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Research Article

"Analysing Student Knowledge, Engagement, and Pedagogical Effectiveness in Sustainable Finance Education: An AI-Driven Mediation Modelling Approach"

Dr. Gaurav Rajput[1], Dr. Archana Sarkar[2]
[1]*Assistant Professor, Indukaka Ipcowala Institute of Management, Charotar University of Science and Technology, Anand, Gujarat, India.*
[2]*Assistant Professor, Indukaka Ipcowala Institute of Management, Charotar University of Science and Technology, Anand, Gujarat, India.*

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ABSTRACT

Purpose: This study investigates the relationships between pedagogical effectiveness, student engagement, and student knowledge in the context of sustainable finance education. It aims to understand how effective teaching methods influence student engagement and knowledge acquisition and whether student engagement mediates the relationship between pedagogical effectiveness and student knowledge.

Study design/methodology/approach: The research employs a mediation analysis using multiple regression models to analyse data collected from a sample of 210 students. Cronbach's Alpha is used to assess the reliability of the measurement scales, while variance inflation factor and residual plots are used to examine multi-collinearity and linearity. The Sobel test and bootstrap mediation analysis are also conducted to evaluate the significance of the mediation effect.

Findings: The study finds that pedagogical effectiveness significantly influences both student engagement and student knowledge. Student engagement partially mediates the relationship between pedagogical effectiveness and student knowledge. High R2 values indicate that a substantial portion of the variance in student engagement and knowledge is explained by pedagogical effectiveness. The results are further validated by the Sobel test and bootstrap analysis, confirming the significance of the mediation effect.

Originality/value: This research contributes to the field of educational methodology by providing empirical evidence on the importance of pedagogical effectiveness in enhancing student engagement and knowledge in sustainable finance education. The use of robust statistical techniques and mediation analysis adds to the originality and value of the study.

Research limitations/implications: The study's reliance on self-reported data introduces potential response biases, which may affect the accuracy of the findings. Future research should consider more diverse samples and incorporate additional variables to provide a more comprehensive understanding of the relationships studied.

Practical implications: Educational institutions can use these findings to develop more effective pedagogical strategies that enhance student engagement and knowledge acquisition. By focusing on improving teaching methods, educators can create a more engaging learning environment that promotes better student outcomes.

Social implications: The study's implications extend to the broader educational community, highlighting the importance of effective teaching practices in producing knowledgeable and skilled graduates. Enhanced student engagement and knowledge in sustainable finance can contribute to more responsible financial decision making and a more educated workforce, benefiting society as a whole.

Keywords: Student Engagement, Sustainable Finance, AI, Mediation Analysis.

INTRODUCTION

The pressing need for sustainable development has brought significant attention to the role of education in fostering sustainability, particularly in the realm of finance. Sustainable finance is essential to address demanding global

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challenges such as climate change, social inequality, and corporate governance issues. It enables the capital flow into such projects and businesses that promote renewable energy, social equity, and ethical governance practices to support long-term value creation and foster a more resilient and inclusive economy. There has been a substantial increase in the area of research and inclination towards sustainable finance, which incorporates environmental, social, and governance (ESG) criteria into business and investment choices. This growing interest stems from the urgent need for a more sustainable global economy that tackles climate change, social inequality, and corporate governance issues (Baker et al., 2018). Sustainable finance education works with an aim to equip future financial professionals with the necessary knowledge and skills to integrate environmental, social, and governance criteria into their decision-making processes (Bebbington & Unerman, 2018).

This study also talks about the pedagogical effectiveness and pedagogy is the art and science of teaching which is a key fundamental that outlines the educational experiences and affects the student outcomes. Pedagogical effectiveness, which refers to the impact of teaching methods on student learning and engagement, is fundamental to the success of sustainable finance education. Pedagogy is effective when it not only conveys theoretical knowledge but also engage students' in practical and real life applications. In our study pedagogical effectiveness can be determined by engaging students in realistic applications of sustainable finance. Educational theorists such as Piaget and Vygotsky, stress on the significance of students constructing their own understanding and knowledge through experiences and interactions (Piaget, 1973; Vygotsky, 1978). This change has led to the implementation of innovative teaching strategies, including collaborative learning, inquiry-based learning, and experiential learning, which aids in enhancing student engagement and achievement (Prince, 2004). This approach is particularly relevant in sustainable finance education, where (Barth et al., 2007) found that experiential learning methods, such as case studies and project-based learning, effectively increase student engagement and deepen their understanding of sustainability issues. (Brundiers, Wiek, and Redman, 2010), says that sustainability education should foster critical thinking, problem-solving skills, and the ability to apply knowledge in diverse contexts. These competencies are essential for future finance professionals who must navigate the complexities of ESG criteria and their implications for business and investment decisions. It is essential to cultivate a mind-set of lifelong learning among students. The field of sustainable finance is rapidly evolving, with new regulations, standards, and best practices emerging regularly. Encouraging students to stay informed about these developments and to continuously seek out new knowledge and skills will ensure that they remain effective and relevant in their careers (Clark, Feiner, & Viehs, 2015).

