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Empowering Youth for Sustainable Development Through Mathematical Knowledge: A Quantitative Perspective

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This study explores the role that mathematical knowledge plays in empowering young people toward meaningful participation in the Sustainable Development Goals (SDGs). Using a quantitative research design, data were collected from 310 bachelor-level students across three higher education institutions in Makwanpur District, Nepal 2025. The study measured students' perceptions of their mathematical capabilities, awareness of SDGs and participation in sustainability initiatives using structured Likert scale questionnaires. Data analysis using non-parametric tests (Mann-Whitney U, Kruskal-Wallis H) and Spearman correlation revealed several key findings. Significant gender- and faculty-based differences were measured in students' perceptions on sustainability participation with Mann-Whitney U = 8823.000. Furthermore, a weak but statistically significant positive correlation was found between mathematical knowledge and SDG awareness with Spearman's rho correlation ρ = .210. Though, awareness did not consistently lead to higher sustainability participation, indicating a gap between knowledge and action. These findings emphasize the importance of integrating real-world sustainability contexts into mathematics curricula and providing facilitating institutional environments. The study concludes that while mathematical competencies can create SDG awareness, transforming this awareness into practice requires interdisciplinary collaboration, inclusive teaching strategies and student-centered participation platforms. Further, this study implies that Mathematical knowledge enhances SDG awareness, but active youth participation needs supportive, interdisciplinary and practical learning environments.

Keywords: sustainable development goals, mathematical knowledge, youth empowerment, higher education, Nepal

INTRODUCTION

Sustainable development has emerged as a global importance, addressing the crucial need to balance economic growth, social inclusion, and ecological protection (United

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Nations, 2015; Bulut & Borromeo Ferri, 2025; Li & Tsai, 2021). The youth, as key stakeholders in the coming future, play a key role in attaining sustainable development goals (SDGs) by contributing innovative and context-based solutions and leads towards societal transformation (Bachmann et al., 2022; Sebhatu & Enquist, 2022; UNESCO, 2020). However, for young people to actively participate in sustainable development, they must be prepared with critical skills, mainly in mathematics, which serves as a fundamental tool for problem-solving, data interpretation and analysis and evidence-based policymaking (Boaler, 2016; Chuan & Tsai, 2021; Nguyen et al., 2024). Further, decision making on real-world policy deals frequently with the researchers who depend on quantitative data on the effects of the application of alternative policy options. Therefore, modern decision theory makes extensive use of quantitative data, if sufficiently valid and accurate data are available (TEEB, 2020). As mathematical knowledge plays a key role in empowering Nepalese youth by enhancing problem-solving, financial literacy taking involvement in the digital economy. The studies indicate that students' achievement in mathematics is shaped by both contextual and behavioural factors. It highlights the importance of effective learning environments (Tiwari, 2023) with practical experiences (Adhikari et al., 2024). Besides this, numeracy skills significantly influence financial literacy and adoption of digital payment systems aligning mathematics directly with economic enablement (Thapa, 2025).

According to Steen (2001), mathematics is not only an academic subject but an influential instrument for understanding and addressing real-world challenges, including climate change, different resource organization and social justice Quantitative literacy empowers youth to interpret statistical data, measure sustainability indicators and develop models that inform policy and practice (Gravemeijer et al., 2017; Makramalla et al., 2025; Vásquez et al., 2023). In the face of its significance, there remains a gap in research exploring how mathematical knowledge specifically empowers youth to contribute to sustainable development, mainly from a quantitative perspective.

Objectives of the Study

- To assess the level of mathematical knowledge among youth in higher education.
- To examine the level of mathematical competencies and SDG awareness among youth in higher education.
- To identify the level of participation sustainability among youth in higher education.

Significance of the Study

As several studies have emphasized the intersection between education, youth empowerment, and sustainable development (Ferguson et al., 2021; Mohammed Tohit & Haque, 2024) . However, few have clearly examined how mathematical competencies develop youth engagement in sustainability initiatives. Research indicates that students having command in quantitative skills are better prepared to analyze and interpret environmental tendencies, evaluate economic policies, and involve in scientific research (Makar et al., 2011). Moreover, mathematical modeling and statistical

reasoning are essential for understanding difficult sustainability issues such as carbon footprints, renewable energy optimization as well as population dynamics also (Kaiser & Sriraman, 2006).

