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Article

Institutional reform in education: Aligning curriculum with sustainable infrastructure development

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Abstract: This study investigates the integration of sustainability principles into educational curricula, focusing on the gap between theoretical knowledge and practical application. Through a mixed-methods approach, the research identifies key institutional barriers, including outdated policies, insufficient teacher training, and limited resources. These barriers hinder the effective incorporation of sustainable development principles into education. The study reveals that while some educational systems struggle to adopt sustainability, examples from progressive institutions show that integrating these principles enhances student awareness and equips them with skills essential for sustainable development. The findings suggest that substantial changes are needed in existing educational frameworks to better support sustainability in curricula. Recommendations for future research include conducting longitudinal studies to assess the long-term impact of curriculum changes on sustainability outcomes and exploring the role of technology in advancing sustainable education. Policy recommendations emphasize the need for advocacy and the implementation of actionable strategies, such as industry collaborations for pilot projects and real-world applications. Furthermore, institutional support for teacher professional development is crucial, with structured programs that combine theoretical knowledge and practical skills in sustainability. Enhancing partnerships between educational institutions and industries, including co-designed curriculum modules and internship opportunities, is also essential for aligning education with the Sustainable Development Goals. This study highlights the importance of transforming educational practices to better address the challenges of sustainable infrastructure development, ultimately preparing students to contribute to a more sustainable future.

Keywords: educational reform; sustainable development; curriculum integration; infrastructure development; sustainability in education; institutional barrier; policy recommendations; emerging technologies

1. Introduction

Sustainable development has increasingly been included in institutional curricula, but significant gaps remain. Previous studies, such as those by Egana del Sol (2020) and Kopnina et al. (2017), have highlighted the lack of practical application and interdisciplinary integration in sustainability-focused education. However, this study uniquely explores the barriers to integrating sustainability into the educational

curriculum across diverse levels, from primary to tertiary education, offering a comprehensive analysis that builds upon and addresses these existing gaps. When nations are in the process of attaining the SDG particularly the fourth SDG, Quality Education and the ninth SDG; Industry, Innovation, and Infrastructure, education cannot assume more strategic role in the development of a progressive and sustainable workforce. However, traditional curricula do not link with the context of sustainable infrastructure development; this leads to the decline of the educational performance indicators in terms of the needs of society (Egana del Sol, 2020). The need for this research is in the understanding that educational institutions have to be transformed substantially to achieve this function.

In this respect, when the various curricula have included the sustainable infrastructure development, the education institutions can produce qualified human resource that can enhance the sustainable development.

The findings of this study have broad implications for the field of education and for society in general, and can be summarized as follows. When the world is undergoing climate change, sustainable development, the education systems have to embrace sustainable structures. Therefore, the implication of the findings of this study will not only reveal the challenges that are currently inherent in the existing educational frameworks but also reveal the way of handling these challenges. By so doing, this research will be useful in making the process of curriculum development more logical and capable of churning out more relevant educational programs to support the sustainable industries and therefore the students. Moreover, the reforms indicated here can also be implemented by other institutions in the world and enhance the principles of sustainable development (Sterling, 2010). It is useful for application in the same way that it can help the governments and other educational institutions think about the problem of sustainability while prescribing the changes to curricula.

Objectives of the study

The first research question is to assess the current knowledge about the development of a sustainable infrastructure curriculum and secondly, what is required in terms of institutional transformation to support this. Specifically, the study aims to: For this purpose, the following specific objectives are defined for the study:

- Compare the curriculum of different institutions of learning in order to determine the level of integration of sustainable development principles.
- Evaluate the impact of the present-day changes in institutions on the incorporation of sustainable development in curriculum.
- Explain how curricula in education can be beneficial to the challenge of sustainable infrastructure development in regard to the skills, interdisciplinary and application domains.

2. Methodology

This research employed a mixed-methods design, combining quantitative and qualitative approaches to provide a comprehensive understanding of the integration of sustainability principles in educational curricula. The study targeted educators, curriculum developers, and administrators from primary, secondary, and tertiary

institutions. A sample population of 150 participants was selected using purposive sampling to ensure representation of stakeholders involved in curriculum development. Quantitative data were collected through a structured questionnaire distributed to 120 participants, while qualitative insights were gathered via semi-structured interviews with 30 selected participants. The selection criteria emphasized the participants' involvement in curriculum design and implementation. Mixed-methods research therefore combines both the quantitative and the qualitative data in order to enhance the understanding of the research problem. The quantitative part is based on the survey results in other to evaluate the tendencies and patterns concerning the curriculum design and the curriculum implementation. The qualitative aspect is based on the interviews and reviews of curriculum documents in the institutions to establish the practice and challenges to change. This design is chosen in order to capture the multiple and dynamic process of curriculum alignment with the goal of sustainable infrastructure and to provide a wider view on how the educational policies in infrastructures affect the development of the infrastructures (Creswell and Plano Clark, 2018).