The success of pedagogical methods is typically assessed by their impact on student learning outcomes. Research indicates that active learning strategies, where students participate in discussions, problem-solving, and hands-on activities, significantly improve comprehension and retention of information compared to passive learning methods such as lectures (Freeman et al., 2014). Furthermore, formative assessment practices, which provide ongoing feedback to students, are essential for identifying learning gaps and guiding instructional adjustments (Black & Wiliam, 1998).

Students, as the next generation of leaders and decision-makers, are vital in steering this sustainable future. Student engagement is a critical factor in the pedagogical effectiveness of sustainable finance education. Consequently, it is essential for the education system to successfully impart knowledge and encourage engagement in sustainable finance. Students engaged are more likely to internalize sustainable finance principles and apply them in their future professional roles (Cebrian, Grace, and Humphris (2013). Educational programs significantly improve student knowledge and engagement in sustainable finance. (Clark, Feiner, and Viehs 2015), asserts that including ESG factors in financial analysis not only supports sustainability but also improves financial performance. This dual advantage highlights the significance of embedding sustainable finance into educational programs, equipping students to play a vital role in the financial industry's shift towards sustainability.

Integrating all these elements into sustainable finance education also requires a commitment to fostering a learning environment that emphasizes collaboration and critical inquiry. Collaborative learning environments encourage students to engage in discussions, share perspectives, and work together on projects that simulate real-world financial challenges involving ESG considerations. This approach not only enhances their understanding of sustainable finance but also prepares them to work effectively in diverse and dynamic professional settings (Stough et al., 2018).

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Despite the recognized importance of sustainable finance education, several challenges hinder its widespread adoption. These include limited curriculum time, insufficient teaching resources, and a lack of faculty expertise in sustainable finance (Bebbington & Unerman, 2018). One effective approach to enhancing pedagogical effectiveness in sustainable finance education is the incorporation of technology. Digital tools and platforms can facilitate interactive learning experiences, provide access to a wide range of resources, and enable the simulation of real-world scenarios (Bebbington, Unerman, & O'Dwyer, 2014). Online case studies and simulations can allow students to experiment with ESG criteria in investment decisions, thereby deepening their understanding and engagement.

Moreover, the use of real-world case studies and guest lectures from industry professionals can bridge the gap between theoretical knowledge and practical application. Industry professionals can provide valuable insights into current trends, challenges, and best practices in sustainable finance, thus enriching the educational experience and providing students with a clearer understanding of the practical implications of their studies (Schaltegger & Burritt, 2010). This direct engagement with the industry also helps to build networks and connections that can be beneficial for students as they transition into their professional careers.

Another promising strategy is the integration of interdisciplinary learning. Sustainable finance intersects with various fields such as environmental science, economics, and social studies. By incorporating perspectives from these disciplines, educators can provide a holistic understanding of sustainability challenges and solutions (Jones, Selby, & Sterling, 2010). This interdisciplinary approach not only enriches the learning experience but also prepares students to tackle complex, multifaceted problems in their professional careers.

In the face of the benefits of innovative pedagogical approaches, several challenges obstruct their widespread implementation. These include limited resources, large class sizes, and insufficient professional development opportunities for educators (Darling-Hammond, 2000). Additionally, the increasing diversity of student populations necessitates culturally responsive teaching practices that address the varied backgrounds and experiences of learners (Gay, 2002). In the context of sustainable finance, educators must also stay updated with the rapidly evolving landscape of sustainability practices and standards, which requires continuous learning and adaptation. Continuous training and development programs can equip educators with the latest knowledge and skills in sustainable finance and innovative teaching methods. According to Darling-Hammond (2000), ongoing professional development is essential for educators to adapt to new educational demands and improve their teaching practices.

