1. *Best-fit Model*

Figure 1 shows the best-fit model for teacher's self-efficacy in ESD. The model estimates the effects between measured and latent variables using regression weights. The model indicates the direct or unmediated effect of transformational leadership and the teacher's attitude on ESD teacher's self-efficacy with an estimated degree of influence of beta 6.56 or 7 and 10.54 or 10.5, with an error of .13 and .06, respectively. This means that when transformational leadership of school heads decreases by one unit, teacher's self-efficacy decreases by 6. 56 plus or minus .13. The same way with teacher's attitudes towards ESD when increased by one unit, the teacher's self-efficacy also increases by 10.54 plus or minus .06. With the p-value of 0.000 which is less than 0.05, the estimated effect is significant at alpha 0.05 level of significance. In addition, the model also illustrates the total indirect or mediated effect of transformational leadership of school heads on the teacher's attitude towards ESD with a covariance estimate of beta .082 or .08 degree of relationship, which is significant at alpha 0.05 level of significance

as evidenced by p – value of .000. Moreover, the regression coefficients are statistically significant for all the values that meet the requirement of a minimum of 0.3, which indicates that the variance is explained by latent factors or latent variables, which is good news for the model.

Moreover, Model 3, the best-fit model, is significantly supported by the paradigm of Social Cognitive Theory (1986), asserting that individuals learn and develop skills through interaction with their environment, encompassing social influences, personal factors, and behavioral elements. In education settings, particularly regarding ESD, the interplay of social cognitive theory highlights the interconnection of transformational leadership, teachers' attitudes towards ESD, and their self-efficacy in ESD. Transformative leaders are pivotal in cultivating a supportive and innovative atmosphere, fostering sustainable education. Through positive modeling, goal setting, and fostering collaborative practices, school heads can significantly improve teachers' attitudes towards ESD, enhancing teachers' self-efficacy. The interplay of Social Cognitive Theory illustrates the interconnectedness of transformational leadership, teachers' attitude, and teachers' self-efficacy in the ESD context. Hence, the third null hypothesis is rejected.

Transformational leaders are known for enhancing teachers' self-efficacy by providing the necessary support and development opportunities. When school leaders effectively motivate and inspire their staff, teachers tend to believe more in their capabilities, enhancing their professional performance and commitment to their roles (Ahamad & Kasim, 2016; Ibrahim, 2022). The findings of this study posited the strong correlation between school heads' TL (as discerned by teachers) and teachers' self-efficacy in ESD. Corroborating this outcome, Sunaryo et al. (2023) assert that when school leaders demonstrate inspirational motivation and individualized consideration, they cultivate an environment conducive to job satisfaction, significantly impacting teachers' performance. It was also discovered that the school heads' TL significantly influences teachers' self-efficacy in ESD. Parallel to the claim, a study by A'yun and Sulisworo (2024) contended that transformational leaders enhance teachers' self-efficacy by offering essential support and development opportunities, directly influencing teachers' innovative behavior and performance. The result also corroborates with Duran & Mariñas (2024) and O'beid (2023), claiming that teachers' self-efficacy is also vastly credited to transformational leadership influences. The benefits of a strong leadership style utilizing transformational leadership in educational institutions demonstrate that investing in leadership development is crucial for enhancing educational environments and outcomes. Fostering a supportive, engaging, and innovative school culture highlights the transformative influence that effective leaders can exert in academic institutions.