So, this study seeks to link this gap by examining the role of mathematical knowledge in empowering youth for sustainable development through a quantitative perspective. By analyzing survey of 310 university students of 3 higher institutions of Makwanpur district in Nepal, this research aims to determine how mathematical skill influences their ability to contribute effectively to SDGs. Moreover, the findings will provide insights for educators, policymakers and different youth organizations to strengthen STEM education and bring into line it with sustainability objectives.

LITERATURE REVIEW

Mathematical Knowledge as a Facilitator for Sustainable Development

Sustainable development focus for achieving certain human needs derived from quantitative economic values (Ulhoi & Madsen, 1999), but is also an opportunity for achieving certain social needs, culture, tradition and different social values. So, it is both a development pattern and an spirit that inspires growing living standards without jeopardizing the earth's natural ecosystems or causing ecological issues which can subsidize to extinction of species and changes in climate (Browning & Alessandro, 2019). Also, Evers (2018) links the notion with the organizing principle for achieving human development goals while conserving natural systems' potential to continue supplying critical natural resources and ecosystem services.

In many countries' school curricula, Mathematics is addressed as a compulsory and serves as a gateway to various fields of science which provides a foundation for analytical skills, problem-solving as well as critical thinking and are essential in addressing sustainability issues (Kuznetsova & Matytcina, 2018). Consequently, a solid grasp of mathematical knowledge and skills is crucial in the pursuit and achievement of education for sustainable development (Widiati & Juandi, 2019) as mathematical knowledge is gradually recognized as essential for addressing complex sustainability challenges.

Vasquez et al. (2023) claim that integrating sustainability into mathematics education empowers students to make informed decisions for sustainable development. Manandhar and Chhetri (2023) also highlight that impact and sustainability are deeply interconnected and quantitative tools can clarify these linkages. Ernest (2020) discussed that Mathematics Education for Sustainable Development (MESD) goes beyond the boundaries of conventional mathematical philosophy and considers the ability of mathematical applications to lead both human life and the existing social world. Therefore, it is important for pre-service teachers to be aware and well-informed about the conceptual and practical components of MESD. Moreover, MESD seeks to make mathematics learning more significant and genuine while also promoting the development of 21st-century competencies such as critical thinking, creativities as well as communication with collaboration (Widiati & Juandi, 2019).

Youth Empowerment Through Quantitative Skills

Youth empowerment means enabling young people to take charge of their growth through active inclusion in all aspects of society. It strengthens their wellbeing and fosters meaningful contributions to community development (Ogamba, 2019). Youth empowerment refers to the process of equipping young people with skills, knowledge, and opportunities to actively participate in decision-making and problem-solving for societal transformation. In the context of sustainable development, empowering youth through mathematical knowledge fosters critical thinking, innovation, and evidence-based action (Checkoway, 2011). Mathematics enhances analytical capacities, enabling youth to address real-world challenges such as resource management and climate change (UNESCO, 2017). Moreover, empowerment through education increases self-efficacy and civic engagement (Zimmerman, 2000).

The previous studies indicate that youth were less involved in SDG-related programs. As a result, they lack the exposure of SDGs. Therefore, traditional and social media should be fully utilized to make them aware of SDGs (Zaharrudin & Zakaria, 2021). It will facilitate youth with mathematical skills which develops their individual capacity to involve with SDGs.

Another study by Vasquez et al. (2023) highlights that students trained in quantitative methods are better equipped to analyze sustainability data and contribute for decision-making processes through the different indicators. One of the report by OECD (2018, 2021) focuses towards the students with different mathematical abilities are more likely to participate in sustainability initiatives projects, signifying the critical role of quantitative literacy in promoting youth engagement. Nuringsih & MN (2021) considered knowledge to be principal factor and highlighted the importance of sustainability key factors in the commercial courses so that youth can follow the SDGs.

Integration of Sustainability in Mathematics Education

A study from Vasquez et al. (2023) highlights the need for incorporating sustainability into mathematics education to empower students in making decisions for sustainable development as the integration of sustainability concepts into mathematics curricula which has been explored to promote interdisciplinary learning. Since the world faces with various sustainability challenges, the serious role of mathematics teachers in nurturing responsible and globally a sensible citizen cannot be underestimated because of the nature of the subject (Kanandjebo, 2024). From this sense, Alsina and Mulà (2019) propose that mathematics teachers of the different stages have to be actively involved in developing their students' sustainability capabilities and so becoming agents of social change.