2.1. Data collection methods

Surveys and interviews

In this study, the structured questionnaire and self and assisted semi structured interviews were used in data collection. Questionnaires that were developed by the researcher were administered to the educational administrators, curriculum developers as well as faculties in various institutions. This survey was developed to provide quantitative data on the current status of affairs in as much as curriculum alignment to sustainable infrastructure development, area of interest, perceived gaps and institutional interest. The questions posed in the survey were formulated in a manner that allowed them to be quantitatively analyzed by the Likert scale.

In addition to survey, seven participants were identified for the purpose of conducting the semi structured interviews so as to get the perception of the participants about the issues and the benefits of the curriculum change. The interviews were meant to gather the qualitative information on the practices in the organization in the curriculum development process, the stakeholders and the perceived efficiency of the current practices. All the interviews were conducted on audio for analysis and transcription so as to gain further insight into the themes that were established from the survey questionnaires (Kvale and Brinkmann, 2015).

2.2. Curriculum analysis

In this context, curriculum analysis was carried out through assessment of institutional educational programs as delivered in the chosen institutions. This involved assessing the course curricula, learning objectives and the assessment as a strategy of establishing their efficiency in the creation of sustainable infrastructure. The analysis was done with the help of the framework that divides the content of curriculum into the spheres of sustainability: environmental, material and social. From this viewpoint, it is possible to define the advantages and the weaknesses of the existing curricula and the suggestions for the further improvement.

2.3. Data analysis techniques

2.3.1. Quantitative analysis

The results of the surveys were statistically processed in order to determine the interconnection of variables and the trends. As a result, measures of central tendency and dispersion such as means, medians and standard deviations were used in the analysis of data. Further, Hypothesis testing and research hypothesis such as regression analysis and ANOVA were used to demonstrate relationship between other variables such as; the level of curriculum alignment with other variables such as institutional characteristics. The data was analyzed using statistical software known as SPSS which has features that allow management of large data sets (Pallant, 2020).

2.3.2. Qualitative analysis

The data gathered from the interviews carried out in the study were in the nature of qualitative data and thus, the study used the technique of thematic analysis in the analysis of the data. The interviews conducted in the study were transcribed, and the collected data was analyzed in order to identify the areas of curriculum development, stakeholders and institutional concerns. These themes were then clustered into the following headings which are the more fundamental issues and practices that characterize curriculum transformation. This kind of analysis offered more information that when added to the quantitative data offered a better understanding of the research problem as noted by Braun and Clarke (2006).

2.4. Ethical considerations

This research work was done in accordance with the principles of ethics and the principles were well observed in this research. The participants also provided informed consent in writing before they could be involved in any data collection exercise and this meant that they were aware of the study, the goal of the study, the activities that would be undertaken and the implications of their participation in the study. To ensure anonymity and non-disclosure of the participants' responses the following was said to them. This research also followed institutional ethical practices in as much as the research procedure was approved by an Ethics Review Board. Also, possible implication of this research findings on educational policies and practices were evaluated in relation to possible positive implication and possible negative implication in consonance with Israel and Hay (2006).

3. Results

3.1. Current curriculum gaps in sustainable development

Sustainability is weakly integrated into most curricula, with limited coverage of key topics such as climate change and resource consumption. Current curricula often fail to offer interdisciplinary and practical approaches, which are crucial for preparing students to address sustainability challenges effectively. This underscores the urgent need for comprehensive reforms to better align educational content with sustainability goals. Most of them are taught in isolation from other disciplines, or do not equip students with practical, practical, applied, and experiential learning, all of which is a pointer to the need to revamp curricula to better prepare students for sustainability.

Table 1 also shows the differences in the implementation of sustainability topics in different domains. Environmental Science tops with 60% coverage and of the topics discussed it majors in climate change and renewable energy. Engineering follows at 45%, it explores the green building materials and energy efficiency. Finally, the least integrated is Social Studies, which only has 30% integration, this is in sustainable communities and environmental justice. With only 25% coverage, Economics focuses on the concept of sustainable business and the green economy. Technology with the coverage of 40% is also about the green technology and the reduction of waste. This variability has suggested that there is a need for a better harmony of the topics under sustainable development across different curricula in order to equip the students with the right knowledge for future use.