Second, teachers' attitudes toward ESD significantly hone their self-efficacy, which refers to their confidence in effectively teaching sustainability concepts and practices (Milama et al., 2019). The findings indicated a substantial correlation between teachers' attitudes toward ESD and their self-efficacy. Correspondingly, findings discovered that teachers' attitudes toward ESD strongly impact self-efficacy in this area. Conforming to this, Chen et al. (2023) indicate that favorable attitudes toward ESD enable educators to explore creative teaching techniques and integrate sustainability across diverse subjects. Further worth noting, Sigiyuwanta (2024) expounded that teachers with favorable attitudes toward ESD are more likely to be involved in related professional development and effectively integrate ESD practices into their teaching, influencing their self-efficacy. When educators acknowledge the significance of sustainability, they have better tendencies to be more equipped in teaching topics with enhanced initiatives, creating innovative lesson plans, and engaging students in sustainability-oriented projects (Pamuk et al., 2022). This approach helps enhance teaching efficacy and fosters professional fulfillment, strengthening their self-efficacy. Comprehending this link can significantly influence teacher training and professional development initiatives to strengthen the integration of ESD into educational curricula.

Third, teachers' participation in professional development initiatives centered on Education for Sustainable Development markedly improves their self-efficacy and confidence in effectively imparting sustainability concepts and practices (Murphy et al., 2020). This study's results revealed a significant correlation between teachers' participation in professional development and their self-efficacy in ESD, with PPD substantially impacting self-efficacy. Augmenting on similar assumption, Du et al. (2022), assert that involvement in professional development programs furnishes educators with critical knowledge and competencies pertinent to ESD. This also corroborates with the study of Kang (2021), asserting the importance of encouraging teachers to participate in a professional development program in the context of ESD. Alongside this, Uchacz (2024) suggests

that professional learning communities are also seen as a significant factor between the leader and the teacher, significantly contributing to the acquisition and efficacy of instructional development. Coherent with their empirical contentions, Rogalska-Marasinski (2021) points out that educators who partake in ESD-focused professional development frequently encounter innovative pedagogical methods that improve their instructional practices. These programs frequently provide educators with current perspectives on sustainability issues, instructional strategies, and vital resources for integrating ESD into their teaching. Meanwhile, Boeve-de Pauw et al. (2022) argue that teachers' participation in professional development is crucial for enhancing their competencies in ESD. As educators gain more profound knowledge, their confidence in tackling intricate sustainability issues is enhanced, increasing their self-efficacy. Henceforth, as educators enhance their pedagogical approaches through these professional experiences, their confidence in facilitating significant learning experiences grows, favorably impacting their self-efficacy.

Lastly, structural equation modeling (SEM) is a vigorous statistical solution enabling scholars from diverse fields to scrutinize intricate relationships among distinctive variables simultaneously. SEM can provide valuable insights into how these constructs interrelate in educational settings, particularly concerning transformational leadership, teacher attitudes, and self-efficacy in ESD. After stratification of the models based on the analysis and theoretical relevancy, Model 3 is the optimal model in elucidating the influence of the school head's TL and teachers' attitudes on their self–efficacy in ESD. From a socio-cognitive perspective, it could be justified that favorable experiences and successful implementation of ESD by transformative leaders foster positive attitudes, which, in turn, reinforce teachers' self-efficacy (Wang & Shao, 2024). Coherent with this theoretical association, Kang (2021) robustly endorsed the predictive link among transformational leadership, teachers' attitudes, and teachers' self-efficacy in ESD after applying a structural equation model in his research pursuit. Similarly, Min & Kwon (2023) emphasized that TL significantly influences teachers' attitude regarding their profession and self-efficacy toward ESD (Kang, 2021; Sigiyuwanta, 2024). The findings revealed that SEM is crucial for understanding the complex interrelationships among transformational leadership, teacher attitudes, and teacher self-efficacy. The robust correlation among these components indicates that educational institutions should consider these dynamics when developing programs for these interactions, establishing a self-reinforcing loop that promotes effective education for sustainable development. Furthermore, transformational leaders who foster positive teacher attitudes will likely enhance their professional development (Ibrahim et al., 2020), which will bolster teachers' self-efficacy, allowing them to implement sustainable practices more efficiently in their classrooms (Zhao & Zhang, 2024), ultimately leading to improved educational outcomes.