Thus, the integration of sustainable finance into educational curricula through effective pedagogical practices is fundamental to preparing students to contribute meaningfully to the financial industry's evolution towards sustainability. By adopting student centric approaches and active learning strategies, educators can enhance student engagement, understanding, and achievement. Ongoing research and professional development are critical to overcoming the challenges associated with implementing these practices and ensuring that all students have access to high quality education that meets their diverse needs.

No studies exist examining the impact of pedagogical effectiveness in sustainable finance education on student knowledge with the mediating effect of student engagement. Thus, this study conducted a mediation analysis in order to investigate the effect of pedagogical practices on student knowledge considering the student engagement as a mediating variable. The implication of the findings is beneficial for the educators who can utilize the insights from this study to enhance their teaching methods, making them more interactive and engaging. This will better prepare students with the necessary knowledge and skills in sustainable finance, enabling them to navigate the complexities of the financial markets while considering ESG factors. By improving the quality and effectiveness of sustainable finance education, this research supports the development of finance professionals who are well equipped to tackle global sustainability challenges. This, in turn, contributes to the advancement of sustainable development goals through better educational practices. Ultimately, the role of sustainable finance education and effective pedagogical practices in this transformation are not only to impart knowledge but also to inspire and empower the next generation of financial professionals to drive sustainable change in the industry.

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LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Sustainable Finance Education

The concept of sustainability originates from the global awareness movement regarding the effects of global warming on the environment and humanity. This movement was institutionalized through environmental policies introduced on the global stage by the United Nations (Christopher and Nithya, 2024). Over time, the concept of sustainability has expanded to include various business practices, particularly in finance.

Finance plays a crucial role in promoting sustainability, being responsible for capital allocation. However, it also contributes to inequitable capital distribution (Oner, 2019). Goldin and Reinert (2006) highlight that financial markets are significant resources but suffer from imperfections due to information asymmetries, leading to market failures. This situation results in financial crises and corporate scandals, which undermine the benefits of capital allocation and domestic savings enhancement.

According to Nahar et al. (2023), sustainable finance involves offering a range of financial services that incorporate Environmental, Social, Governance (ESG) criteria into financing decisions to provide enduring benefits for stakeholders, including financing clients and society (Haigh, 2012; OECD, 2020; Nirino et al., 2021). Sustainable finance includes activities and factors that promote financial sustainability and contribute to achieving broader sustainability objectives (Kumar et al., 2022; Migliorelli, 2021). Studies suggest that sustainable finance is closely related to the concepts like 'green,' 'climate,' 'social,' 'micro,' and 'ethical' finance, all of which fall within the sustainability domain (Akomea–Frimpong et al., 2021; Muganyi et al., 2021; Sarma & Roy, 2021).

Universities act as key agents of transformation towards sustainable development by educating students. Wright and Horst (2013) assert that the goal of education for sustainable development is to foster a self-sustaining society through sustainable practices and responsible citizenship. Sidiropoulos (2014) emphasizes the importance of focusing on students' values and behaviours to encourage sustainable behaviour, better problem-solving, and decision-making. Additionally, Wright (2007) notes that universities enhance understanding of environmental and social issues, acting as catalysts for individual behaviour change and collective institutional transformation through social marketing knowledge.

In recent times, there is a pressing need for a more critical and reflective approach in finance education to foster sustainable thinking (Oner, 2019). Integrating finance with sustainability is essential to achieving sustainable development goals. Brunstein et al. (2019) argue that the global financial crisis has exposed market corruption and sparked a debate about the foundational principles of finance education and industry. They contend that business school curricula must evolve beyond traditional financial values to better prepare future investors and financial leaders. Hira (2012) supports this view, advocating for a shift in financial education to acknowledge the importance of attitudes and values and promote long-term financial security. Thus, the integration of finance and sustainability is paramount for achieving sustainable development.

Pedagogical Effectiveness

Pedagogy has been defined as either the study or discipline related to learning and development (Ax et al., 2008) or as a specific approach to educational learning that involves information transfer (Knowles, 1980). Kemmis and Smith (2008), however, assert that in the European tradition, pedagogy includes both the methods and the reasons behind teaching, shaping a teacher's perspective on teaching and the societal rationale for learning. This view is echoed by Christie et al. (2013), Fien (2001), Hegarty and Holdsworth (2015), and Trigwell, Prosser, and Waterhouse (1999), who suggest that pedagogy embodies an educator's construction, philosophy, and beliefs about their practice. Pedagogy plays a crucial role in shaping how sustainability education is delivered and its outcomes, and according to Kemmis and Smith (2008), it should be distinguished from mere teaching methods or activities.