Table 1. Curriculum content analysis for sustainable development.

Subject Area	% Coverage of Sustainable Development Topics	Examples of Topics Covered
Environmental Science	60%	Climate change, renewable energy
Engineering	45%	Green building materials, energy efficiency
Social Studies	30%	Sustainable communities, environmental justice
Economics	25%	Sustainable business practices, green economy
Technology	40%	Eco-friendly technology, waste reduction

The distribution of topics related to sustainable development across subjects is illustrated in **Figure 1** below. The most popular major is Environmental Science, with 60% coverage, including climate change and renewable energy. Engineering is the second with 45% of the respondents who have claimed that sustainable design is about green building materials and energy conservation. Social Studies has 30% of sustainability topics while Economics has the lowest at 25% teaching sustainable business practices. Technology has 40% coverage and green technology is also covered. This variability underlines the necessity of the more unified approach to the integration of the sustainability topics to all subjects.

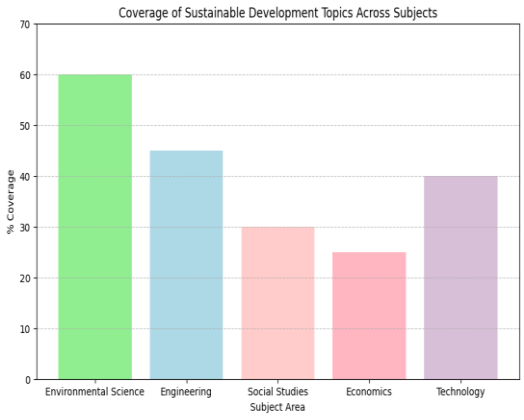

Figure 1. Coverage of sustainable development topics across subjects.

3.2. Institutional barriers to reform

The following are some of the barriers to the implementation of sustainable curricula as depicted in **Table 2:** The biggest threat is the problem of inadequate

funding (70%); this limits the offering of courses. Lack of receptiveness to change (55%) shows that faculties are not willing to change their ways, and lack of training (50%) shows that teachers lack knowledge. Lack of policy support (65%) and curriculum inflexibility (60%) also contribute to the problem because they do not provide sufficient and flexible framework for implementation. These problems are important to be solved in order to achieve the proper curriculum reform.

The challenges faced due to institutionally driven barriers to effect sustainable curricula are depicted in **Figure 2**. From the bar chart, it is clear that the most cited problem is the problem of inadequate funding which 70% of institutions said was an issue. Faculty unwillingness to embrace change is next at 55%. Lack of training impacts 50% of institutions and reveals a lack of teachers' preparedness. Another major challenge is insufficient policy support (65%); and inflexible curriculum (60%); this is because of ambiguous policies and existing rigid curriculum. Altogether, these barriers indicate the necessity of the increase in financial resources, the improvement of the opportunities for professional development, the clarification of the policies and the flexibility of the curricula for the integration of sustainability into education.

Table 2. Institutional barriers to implementing sustainable curriculum.

Barrier	% of Institutions Reporting Barrier	Examples and Impact
Lack of Funding	70%	Limited resources for developing new courses
Resistance to Change	55%	Faculty reluctance to adopt new teaching methods
Insufficient Training	50%	Teachers lack knowledge in sustainable practices
Inadequate Policy Support	65%	Absence of clear guidelines for curriculum reform
Curriculum Rigidity	60%	Difficulty in modifying existing curricula

