

Enhancing ESG practices in STEAM and engineering education

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Abstract. The push to integrate Social and Governance (ESG) practices into education in Science, Technology, Engineering, Arts and Mathematics (STEAM) and engineering fields has been gaining momentum. This research aims to investigate how improved ESG practices could impact human resource management in STEAM and engineering education. The main goal of this research is to evaluate how sustainable practices affect outcomes and workforce development. By using the Experience Sampling Method (ESM) to gather real-time data, the study collected feedback from teachers and students from institutions. The study also utilized a PANEL dataset to analyze long-term trends and patterns. The results show that incorporating ESG practices into curriculum design and institutional policies significantly boosts student engagement, satisfaction, and overall educational quality. Teachers reported improved teaching experience and increased motivation, while students showed greater awareness of sustainability issues. Additionally, the research points out connections between ESG efforts and improved retention rates in engineering programs. Overall findings indicate that a strong focus on ESG practices not only creates an inclusive educational environment but also equips students for future challenges in a rapidly changing job market. The importance of this study is in how it can help policymakers and schools understand the advantages of incorporating ESG principles, which can lead to creating a fair educational system.

1 Introduction

The incorporation of Environmental, Social and Governance (ESG) principles in the sector within Science, Technology, Engineering, Arts and Mathematics (STEAM) fields and engineering disciplines has become increasingly essential in today's ever-changing academic and professional settings [1]. Traditional educational models often fail to emphasize the importance of practices, resulting in a gap in preparing students for the intricate challenges of contemporary society [2,3,4]. Research indicates that integrating ESG values into the curriculum not only enhances the quality of education but also fosters social awareness and environmental responsibility among students.

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While there is growing acknowledgment of ESG practices, there is research exploring their effects on human resource management and educational outcomes in STEAM and engineering education [5,6]. Previous studies have mostly concentrated on aspects of sustainability in education, such as consciousness or ethical considerations, rather than addressing the holistic integration of ESG principles [7,8,9]. Studies have highlighted that sustainable educational programs can significantly boost student engagement and satisfaction [10,11,12]. Nonetheless, further exploration is needed to understand the impacts of these practices on workforce development and institutional performance [13,14,15].

The main goal of this study was to investigate how enhanced ESG practices impact human resource management in STEAM and engineering education, focusing specifically on the experiences of students and educators. Using the Experience Sampling Method (ESM) to collect real-time data, the study aims to gain an understanding of how ESG integration affects the dynamics. The PANEL dataset was used to analyse long-term trends, providing a perspective on the effects over time.

Research has demonstrated that experiential learning methods like ESM are effective in capturing the intricacies of settings and offering insights. By utilizing this approach, the current study aims to reveal connections between ESG initiatives and important educational outcomes such as student retention and educator motivation [16,17,18]. This research intends to address gaps in existing literature by presenting support for the advantages of ESG integration in STEAM and engineering education [19,20].

In summary, this study proposes that incorporating ESG practices into STEAM and engineering education will result in enhanced quality, increased student engagement, and better readiness for professional challenges.

The research outcomes aim to provide insights for policymakers and educational institutions regarding the significance of approaches, thus aiding in the creation of a fairer and more progressive educational structure. The subsequent parts of this document are structured as follows: The Methods section outlines the research methodology encompassing the Experience Sampling Method (ESM) and utilization of the PANEL dataset for data collection and analysis. The Results segment showcases the discoveries, emphasizing how ESG practices impact achievements and human resource management. The Discussion part interprets these findings by drawing comparisons with research exploring their implications for policy implementation and practical application. Lastly, the Conclusion section encapsulates the discoveries, highlights the study's contributions to academia, and proposes avenues for exploration.

2 Methods

The research was carried out in institutions situated in different geographic locations, ensuring a comprehensive coverage of STEAM and engineering programs. These institutions varied from urban to settings encompassing climates and socio-economic conditions to capture a wide range of educational contexts. This diversity played a role in understanding the effects of ESG practices across settings.

2.1 Materials and equipment

For data collection, we employed the Experience Sampling Method (ESM) along with the PANEL dataset [16,17,18]. The ESM utilized mobile apps and online surveys to gather real-time data from participants, including students and educators from STEAM and engineering fields. The longitudinal PANEL dataset, tracking metrics over time, was utilized to analyze trends and patterns related to ESG practices.

Assumptions

- 1 Several assumptions were considered in this study;
- 2 Participants would provide accurate responses due to the nature of data collection.
- 3 The selected institutions adequately represented the population of STEAM and engineering programs.

It was assumed that integrating ESG practices into the curriculum would have an impact on outcomes and human resource management.

2.2 Data collection

The ESM data collection spanned a semester, with participants prompted to complete surveys at intervals during their routines.

This approach enabled the collection of contextually relevant information, offering insights into the impacts of ESG practices on student engagement and teacher motivation. To gather current data on outcomes such as student retention rates, graduation rates, and post-graduation employment statistics, we accessed the PANEL dataset. This dataset served as a foundation for examining long-term trends related to the implementation of ESG practices.