Improving academic professional development is essential for enhancing pedagogical effectiveness. Recommendations from Holdsworth et al. (2008) over a decade ago remain pertinent, stressing the importance of academic professional development to deepen understanding of pedagogy, program content, and structure, thereby supporting better curriculum development and learning outcomes (Holdsworth et al., 2008, p. 143) to foster transformative educational experiences in sustainability education.

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Owens (2010) argues that just because educators were traditionally taught through passive methods—sitting in rows, taking notes, and memorizing facts for multiple-choice exams—doesn't mean current teachers should continue using ineffective pedagogies. Traditional finance education, based on established principles, is criticized by Brunstein, Sambiase, Kerr, Brunnquell, and Pereraeta (2019) for failing to grasp the societal and economic roles of finance.

There is a movement toward replacing traditional teaching methods with student-activating learning approaches for sustainable development issues (Wan Mohamed, 2018). These approaches are said to enhance critical thinking, transformative thinking, and reflective abilities in students (Ceulemans & De Prins, 2010; Juarez-Najera, Dieleman, & Turpin-Marion, 2006; Lozano et al., 2017; Seatter & Ceulemans, 2017). Student-centered pedagogical approaches are also believed to foster diverse learning processes, aiding students' development and critical thinking abilities (UNESCO, 2012). Thus, employing such pedagogical strategies in teaching sustainability and sustainable finance is expected to create a more enriching and effective learning experience.

Impact of pedagogical effectiveness on Student Knowledge

Pedagogical effectiveness plays a critical role in the educational process, directly influencing student knowledge and learning outcomes. According to Weimer (2013), student-centered learning shifts the focus from teaching to learning, promoting greater student autonomy and motivation. This approach is especially important in sustainable finance education, where students need to develop a deep, intrinsic understanding of sustainability principles and their application in finance. Active learning and constructivist approaches in sustainable finance education significantly enhance students' critical thinking and problem-solving skills. Juarez-Najera, Dieleman, and Turpin-Marion (2006) found that students who engage in experiential learning activities, such as case studies and group projects, are better able to analyze complex sustainability issues and develop effective solutions. Student-centered learning approaches help students develop a deeper understanding of sustainability principles and their application in finance. According to UNESCO (2012), personalized learning experiences enable students to connect theoretical knowledge with practical applications, fostering a comprehensive understanding of sustainable finance. Active learning techniques, such as simulations and hands-on projects, improve the retention of sustainable finance concepts. Freeman et al. (2014) found that students who engage in interactive learning activities are more likely to retain and apply the knowledge they have gained, leading to better long-term educational outcomes. Thus, pedagogical effectiveness in sustainable finance education has a critical role in enhancing student knowledge.

Student Engagement as a Mediator

Student engagement encompasses students' involvement and dedication, reflected in their willingness to partake in regular school activities such as attending classes, completing assignments, and adhering to instructions. Early conceptualizations of student engagement can be traced back to the works of Astin (1984), Pace (1984), and Chickering and Gamson (1987). Additionally, Chapman (2003) viewed students' participation in lessons, curriculum planning, classroom management, and other pedagogical activities as components of student engagement. Fredricks et al. (2004) identified that student engagement comprises distinct elements, including behavior, emotion, and cognition. Practical factors such as attitude, personality, motivation, effort, and self-confidence are also linked to student engagement (Mandernach et al., 2011; Olivier et al., 2020). This perspective is supported by Jaggars and Xu (2016), who discovered that quality interaction within course parameters positively correlated with student grades in online courses. By assessing the level of student engagement and considering these emotional aspects, instructors can effectively design lessons and activities that encourage students to be more active participants in their learning and coursework (Basbeth et al., 2021; Mandernach et al., 2011). Kuh (2009) conducted the National Survey of Student Engagement and concluded that student involvement in effective educational practices—such as academic challenge, active and collaborative learning, student-faculty interaction, enriching educational experiences, and a supportive campus environment—contributed significantly to achieving the overall desired outcomes after college. Consequently, student engagement has been garnering increasing attention in the field of education. Student engagement is crucial as a mediator between pedagogical effectiveness and student knowledge because it bridges the gap between teaching methods and learning outcomes. By focusing on student engagement, educators can significantly improve the effectiveness of their pedagogical practices and achieve better learning outcomes.

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Hypotheses

H1a: There is no significant relationship between pedagogical effectiveness and student engagement.