Critical Mathematics Pedagogy and Social Justice

Social justice means fair access to resources and opportunities and in mathematics education, it uses quantitative tools to address poverty, inequality and climate change (Gutstein, 2006). Mathematics education involves using mathematical knowledge to

critically examine social issues such as poverty, exclusion as well as environmental degradation also (Bartell, 2013). By situating mathematics within practical contexts, critical instruction enables students to recognize the role of quantitative reasoning in promoting equity and sustainable outlooks (Gutiérrez, 2013). Thus, empowering youth with mathematical knowledge not only develops their problem-solving skills but also prepares them to act as mediators of social transformation.

Reviewing the literature provides an overview to discuss the benchmark with so many pedagogical approaches for proceeding SD in Mathematics education, as pedagogical approaches taught by teacher educators and are implemented by prospective teachers and therefore similar to them (Kanandjebo, 2024; Thakuri, 2023; Kacmaz & Dubé, 2022) . Critical mathematics pedagogy enables learners focusing on the role of mathematics education in promoting social justice. One of the studies by Skovsmose (1994) focuses towards on mathematics education is that it should enable students to critically analyze societal structures and contribute to transformative activities. This approach brings into line with the goals of sustainable development by fostering critical thinking and active involvement among youth.

A study by Su et al. (2023) concluded that the integration of education for sustainable development concepts in mathematics teaching and learning is still in the early stages of development, particularly in terms of learning content, pedagogy and the learning environment. Thus, it is imperative that mathematics education make a transition towards a holistic, integrative and interdisciplinary education in order to develop students' knowledge in a combined way about this natural world and its actions (Li & Tsai, 2021).

Gaps in Current Research

Prior studies have largely remained theoretical or pedagogical. By situating the analysis within the context of Nepalese higher education, the study broadens the global discourse on mathematics and sustainability, offering both theoretical advancement and practical implications for curriculum, policy and institutional practice.

Theoretical Framework

This study draws on three interrelated frameworks: Human Capital Theory propounded by Becker (1993) focuses that investment in skills development, including mathematics, enriches individuals' and nations' productive capacities whereas **c**onstructivist learning theory propounded by Piaget and Vygotsky (1970, 1978) highlights about the learning through real-world situation, supporting the integration of SDG contexts in mathematics teaching. Furthermore, Capability Approach propounded by Sen and Nussbaum (1999; 2000) argues that education enables individuals to expand their choices and freedoms. Mathematical literacy, in this view empowers youth to analytically measure and doing activities on sustainability issues.

Finally, together these theories create a solid foundation for exploring how mathematical knowledge empowers youth to involve with sustainable development. Since human capital theory focused on the value of education for societal sectorial progress; also constructivist learning theory supports the pedagogical approach to

learning mathematics through real-world contexts and the global scenario; and the Capability Approach focuses the broader developmental impact of education on human freedom and different activities.

CONCEPTUAL LINKAGES OF THIS STUDY

This study establishes a series of logical and research-informed linkages among main variables, grounded in the guiding theories of Human Capital, Constructivism and the Capability Approach. The following conceptual relationships show how mathematical knowledge can help as a transformative effort in empowering youth for sustainable development:

- **Mathematical Knowledge**

Mathematical skills such as problem-solving, data interpretation, and statistical reasoning contribute directly to students' quantitative knowledge. This capacity agrees them to analyze and understand real-world data and sustainability indicators (Bron & Prudente, 2025; Zhao & Abdullah, 2025).

- **SDG Awareness and Critical Thinking**

As students become more knowledgeable in quantitative reasoning, they are better equipped to understand complex development challenges set in the SDGs. They can involve critically with information, identify patterns and evaluate sustainability ideas and solutions from local to global contexts (Hembrough, 2025; Jainan et al., 2025).

- **Youth Empowerment and Active Participation**

Awareness of sustainability issues and the ability to reason quantitatively substitute youth agency. Students become more confident in their role as contributors to social changes and they activate themselves in developmental activities (Assalihee & Boonsuk, 2023; Rojas et al., 2025).

- **Contribution to Localize SDGs**

Empowered youth are more likely to involve in different sustainability projects, advocate for change, and use data-driven reasoning to propose innovative ideas and solutions in their local context. However, this step also requires enabling environments such as supportive institutions and sharing platforms (Fiorani et al., 2025).