In terms of data analysis, we utilized both quantitative methods. Descriptive statistics were used to summarize the frequency and distribution of responses for ESM data. Additionally, inferential statistics such as T-tests and ANOVA were applied to assess the significance of observed differences among groups exposed to varying levels of ESG integration. Regression models were employed to analyze the PANEL dataset, aiming to uncover correlations and potential causal relationships between ESG practices and educational outcomes. Multivariate analysis was carried out to account for confounding variables in order to ensure the reliability of our findings.

The results were presented through a mix of tables, graphs, and narrative explanations. Visual aids were used effectively to emphasize trends and relationships within the data, making it easily understandable. These findings were placed in context, with existing literature to offer a view of how ESG practices impact STEAM and engineering education.

In short, this methodical strategy enabled an intricate investigation into the impact of ESG practices on results and HR management. By integrating up-to-date information from ESM with long-term data from the PANEL dataset, a thorough and all-encompassing examination was conducted to ensure the credibility and accuracy of the results.

3 Results

In this section, we discuss the results of our research focusing on how ESG practices influence results and workforce management in STEAM and engineering education. The outcomes are organized based on the goals set out in the Introduction.

Effects of ESG Practices on Student Engagement and Satisfaction. Our examination of the Experience Sampling Method (ESM) data unveiled insights into the impacts of incorporating ESG practices on student engagement and satisfaction. Below is a summary table that highlights the discoveries from the ESM data.

Table 1. ESM Data on Student Engagement and Satisfaction

Measure	Mean (ESG Integrated)	Mean (Non-ESG Integrated)	t-value	p-value
Student Engagement Score	4.5	3.2	5.67	<0.001
Student Satisfaction Score	4.7	3.4	6.12	<0.001
Participation in Activities	85%	60%	4.98	<0.001
Awareness of Sustainability	90%	50%	7.45	<0.001

The results from the data indicate that students enrolled in programs that incorporate social and governance (ESG) principles expressed levels of engagement and satisfaction compared to those in programs without ESG integration. Additionally, students who were exposed to ESG practices demonstrated participation in activities and showed a heightened awareness of sustainability. The study also examined how ESG practices influence educator motivation and teaching experiences through ANOVA analysis, with the findings detailed in the table.

Table 2. ANOVA Results on Educator Motivation and Teaching Experience

Measure	F-value	p-value	Mean Square Between Groups	Mean Square Within Groups
Educator Motivation Score	12.45	<0.001	15.76	1.27
Teaching Experience Score	10.32	<0.001	13.45	1.30
Professional Development Score	9.87	<0.001	14.12	1.43
ESG Training Participation	8.56	<0.001	16.22	1.89

The results from the ANOVA analysis show disparities in educator drive and teaching background between programs that incorporate ESG principles and those that do not. Educators involved in ESG-integrated programs expressed levels of motivation. Reported more positive teaching experiences emphasizing the advantages of ESG practices in creating a supportive and engaging educational setting.

Long Term Patterns and Connections

Examining the PANEL dataset unveiled enduring trends and associations. Institutions implementing ESG practices witnessed a rise in student retention rates and graduation rates over time. Additionally, a favorable link was observed between ESG initiatives and post-graduation employment data, indicating that integrating ESG not only enhances outcomes but also enhances graduates' job readiness and employability.

Synopsis of Main Discoveries

1. Student Engagement and Satisfaction: ESG strategies significantly enhance student engagement, satisfaction, participation in activities, and awareness of sustainability.
2. Educator Drive and Experience: Educators participating in ESG-based programs demonstrate heightened motivation levels. Express positive teaching experiences.
3. Long Term Trends: The integration of ESG is positively associated with increased student retention rates, improved graduation rates, and enhanced post-graduation employment results.

These findings offer evidence supporting the incorporation of ESG practices into STEAM (Science, Technology, Engineering, Arts, Mathematics) education field highlighting their benefits for both students and educators

4 Discussion

As seen in Table 1, among student engagement measures, ESG integration has the most obvious impact in developing awareness of sustainability, followed by participation in activities, and satisfaction with educational experiences has the strongest correlation with long-term retention. Incorporating ESG principles leads to a strong improvement of existing approaches that are based on traditional academic frameworks without sustainability considerations [8,9]. The implementation of ESG-driven curriculum will facilitate the management of student engagement and educator motivation, while also collecting extensive longitudinal performance data, which will become the basis for policy adjustments, curriculum modifications, institutional reforms, and student support strategies by educational policymakers and academic institutions [10,11].

The effectiveness of ESG-driven learning frameworks must first be optimized, and the integration of the curriculum structure should then be improved to guide students and educators to actively participate in sustainable learning and apply ESG principles in practice. Suppose ESG score is the score value of the student engagement level of the ESG-integrated group, E_{actual} is the actual value of engagement level of the non-ESG-integrated group, E_{max} is the maximum value of student retention in ESG-focused institutions, and E_{min} is the minimum value of engagement scores in conventional programs.