The result from the SEM in this research pursuit shows that school heads' TL significantly influences teachers' self-efficacy in ESD. Pronounced by four key components, including idealized influence, individualized considerations, inspirational motivation, and intellectual stimulation, it is deduced that TL can foster a conducive environment conducive for teachers' career growth and development, leading to enhanced self-efficacy. In conjunction with this, attitudes directly influence a teacher's self-efficacy in ESD. With key components of implementation, limitations, and adequacy, positive attitudes towards ESD enhance educators' trust in ESD and promote innovative pedagogical approaches that engage students. Transformative leaders are instrumental in cultivating a supportive and innovative atmosphere fostering sustainable education. Through positive modeling, goal setting, and collaborative practices, school heads can significantly improve educators' attitudes towards ESD, enhancing their self-efficacy. Analogously, school heads' TL and teachers' attitudes toward ESD strongly influence the educators' self-efficacy in ESD. A nurturing and motivating leadership atmosphere and affirmative teacher dispositions bolster educators' confidence in integrating sustainability principles into their instruction (Yang, 2023; Önal, 2020). By emphasizing transformational leadership and cultivating positive attitudes towards ESD, educational institutions can profoundly influence teachers' self-efficacy, thereby advancing the overarching objective of SDG 4. This comprehensive approach improves the teaching profession and equips students to tackle critical sustainability challenges in their future pursuits.

4.0 Conclusion

The study's findings concluded that Model 3 is the best-fit model that elucidates the direct influence of transformational leadership of school heads and teachers' attitudes on teachers' self-efficacy in ESD and the interconnections between these variables. Such a model affirms the theory used, the Social Cognitive Theory, which states the dynamic interplay of environmental factors and behavior in shaping individual performance and

development. The findings demonstrate that transformational leadership of school heads, teachers' attitudes towards ESD, and teachers' participation in professional development significantly influence teachers' self-efficacy based on correlation and regression analyses. However, when subjected to structural equation modeling, the significance of teachers' participation in professional development diminishes after data stratification and consideration of theoretical relevance, indicating that although professional development may enhance teachers' self-efficacy in broader analyses, its direct influence may be diminished when contextual and theoretical factors are considered, underscoring the necessity for nuanced approaches to comprehending the determinants of teacher self-efficacy.

The optimal realization of the SDG 4 goals is deeply rooted in the teacher's self-efficacy. In the higher institutional realms, educational institutions are tasked with catalyzing opportunities that empower educators to become self-assured and capable of incorporating Education for Sustainable Development (ESD) into their pedagogical approaches. This is an ongoing and indispensable reform in cultivating an academic atmosphere that robustly upholds inclusive, equitable, and high-quality education toward lifelong learning for learners. Thus, the empirical relevance of studies delving into teachers' self-efficacy in higher education is responsive to this global demand. The study's findings revealed the structural equation model 3 is fundamental for understanding the complex interrelationships among TL of school heads, teachers' attitude, and teachers' self-efficacy in ESD. This study intends to establish a foundational benchmark for future research and apply the best-fit model in different localities in a particular educational context. Further studies should be done to test the robustness of the theory used and strengthen the claims of this study's findings. Converging with this conclusion, the enhancement of teachers' self-efficacy may enable policymakers and educational leaders to expedite advancements toward SDG 4 and streamline how education can be leveraged for continuing sustainable development. Ingrained in these dynamics, education stakeholders can develop targeted strategies that may enhance the professional environment for teachers, ultimately leading to improved educational outcomes. With high hopes, this empirical pursuit strives to serve as a baseline for future research in ESD.

5.0 Contributions of Authors

As the only author of this research, the researcher bears full responsibility for all facets of the study, encompassing conceptualization, data collecting, analysis, writing, editing, and manuscript finalization, which is a requisite for his doctoral degree.

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7.0 Conflict of Interests

The author asserts that there is no conflict of interest about the publication of this research.

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