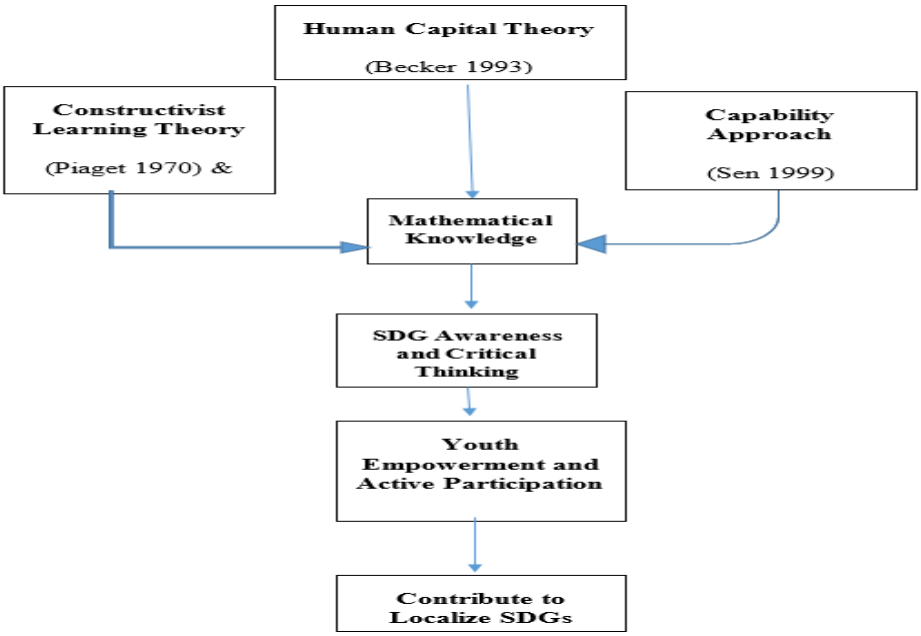

Figure 1
Conceptual Framework

METHOD

Research Design

A quantitative cross-sectional survey design was used to examine the relationship between mathematical knowledge, SDG awareness and youth participation in the sustainability initiatives. The design was chosen to capture different measurable patterns of perception and engagement among university students using structured data collection with related statistical analysis.

Population and Sample

The target population contained undergraduate students enrolled in three higher education institutions in the Makwanpur District of Nepal. From diverse faculties (Management, Education, Science) a total of 310 students participated in this study which was selected through stratified random sampling to ensure representation among the faculties and gender groups during 2025.

Research Instrument

Using a structured, self-administered questionnaire on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), primary data were collected. The instrument consisted of four sections: demographic information, perceptions of mathematical knowledge, awareness and understanding of the SDGs and participation in sustainability initiatives.

Reliability of the Instrument

To measure the internal consistency of the instrument, Cronbach's alpha was computed using SPSS (version 27) and the overall reliability coefficient was $\alpha = 0.72$, which indicates an acceptable level of internal consistency (George & Mallery, 2003) . From this measurements, items within the questionnaire were appropriately correlated and reliable after construction among the variables mathematical knowledge, SDG awareness and participation in sustainability initiatives.

Data Collection Procedure

At first, a pilot test was conducted with 30 students to refine item clarity and structure. For this, questionnaires were distributed in physical form and the final data were collected over a two-week period under informed consent protocols, ensuring voluntary involvement.

Data Analysis Techniques

Using IBM SPSS Statistics version 27, data were analyzed and the analysis included: Mann-Whitney U test to examine gender-based differences, Spearman's rank-order correlation to evaluate the relationship between mathematical knowledge and SDG awareness and Kruskal-Wallis H test for differences across the faculties. All statistical tests were observed in a 95% confidence level ($\alpha = 0.05$).

FINDINGS

Objective 1: To assess the level of mathematical knowledge among youth in higher education.

From the above objective, the following null hypothesis was drawn: H01: There is no significant difference between male and female in their perceptions on mathematical knowledge.

Table 1
Gender-Based Differences in Perceptions of Mathematical Knowledge

Test Statistics[a]	
	Mathematical Knowledge
Mann-Whitney U	8304.500
Wilcoxon W	28204.500
Z	-3.650
Asymp. Sig. (2-tailed)	.001

a. Grouping Variable: Gender

Source: (Survey Study, 2025)

From the data, to assess whether male and female students differed significantly in their perceptions of mathematical knowledge, a Mann-Whitney U test was conducted. This non-parametric test was appropriate because the data were derived from a 5-point Likert scale, which is ordinal in nature and does not assume normal distribution.