H2a: There is no significant relationship between pedagogical effectiveness and student knowledge without considering student engagement.

H3a: There is no significant relationship between pedagogical effectiveness and student knowledge when controlling for student engagement.

H4a: There is no significant relationship between student engagement and student knowledge when controlling for pedagogical effectiveness.

H5a: There is no significant relationship between student engagement and student knowledge.

H6a: Student engagement does not mediate the relationship between pedagogical effectiveness and student knowledge.

H7a: The indirect effect of the pedagogical effectiveness on student knowledge through student engagement is equal to zero.

H8a: The confidence interval for the indirect effect includes zero.

STUDY METHODOLOGY

Research Design

This study employs a quantitative research design to investigate the relationships among pedagogical effectiveness (X), student engagement (M), and student knowledge (Y) within the context of sustainable finance education. The research specifically aims to explore the mediating role of student engagement in the relationship between pedagogical effectiveness and student knowledge.

Data Collection

Data was collected through a structured survey which was first circulated among two professors of the related field and later circulated among participants who responded to measure three latent variables: pedagogical effectiveness (X), student engagement (M), and student knowledge (Y). The survey included multiple observed variables for each latent construct to ensure comprehensive measurement. All the items were measured on a 5-point Likert scale from strongly disagree to strongly agree.

Sample

The sample comprised 210 college students studying in private and government university in Charotar region consisting of 102 females and 108 males. Among these participants, 144 were undergraduates, while the remaining students are pursuing postgraduate studies. The data collected includes scores from 31 observed variables corresponding to the latent variables X, M and, Y.

Statistical Analysis

The statistical analysis has been performed using Python. Reliability of the constructs was assessed using Cronbach's Alpha and Composite Reliability. Variance Inflation Factor (VIF) was computed for each observed variable to assess multi-collinearity. Residual plots for the regressions of Y on X, Y on M, and M on X were examined to check the non-linearity or heteroscedasticity.

Mediation analysis was conducted using Ordinary Least Squares (OLS) regression following the three-step approach by Baron and Kenny (1986). The analysis aimed to determine the direct, indirect, and total effects of pedagogical effectiveness on student knowledge through student engagement. Four Ordinary Least Squares (OLS) regression models were specified to test the mediation effect –

1. Model 1: M~X examines the effect of independent variable X on the mediator M.
2. Model 2: Y~X assesses the direct effect of X on the outcome variable Y.

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3. Model 3: Y~X+M evaluates the effect of both X and M on Y.
4. Model 4: Y~M evaluates the individual effect of M on Y without considering X.

The Sobel test method is applied for testing the significance of mediation effect. The test statistic is computed as –

$$Z = \frac{a * b}{\sqrt{(b^2 - sa^2) + (a^2 - sb^2)}}$$

Where, a is the coefficient for the path from X to M, b is the coefficient for the path from M to Y, sa and sb are the standard errors of a, and b. The z-value obtained can be used to determine the significance of the mediation effect.

Bootstrap mediation analysis was performed to assess the indirect effect and to construct confidence intervals for this effect. 3000 bootstrap samples were created to perform bootstrap analysis. It helped in understanding the indirect effect in mediation model making it a valuable addition to the Sobel test (Preacher & Hayes 2008, Efron & Tibshirani 1993).

K-Fold cross validation technique is used to assess the performance and generalizability of a predictive model. It involves partitioning the data into k subsets or "folds." The model is trained on k−1 folds and tested on the remaining fold. The method provides a more accurate measure of how the model will perform on unseen data and ensures that every data point gets an opportunity to be in the training and testing set.

RESULTS, ANALYSIS AND DISCUSSION

Reliability Analysis

In this section, we delve into the reliability and validity of the constructs used in our mediation analysis.

Reliability Values

Construct	Cronbach Alpha	Composite Reliability
X	0.96	0.95
M	0.94	0.93
Y	0.94	0.93

Table no. 1

The values indicate excellent reliability for all three constructs, as Cronbach's Alpha values above 0.90 are generally considered to denote excellent internal consistency (Nunnally & Bernstein, 1994). High composite reliability values greater than 0.90 demonstrate that the measurement items are well-correlated and consistently measure the latent construct (Fornell and Larcker, 1981). The implications of these results are significant for the validity of our mediation analysis conducted using Python.

Multicollinearity and Autocorrelation

Multicollinearity of the observed variables within latent constructs X and M.