With the help of data-driven analysis, the study integrates empirical data and establishes a predictive engagement model, retention analysis, impact evaluation, and a longitudinal trend assessment model. It can be seen that embedding ESG practices into curricula is of great significance to promote sustainable education reform and create a more inclusive academic environment for students and faculty [12]. The ESG-related educational practices are digitally monitored, assessed, optimized, and validated at the institutional level, and they are especially demanding for the level of educational governance and policy adherence of various STEAM programs. These institutional attitudes toward sustainable learning methodologies are significantly influenced by policy interventions and institutional culture, as seen previously. The two variables enable effective measurement of educational impact to be obtained in real-time analysis.

As can be seen from the PANEL dataset, ESG-integrated education has the strongest comprehensive strength in the field of student retention, which is significantly ahead of other educational strategies that lack ESG components.

This implies that although students perceive ESG-based education to be valuable and easy to adopt, their long-term implementation can entail certain problems that some educators find difficult to contend with effectively, such as the need for additional faculty training or curricular restructuring. The proposal of a structured ESG adoption framework is an inevitable requirement for responding to the transformation of higher education paradigms and the improvement of workforce readiness [13,14]. To the contrary, testing hypothesis H1 enabled it to be concluded that ESG-based curricula do have a significant positive effect on student retention ($p < 0.001$). This is in line with previous findings on sustainability education outcomes.

H1: Integrating ESG (Environmental, Social, and Governance) practices into engineering and STEAM education has a positive impact on student satisfaction, retention rates, and engagement.

With regard to hypothesis H2, the ESG-educator engagement relationship has not been fully validated in the present research, and, consequently, the conclusions drawn in prior studies suggesting a direct causality are not backed up. Although our new methodology improves the estimation of ESG impact on retention, we point out two potential sources of bias in our current approach: heterogeneity in institutional ESG adoption levels and variance in student responses to ESG curricula.

H2: Unlike conventional teaching approaches, ESG-based curriculum integration leads to significant improvement in educator motivation and teaching experiences.

With respect to educational quality improvements, the results of the present study do not show any significant influence on institutional rankings. To the contrary, significant relationships are found between ESG implementation and teaching motivation ($p < 0.001$) and between student awareness of sustainability and retention rates ($p < 0.001$). This paper formulated recommendations for educational institutions based on ESG adoption trends, explored the implementation process, challenges, and outcomes of ESG-based education, conducted the quantitative analysis and comparative evaluation of student satisfaction and retention, proposed evidence-based models for faculty training and curriculum restructuring based on ESG principles, analyzed the predictive relationship of sustainability education and student outcomes, and discussed the institutional adoption factors and governance mechanism of ESG frameworks under the background of higher education modernization [15]. The results indicate that the analyzed external variables have a direct or indirect influence on educational performance and workforce preparedness.

Finally, further applications of the ESG-based educational model proposed include revealing the structure of sustainability adoption trends in any academic setting. It is recommended that the model be extended by the inclusion of other variables in order to increase its predictive capacity. In order to further strengthen ESG integration in the field of STEAM education, in addition to improving curricular design, we should speed up the development of a policy-driven assessment system, build institutional ESG monitoring mechanisms, pay attention to faculty engagement and student feedback mechanisms, and provide support structures for ESG-based learning initiatives in higher education institutions. Future work on measuring ESG's impact on workforce development might focus on improving the predictions by leveraging multi-source data fusion of longitudinal educational outcomes. It would also be especially interesting to continue the study of the factors that impact institutional adoption of ESG policies by including aspects such as the economic incentives, governmental regulations, and faculty engagement strategies, assessing the effects that involvement in industry-driven sustainability programs designed to enhance ESG competence and the structural adaptation of engineering curricula have.

5 Conclusion

This research study presents evidence supporting the effects of incorporating Environmental, Social, and Governance (ESG) practices into STEAM and engineering education. The key findings emphasize enhancements in student engagement, satisfaction, and educator motivation in ESG integrated programs. Through the Experience Sampling Method (ESM), it was discovered that students in these programs expressed levels of engagement and satisfaction. Additionally, analysis of the PANEL dataset indicated student retention and graduation rates well as better post-graduation employment outcomes.

These results emphasize the significance of ESG practices in enriching quality and equipping students for challenges. The study's contributions include data illustrating both long-term benefits of ESG integration, presenting a compelling case for educational policymakers and institutions to embrace these practices.

The findings from this study suggest avenues. Firstly, delving into the components of ESG practices that have a significant impact on educational outcomes could be valuable. Identifying which aspects of ESG integration are most effective can aid in refining and enhancing curriculum designs. Secondly, conducting studies to track the career paths of students from ESG integrated programs could provide insights into the lasting effects of sustainability education.

In conclusion, delving into the obstacles and challenges of implementing ESG practices in settings would help us grasp how to successfully encourage and maintain these initiatives. The melding of ESG practices into STEAM and engineering education has proven to offer advantages, enhancing the environment to be more engaging, motivating, and effective. As schools strive to prepare students for a changing world, integrating sustainability principles becomes crucial for nurturing an accountable educational structure.

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