From the table, the results show a statistically significant difference between male and female students as the value of $U = 8304.500$, $Z = -2.504$, $p = .001 < .05$ (2-tailed). Since

the p-value was less than .05, the null hypothesis (H_{01}) was rejected which indicates that gender had a significant difference in higher self-assessed skill.

H02: There is no significant difference among faculties in their perceptions on mathematical knowledge.

Table 2
Hypothesis Test Summary

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Mathematical Knowledge is the same across categories of Faculty.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

The above table shows the results of a test (called an Independent-Samples Kruskal-Wallis Test) that checks if faculties have the same opinions on mathematical knowledge. The test assumes that there's no difference with a standard limit of p=0.05. The result with a value of p=0.00<.05 shows a clear difference in how faculties perceive mathematical knowledge supporting the study's goal to measure this knowledge among youth in higher education.

Table 3
Faculty-Based Differences in Perceptions of Mathematical Knowledge

Pairwise Comparisons of Faculty					
Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
B.Ed.-BBS	-4.453	12.177	-.366	.715	1.000
B.Ed.-BSc	-63.192	13.891	-4.549	.000	.000
BBS-BSc	-58.740	12.369	-4.749	.000	.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

To evaluate differences among faculties (i.e. B.Ed., BBS and B.Sc.), a Kruskal-Wallis H test was used. This test is a non-parametric which is alternative to one-way ANOVA and is appropriate for comparing more than two independent groups with ordinal data. The analysis showed a statistically significant difference in students' perceptions of mathematical knowledge across different faculties: Since p = .001<.05, the result comes to conclude on the rejection of the null hypothesis (H_{02}), showing that at least one faculty group differs significantly in their perception of mathematical knowledge.

As given the significant Kruskal-Wallis result from the above data, post hoc analysis was done since it was necessary to determine which specific faculty groups were different. From the result, a significant difference was found between B.Ed. and B.Sc. students (p = .001), suggesting these two faculties clearly shows different levels of self-reported mathematical knowledge. However, the comparison between BBS and B.Ed. students was not statistically significant (p = .715>.05). This high p-value shows that the students from the Management and Education faculties perceived their mathematical knowledge with no meaningful difference in their Likert-scale responses.

Objective 2: To assess the level of mathematical competencies and SDG awareness among youth in higher education.

H03: There is no significant correlation between mathematical competencies and SDG awareness.

Table 4
Correlations Between Mathematical Knowledge and Awareness Understanding

Correlations				
			Mathematical Knowledge	Awareness Understanding
Spearman's rho	Mathematical Knowledge	Correlation Coefficient	1.000	.210**
		Sig. (2-tailed)	.	.000
		N	310	310
	Awareness Understanding	Correlation Coefficient	.210**	1.000
		Sig. (2-tailed)	.000	.
		N	310	310

**. Correlation is significant at the 0.01 level (2-tailed).

From the above data, Spearman correlation was run to assess the relationship between students' mathematical competencies and their awareness on the sustainable development goals (SDGs). Results showed a positive and statistically significant correlation between the two variables ($\rho = .210$, $p < .01$, $N = 310$). This indicates that higher self-reported mathematical knowledge was associated with greater SDG awareness among youth in higher education. That's why, the null hypothesis (H_{03}) is rejected.

Objective 3: To assess the level of participation sustainability among youth in higher education.

H04: There is no significant difference between male and female in their perceptions on participation sustainability.

Table 5
Test Statistics[a]

Test Statistics[a]	
	Participation Sustainability
Mann-Whitney U	8823.000
Wilcoxon W	15039.000
Z	-2.963
Asymp. Sig. (2-tailed)	.003

a. Grouping Variable: Gender

From the above table, to assess whether male and female students differed significantly in their perceptions of participation sustainability, a Mann-Whitney U test was conducted. This non-parametric test was more suitable as the data were derived from a 5-point Likert scale, which is ordinal in nature and does not assume any normal distribution.

The results revealed a statistically significant difference between male and female students as $U = 8823.000$, $Z = -2.963$, $p = .003 < .05$ (2-tailed). Since the p-value was less than .05, the null hypothesis (H_{01}) was rejected. This signifies that gender had a significant difference in higher self-assessed proficiency.

H05: There is no significant difference among faculties in their perceptions on participation sustainability.