X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	
3.46	3.62	4.70	4.22	4.45	4.24	4.17	2.55	2.94	2.41	
M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
3.14	3.46	4.61	3.98	3.09	2.40	4.44	2.78	5.27	3.55	3.10

Table no. 2 – VIF Values

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For the construct X, the VIF values range from 2.41 to 4.70. For the construct M, the VIF values range from 2.41 to 5.27. Generally, VIF values exceeding 5 may indicate problematic Multicollinearity (Hair et al., 2010). Overall, the VIF analysis suggests that while there is moderate Multicollinearity among the observed variables within each construct, it is within an acceptable range.

Regression Model Diagnostics

Path	Durbin-Watson	Condition Number
X -> M (a)	2.14	16.20
M -> Y (b)	2.17	15.8
X -> Y (c')	1.16	16.20
X -> Y (c)	1.824	22.60

Table no. 3

The Durbin-Watson values range from 0 to 4 indicating no significant autocorrelation (Turner & Thayer, 2001). A condition number above 30 generally indicates a potential problem with Multicollinearity, thus it is not a significant issue (Belsley & Welsch, 1980).

Residual Analysis

The residual plots (figure no. 1, 2 &3) display the residuals on the y-axis and the fitted values on the x-axis for the regression of Y on X, Y on M and, M on X.

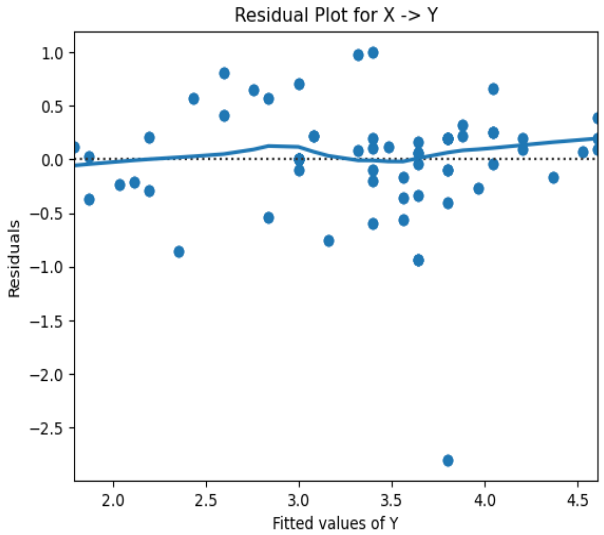

Figure no.1

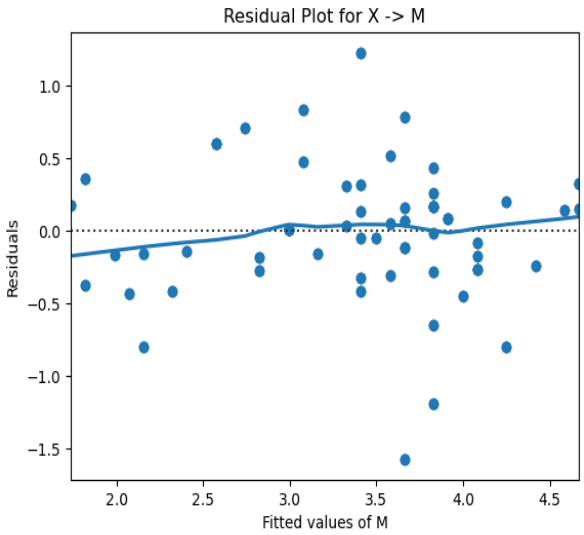

Figure no. 3

The residuals are fairly randomly dispersed around the horizontal axis suggesting that there is no obvious pattern in the residuals, which shows that the models are appropriate and that linear relationship exist among variables. The spread of the residuals appears to be roughly constant across the range of fitted values suggesting homoscedasticity.

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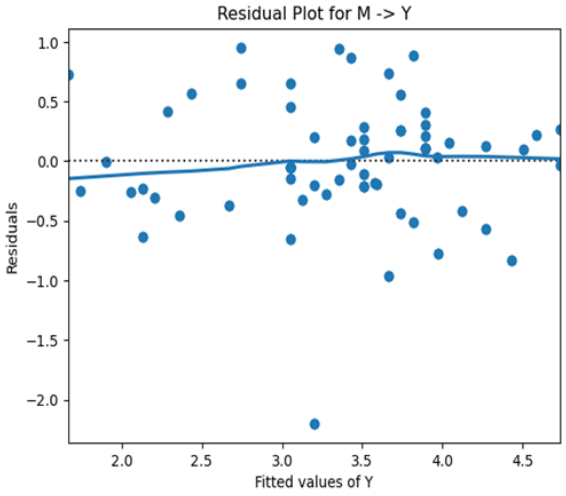

Figure no. 2

OLS Regression and Mediation Analysis

Here are the results of the mediation analysis performed using Python, where X (pedagogical effectiveness) is the independent variable, M (student engagement) is the mediator, and Y (student knowledge) is the dependent variable. The mediation analysis followed the three-step approach suggested by Baron and Kenny (1986), which involves the estimation of the direct, indirect, and total effects.