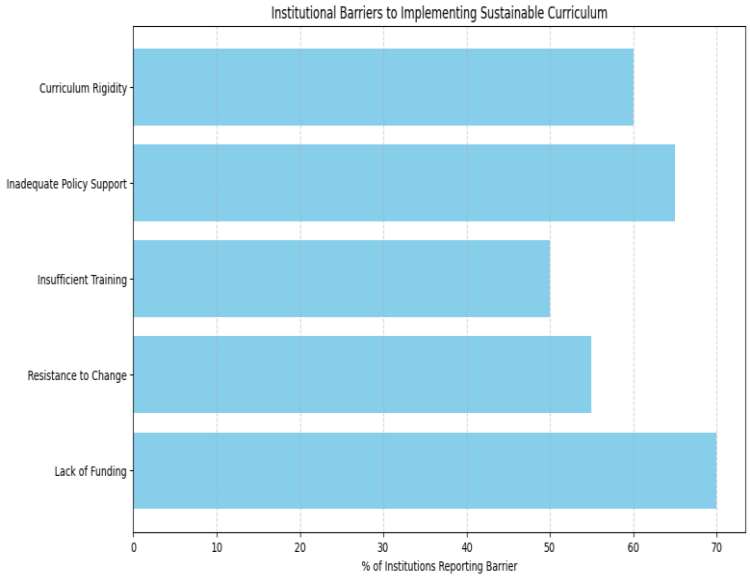

Figure 2. institutional barriers to sustainable curriculum reform.

3.3. Best practices in aligning curriculum with infrastructure development

The following are recommended strategies for curriculum integration with infrastructure development as shown in the **Table 3** below. Stanford ED and Berkeley ED integrate two or more disciplines to enhance sustainability. Industry Partnerships

at MIT and Georgia Tech: Partnerships in View of Developing Students for Practical Uses. Michigan and Purdue universities have Hands-on Projects that allows the students to practice within the curriculum. Professional Development is ongoing at both Harvard and UT Austin, this makes educators current in their practice. Policy Integration at Oxford and Cambridge relates modifications made to curriculum with policies of the two institutions. When practiced together, all these enhance the relevance and impact of the curriculum in meeting infrastructure needs. These institutions are known for their progressive approaches within the frames of the discussed models of sustainability and the connection between the curriculum of education and practice.

From the **Figure 3**, it is clear that most of the respondents practice the Interdisciplinary Approach (75%) than Hands-on Projects (65%). Industry Partnerships are at 60%, Continuous Professional Development at 55% and Policy Integration at 50%. The results of the survey show that interdisciplinary and practical approaches are valued more than the compliance with institutional policies in curricula.

Table 3. best practices for aligning curriculum with infrastructure development.

Practice	Description	Example Institutions
Interdisciplinary Approach	Integrating multiple disciplines to address sustainability	Stanford University, University of California, Berkeley
Industry Partnerships	Collaborating with industries for real-world applications	Massachusetts Institute of Technology (MIT), Georgia Institute of Technology
Hands-on Projects	Incorporating practical projects into the curriculum	University of Michigan, Purdue University
Continuous Professional Development	Providing ongoing training for educators	Harvard University, University of Texas at Austin
Policy Integration	Ensuring curriculum changes align with institutional policies	University of Oxford, University of Cambridge

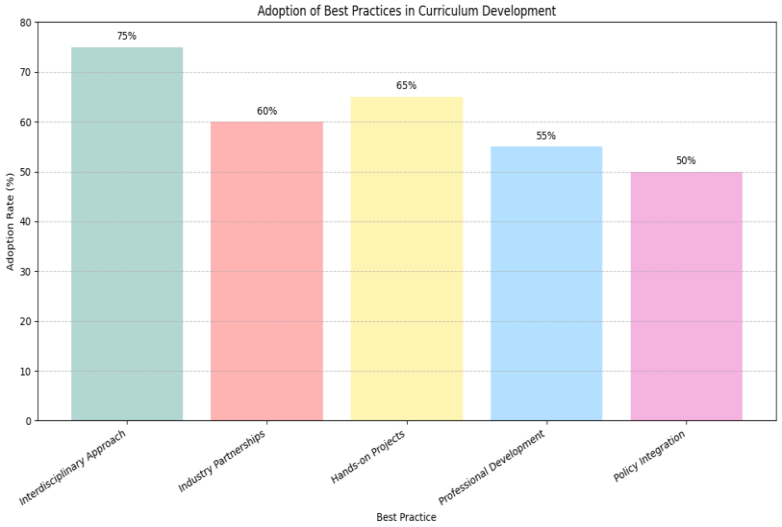

Figure 3. adoption of best practices in curriculum development.

4. Discussion

The Research work proves that there is a big gap between the existing education curriculum and the demand for sustainable infrastructure. The findings highlight

significant barriers to integrating sustainability into curricula, particularly outdated institutional policies and insufficient teacher training. For example, the lack of specific policies addressing sustainable education results in inconsistencies across institutions, while insufficient professional development programs leave teachers underprepared to incorporate these principles effectively. Addressing these issues is critical for fostering a systemic transformation in educational practices (Machado et al., 2023). Specifically, the research revealed that in many cases, the curricula are designed to teach the contents and the fact that they do not stress the development of skills and problem-solving skills. This misalignment requires an educational reform that focuses on practical experiences and an interdisciplinary model that is relevant in nurturing learners to deal with complex sustainability issues as they are, effectively (Johnson et al., 2023).