Table 6
Hypothesis Test Summary

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Participation Sustainability is the same across categories of Faculty.	Independent-Samples Kruskal-Wallis Test	.035	Reject the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

The results of the Independent-Samples Kruskal-Wallis Test revealed a statistically significant difference in perceptions of participation sustainability across academic faculties as $p = .035 < .05$, leading to the rejection of the null hypothesis. This finding indicates that the level of sustained engagement in sustainable development initiatives is not uniform but is instead influenced by a student's disciplinary background. Within the framework of empowering youth through mathematical knowledge, this underscores the critical need to develop faculty-specific strategies that address distinct perspectives and barriers, thereby fostering more effective and inclusive participation in sustainability practices across higher education.

Table 7
Pairwise Comparisons of Faculty

Pairwise Comparisons of Faculty					
Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
BBS-BSc	-7.618	12.355	-.617	.538	1.000
BBS-B.Ed.	31.192	12.163	2.564	.010	.031
BSc-B.Ed.	23.574	13.875	1.699	.089	.268

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

From the above table, a Kruskal-Wallis H test was conducted to determine whether there were significant differences in students' perceptions of participation in sustainability across three faculty groups (BBS, B.Ed., B.Sc.). The results revealed a statistically significant difference among the groups and $p = .035$. Therefore, the null hypothesis (H_{05}) was rejected, suggesting that at least one faculty group perceived sustainability participation in different way. Follow-up pairwise comparisons using Bonferroni correction indicated that the difference was significant between BBS and B.Ed. students ($p = .031$), while no significant differences were found between BBS and B.Sc. ($p = .538 > .05$) or B.Ed. and B.Sc. ($p = .268 > .05$).

These results suggest that students from management and education faculties vary in how they engage with sustainability initiatives, whereas students from other faculty combinations do not show any significant differences.

FINDINGS

Objective 1: To assess the level of mathematical knowledge among youth in higher education

To measure the objective 1, a Mann-Whitney U test revealed a statistically significant difference in students' perceptions of mathematical knowledge based on gender ($U = 8304.500$, $Z = -2.504$, $p = .012$). This result suggests on gender influences that how students rate their mathematical confidence.

A Kruskal-Wallis H test identified significant differences in mathematical knowledge across faculties ($p = .001$). Post hoc analysis found that students from B.Ed. and B.Sc. faculties had significantly different perceptions ($p = .001<.05$), while B.Ed. and BBS students did not differ significantly (since $p = .715>.05$).

Objective 2: To assess the level of mathematical competencies and SDG awareness among youth in higher education.

From the data, Spearman correlation showed a weak but statistically significant positive relationship between mathematical knowledge and SDG awareness ($\rho = .210$, $p < .01$). Students with greater mathematical understanding tend to be more aware of the SDGs.

Objective 3: To assess the level of participation sustainability among youth in higher education.

From the above data, a Mann-Whitney U test indicated a significant gender-based difference in sustainability participation ($U = 8823.000$, $Z = -2.963$, $p = .003$), with one of the gender reporting higher participation. Also Kruskal-Wallis test showed faculty-based differences in perceptions of participation ($p = .035<.05$). As post hoc analysis revealed a significant difference between B.Ed. and BBS students ($p = .031>.05$), however no significant differences between BBS–B.Sc. or B.Ed.–B.Sc. was found.

DISCUSSION

This study underlines the significant role of mathematical knowledge in shaping youth awareness of the Sustainable Development Goals (SDGs). The finding of a weak but statistically significant positive correlation between mathematical competencies and SDG awareness ($\rho = .210$, $p < .01$) aligns with the work of Vasquez et al. (2023) who highlighted the power of quantitative skills in enabling students to critically engage with sustainability data and indicators. This suggests that mathematical literacy provides a introductory toolkit for reviewing complex, data-driven global challenges, a necessity underlined in recent work by Makramalla et al. (2025) who argue that mathematics education must be reoriented towards "sustainable futures" by empowering students to analyze real-world socio-ecological systems. Also developing math apps address a wide array of topics between educational technology key stakeholders (Alam et al., 2025) and further supported by Bulut and Borromeo Ferri (2025), who demonstrated that using mathematical modelling specifically for sustainability contexts in teacher education significantly enhances pre-service teachers' ability to connect abstract formulas to tangible global issues. This research demonstrates through data from 310 Nepalese university students a positive correlation between mathematical competencies and SDG awareness also revealing a critical knowledge–action gap in participation.