OLS Regression Results

Model	Path	Coefficient	P-Value	R^2	Adjusted R^2	F-statistic	P (F-statistic)
1	X -> M (a)	0.838165	0.000	0.731	0.730	566.6	0.000
2	X -> Y (c')	0.805652	0.000	0.635	0.633	361.9	0.000
3	M -> Y (b)	0.516071	0.000	0.702	0.699	244.1	0.000
	X -> Y (c)	0.373099	0.000				
4	M -> Y (Individual Effect)	0.8417	0.000	0.666	0.664	414.1	0.000
	Indirect Effect (a*b)	0.432553					
	Direct Effect (c)	0.373099					
	Total Effect (c' + a*b)	0.805652					

Table no. 4

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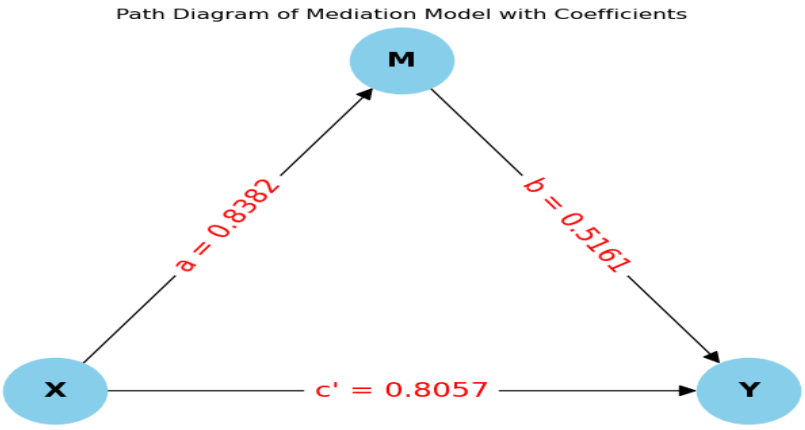

Figure no. 4

The summary statistics for the four models used in the mediation analysis are as follows –

Model 1: Path X→M (a)

Given that the coefficient (β_{XM}) for the path X→M is 0.838165 with a P-value of 0.000, we reject the null hypothesis (H_o). This indicates that there is a strong and significant positive relationship between pedagogical effectiveness and student engagement. R^2 value of 0.731 indicates that approximately 73.1% of the variance in the student engagement is explained by the pedagogical effectiveness. For each unit increase in X, M is expected to increase by 0.8382 units.

Model 2: Path X→Y (Total Effect, c')

Given that the coefficient (β_{XY}) for the path X→Y is 0.8057 with a P-value of 0.000, we reject the null hypothesis (H_o). This indicates that there is a strong and significant positive relationship between pedagogical effectiveness and student knowledge without considering student engagement. R^2 value of 0.635 indicates that approximately 63.5% of the variance in the student knowledge is explained by the pedagogical effectiveness. For each unit increase in X, Y is expected to increase by 0.8057 units.

Model 3: Path M→Y (b)

Given that the coefficient (β_{MY}) for the path M→Y is 0.5161 with a P-value of 0.000, we reject the null hypothesis (H_o). This indicates that there is a strong and significant positive relationship between student engagement and student knowledge when controlling for pedagogical effectiveness.

Path X→Y (Direct Effect, c)

Given that the coefficient (β_{XY}) for the path X→Y is 0.3731 with a P-value of 0.000, we reject the null hypothesis (H_o). This indicates that there is a strong and significant positive relationship between pedagogical effectiveness and student knowledge when controlling for student engagement. R^2 value of 0.702 indicates that approximately 70.2% of the variance in the student knowledge is explained by the pedagogical effectiveness and student engagement combined. For each unit increase in X & M, Y is expected to increase by 0.3731 units and 0.5161 units.