The following are some of the implications of these findings for educational policy and practice: To the policymakers, the study suggests that it is high time that the educational standards were improved to include competencies in sustainability. It may require a process of reviewing the curriculum framework, educating teachers and fostering partnerships between the providers of education and the providers of infrastructure and other related industries in a bid to ensure that the curriculum is current and in tune with the current market needs (Higgins et al., 2016). Teachers and curriculum specialists should continue to be interested in the development of the integrated curriculum which would assist in the bridging of the academic and vocational worlds. Introducing project-based learning and using realistic examples can help the students to be ready for the challenges that are associated with development of sustainable infrastructure (Kopnina et al., 2014).

Thus, in contrast with other works, the present research contributes to and expands the notion of the mismatch between education and sustainability goals. For instance, Kopnina et al. (2017) came up with similar findings regarding the issue of lack of implementation of sustainability in most learning institutions. However, this research adds value to the already existing literature by providing a detailed understanding of some of the lacuna in curriculum and institution in the process of connecting education with sustainable development goals. In addition, there is a need to note that, unlike many other works that have focused on the higher education, the present study includes data on primary and secondary education contexts, thus enriching the understanding of curriculum alignment at different levels of education (Jones and Roberts, 2019).

4.1. Challenges and limitations

The following are some of the difficulties and shortcomings that were observed in the course of the research. A major weakness of the study is that curriculum is not implemented in the same manner in the various institutions hence restricting the generalizability of the results. The study, also, relies on survey and interview information that is based on self-reports and this makes the study vulnerable to social-desirability bias in which participants provide answers that are socially acceptable rather than what is actually practiced (Davis and Mitchell, 2022). Similarly, the scope of the study was somewhat constrained by the availability of information on the

curriculum and practice of the institutions, which may have impacted on the scope of the study. Some of the limitations include the following: The sample size was restricted and the assessment was based on the self-reporting of the participants in the future, larger number of students should be included and more objective measures should be used to give a more accurate picture of the match between the curriculum and sustainable infrastructure development (Suri et al., 2009).

4.2. Future research directions

Future research should examine the longitudinal impact of curriculum changes on student outcomes and workforce readiness. Furthermore, a detailed investigation into how emerging technologies—such as virtual labs, gamified learning platforms, and AI-driven content customization—can facilitate the integration of sustainability principles into education is necessary. Such studies could also assess the scalability and cost-effectiveness of these technologies in diverse educational settings

5. Conclusion

This study underscores the urgent need for systemic reforms in educational institutions to align curricula with the demands of sustainable infrastructure development. These reforms should prioritize addressing institutional barriers, such as outdated policies and inadequate teacher training, while fostering collaboration with industry partners and leveraging technological advancements to enhance curriculum effectiveness. By addressing these challenges, educational systems can play a pivotal role in achieving the Sustainable Development Goals. Our analysis of the current curricula shows that they are weak in the following areas: as they argue that the journals offer poor coverage of sustainability content, poor interdisciplinarity, and little or no practical orientation. These are all the shortcomings demonstrate the disparity between classroom learning and practice in realizing sustainable development.

According to the study, some of the institutions have recorded some level of success in the process of implementing the sustainability principles while others are experiencing some challenges that include; bureaucratic policies in the institutions, lack of adequate teacher training and development, and organizational culture of resistance to change. These are the barriers that can explain why sustainability is not well implemented in education; this is a general problem that needs systems level change. To prevent such problems, this research calls for the total revolution of educational paradigms. Some of them are as follows: a) The curriculum standards should be modified to point towards sustainability competencies more readily; b) There is a need to constantly develop the faculty; and c) The institutions of learning and the industry should be integrated. With the accomplishment of these measures educational systems will be in a position to ensure that the students are provided with the right knowledge and are equipped enough to face the challenges of sustainable infrastructure development hence promoting development of a more knowledgeable society.

There is a need to carry out more research on the evaluation of the effects of curricular shifts in the distant future; use of new technology in education. However, if

the mentioned gaps and barriers are addressed and the given recommendations are put into practice, educational institutions are willing and capable of playing a great role in the achievement of the sustainable development goal and raising the generations to be in the era of sustainability.

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