However, a critical finding of this study is the implementation gap: sharpened awareness did not consistently lead to higher participation in sustainability initiatives. This contrast is crucial. While previous studies like Alsina and Mulà (2019) successfully argued for the transformative potential of integrating sustainability into teacher education, they often focused on pedagogical theory and teacher competence rather than measurable student action. Our results reveal that knowledge alone is insufficient. This gap indicates that without explicit institutional pathways, mentorship and practical engagement opportunities, awareness remains theoretical. This supports the argument by Nguyen et al. (2024) that transformative learning requires problem-based and experiential approaches that move beyond the classroom to connect students directly with community-based sustainability projects.

The observed gender and faculty-based differences in both mathematical knowledge perceptions and sustainability participation suggest that sociocultural and curricular factors heavily influence engagement levels. This finding contrasts with more optimistic, homogenous views of student readiness and echoes concerns raised by Kanandjebo (2024) about the varying levels of awareness and challenges among pre-service teachers. It indicates that a one-size-fits-all approach to integrating sustainability into education is likely to fail. Tailored strategies are needed to address particular obstacles within different academic disciplines as well as in gender groups also. Recent research by Kacmaz and Dubé (2022) on educational competitions suggests that pedagogical approach is critical in this context; different types of mathematical knowledge (procedural vs. conceptual) are fostered by different designs, implying that customizing learning tools for specific faculties could help bridge these engagement gaps.

Furthermore, the faculty-based variations focused that the integration of SDG-related content is inconsistent across academic disciplines. This finding aligns with a recent systematic review by Su et al. (2023) which concluded that the integration of Education for Sustainable Development (ESD) in mathematics is still in its earlier periods resulted lacking consistency in learning content and pedagogy across various programs. Therefore, as Li (2025) argues for mathematics education acting as a driver for sustainability in the period of climate change, it must be stable for all disciplines.

CONCLUSION

This study reveals that mathematical knowledge enhances youth awareness of the SDGs, validating its role in sustainable development education. But awareness alone is not enough since leading by mathematical literacy to global impact, youth must be supported by enabling environments that encourage participation, nurture remarkable activity and embed sustainability into institutional practice in real world. This study fills a significant research gap by providing empirical evidence on the role of mathematical knowledge in youth empowerment for sustainable development.

This study includes only a quantitative research design. It would be better if it included a mixed-methods research design. It involves structured research tools to collect the data. It would be more reliable if included unstructured research tools. The quantified result may not include the entire ideas of the respondents to reach the reliable and relevant findings.

Since education systems must not only deliver content but it should also create opportunities for practical engagement-particularly through a lots of interdisciplinary projects and active learning policies. This leads to youth who can compete mathematically to empower youth not only for the content but to lead sustainable development initiatives in their communities.

RECOMMENDATIONS

The future researchers should include mixed method research design for their in-depth studies by including the students of other streams in other districts of Nepal. Furthermore, they should utilize both structured and unstructured data collection tools in their studies. This research findings emphasize to integrate sustainability frameworks into mathematics curricula to link knowledge with practical action, provide institutional support and participatory platforms to bridge the gap between SDG awareness and active youth engagement, adopt interdisciplinary teaching approaches to make sustainability education more comprehensive across various faculties by providing them with operative strategies and equitable opportunities.

REFERENCES

Adhikari, R. P., Nepal, B., Manandhar, D. C., Bhandari, R. B., Dahal, B., & Manandhar, N. (2024). The impact of teachers' qualifications on classroom performance: A comparative analysis. *A Peer Reviewed Journal on Social Science, 2*(2), 33-44. https://doi.org/10.3126/aprjss.v2i2.77488

Alam, S. S., Wen, R., Kacmaz, G., Eyyi, R., & Dubé, A. K. (2025, April 29). An investigation of the mathematics applications in the apple app store: Do they contain benchmarks of educational quality? *Journal of Research on Technology in Education*, 1-17. https://doi.org/10.1080/15391523.2025.2493941

Alsina, Á., & Mulà, I. (2019). Advancing towards a transformational professional competence model through reflective learning and sustainability: The case of mathematics teacher education. *Sustainability, 11*(15), 1-17. https://doi.org/10.3390/su11154039