Model 4: Path M→Y (individual effect of M on Y without considering X)

Given that the coefficient (β_{MY}) for the path M→Y is 0.8417 with a P-value of 0.000, we reject the null hypothesis (H_o). This indicates that there is a strong and significant positive relationship between student engagement and student knowledge. R^2 value of 0.666 indicates that approximately 66.6% of the variance in the student knowledge is explained by the student engagement. A coefficient of 0.8417 indicates that for each unit increase in M, Y is expected to increase by 0.8417 units.

Indirect Effect (a * b)

The indirect effect is 0.4325 representing the portion of the relationship between X and Y that is mediated by M. The significant reduction in the direct effect from 0.8057 to 0.3731 when student engagement is included in the model,

along with the significant indirect effect, supports the presence of a mediation effect. This suggests that student engagement partially mediates the relationship between pedagogical effectiveness and student knowledge. Thus, given the significant reduction in the direct effect and the significant indirect effect, we reject null hypothesis indicating that student engagement mediates the relationship between pedagogical effectiveness and student knowledge. The results of this mediation analysis are consistent with the criteria for mediation as outlined by Baron and Kenny (1986).

Sobel Test

The Sobel test is used to determine the significance of the mediation effect (MacKinnon, Warsi, and Dwyer 1995; Hayes & Scharkow 2013). Sobel Test Statistic (Z-value) is 111.45, which is high with a p-value of 0.0. Given the high Sobel test statistic and the p-value of 0.000, we reject null hypothesis and accept that the mediation effect is significant.

Bootstrap Mediation Analysis

The mean indirect effect, calculated through the bootstrap method, is 48.279 representing the average effect of the independent variable on the dependent variable, mediated through the mediator variable. The standard error is 3.174. The 95% confidence interval ranges from 41.86 to 54.37 indicating that if we were to repeat this study multiple times, 95% of the time, the mean indirect effect would fall between 41.86 and 54.37. Since the confidence interval does not include zero, we reject null hypothesis and accept that the bootstrap mean indirect effect is statistically significant (Crump n.d., Hayes & Scharkow 2013).

K-Fold Cross Validation

This technique used to assess the performance and generalizability of a predictive model (Kohavi, 1995). An average indirect effect of 0.4328 indicates that the mediation effect is relatively strong and consistent across the different subsets of data used in cross-validation. The average direct effect of X on Y, not through the mediator M, with a value of 0.3732 suggests that there is a substantial direct relationship between the independent and dependent variables. An average MSE (Mean Squared Error) of 0.2616 suggests that the model has a reasonably good fit, with relatively small prediction errors on average (James, Witten, Hastie, and Tibshirani, 2013). Given the average indirect effect and direct effect values, along with a reasonable MSE, we reject null hypothesis indicating good model generalizability.

PRACTICAL IMPLICATIONS

The research findings have significant practical implications for educational institutions, involved in sustainable finance education. The strong positive relationships observed between pedagogical effectiveness, student engagement, and student knowledge highlight the critical role of effective teaching methods in enhancing student outcomes. Institutions can leverage these insights to develop and implement more effective pedagogical strategies that foster student engagement, which in turn enhances their knowledge acquisition. Educators can create a more engaging learning environment by focusing on pedagogical effectiveness.

SOCIAL IMPLICATIONS

The social implications of this study extend to the broader educational community and society at large. Enhancing student engagement and knowledge through effective pedagogical practices can contribute to the development of more knowledgeable and skilled graduates, particularly in the field of sustainable finance. This can have a positive ripple effect on the industry and society, because well-educated individuals are more likely to make informed and responsible financial decisions that consider sustainability. Moreover, it may lead to higher student satisfaction and reduced dropout rates, contributing to a more educated and capable workforce.

RESEARCH LIMITATIONS

Despite the robust findings, this study has several limitations that should be acknowledged. The study relies on self-reported data, which can be subject to response biases. Additionally, future research could benefit from diverse educational settings, and the inclusion of additional variables that might influence the relationships studied.

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CONCLUSION

In conclusion, this research underscores the importance of pedagogical effectiveness in fostering student engagement and knowledge acquisition in sustainable finance education. The high reliability and validity of the constructs used in the study support the robustness of the findings. The mediation analysis reveals that student engagement partially mediates the relationship between pedagogical effectiveness and student knowledge, highlighting the crucial role of engagement in the learning process. These insights provide valuable guidance for educators and institutions aiming to enhance educational outcomes through improved teaching practices. Further research is encouraged to explore these relationships in different contexts and with larger, more diverse samples to build on the findings of this study.

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