Assalihee, M., & Boonsuk, Y. (2023). Teaching management strategies on 21st century Islamic education for southernmost Thai private Islamic schools. *Anatolian Journal of Education, 8*(1), 13-28. https://doi.org/10.29333/aje.2023.812a

Bachmann, N., Tripathi, S., Brunner, M., & Jodlbauer, H. (2022). The contribution of data-driven technologies in achieving the sustainable development goals. *Sustainability, 14*(5), 2497. https://doi.org/https://doi.org/10.3390/su14052497

Bartell, T. G. (2013). Learning to teach mathematics for social justice: Negotiating social justice and mathematical goals. *Journal for Research in Mathematics Education, 44*(1), 129–163. https://doi.org/10.5951/jresematheduc.44.1.0129

Becker, G. S. (1993). *Human capital: A theoretical and empirical analysis with special reference to education.* The University of Chicago Press.

Boaler, J. (2016). Mathematical mindsets unleashing students' potential through creative mathematics, inspiring messages and innovative teaching. Jossey-Bass A Wiley Brand.

Bron, J. F., & Prudente, M. S. (2025). Enhancing mathematical creativity, self-efficacy, and problem-solving. *Anatolian Journal of Education, 10*(2), 51-70. https://doi.org/10.29333/aje.2025.1025a

Browning, M. H., & Alessandro, R. (2019). School green space and its impact on academic performance: A systematic literature review. *International Journal of Environmental Research and Public Health, 16*(3) https://doi.org/10.3390/ijerph16030429

Bulut, N., & Borromeo Ferri, R. (2025). Bridging mathematical modelling and education for sustainable development in pre-service primary teacher education. *Education Sciences, 15*(2), 248. https://doi.org/https://doi.org/10.3390/

Checkoway, B. N. (2011). What is youth participation? *Children and Youth Services Review, 33*(2), 340-345. https://doi.org/10.1016/j.childyouth.2010.09.017

Chuan, H. l., & Tsai, T.-L. (2021). Education for sustainable development in mathematics education: What could it look like? *International Journal of Mathematical Education In Science & Technology, 53*(11), 1-11. https://doi.org/10.1080/0020739X.2021.1941361

Ernest, P. (2020). Connecting humans to equations: A reinterpretation of the philosophy of mathematics. *Mathematical Thinking and Learning, 22*(1), 79-80. https://doi.org/10.1080/10986065.2019.1687155

Evers, B. A. (2018). *Why adopt the sustainable development goals? The case of multinationals in the colombian coffee and extractive sector* . International Public Management and Policy.

Ferguson, T., Roofe, C., & Cook, L. D. (2021). Teachers' perspectives on sustainable development: The implications of education for sustainable development. *Environmental Education Research, 27*(9), 1343–1359. https://doi.org/10.1080/13504622.2021.1921113

Fiorani, G., Chiper, R. A., & Gerio, C. D. (2025). A comparative exploration of youth participation in local sustainable development: insights from Italian metropolitan cities ; . *International Journal of Public Sector Management , 38*(3), 386-404. https://doi.org/10.1108/IJPSM-01-2024-0020

George, D., & Mallery, P. (2003). *SPSS for windows step by step: A simple guide and reference.* Allyn & Bacon.

Gravemeijer, K., Stephan, M., Julie, C., Lin, F.-L., & Ohtani, M. (2017). What mathematics education may prepare students for the society of the future? *Int J of Sci and Math Educ, 15*(1), 105–123. https://doi.org/10.1007/s10763-017-9814-6

Gutiérrez, R. (2013). The Sociopolitical turn in mathematics education. *Journal for Research in Mathematics Education, 44*(1), 37-68. https://doi.org/https://doi.org/10.5951/jresematheduc.44.1.0037

Gutstein, E. (2006). *Reading and writing the world with mathematics: Toward a pedagogy for social justice.* Routledge. https://doi.org/10.4324/9780203112946

Hembrough, T. (2025). Rural college students' eco-anxiety and attitude toward discussing environmental sustainability topics post-pandemic. *International Journal of Instruction, 18*(4), 477-498. https://doi.org/10.29333/iji.2025.18426a

Jainan, K., Nuangchalerm, P., & Putra, F. G. (2025). Effects of inquiry-based learning with peer-assisted technique on sixth-grade students' learning achievement in science. *Anatolian Journal of Education, 10*(2), 29-36. https://doi.org/10.29333/aje.2025.1023a

Jean, P. (1970). *Science of education and the psychology of the child.* New York, Orion Press.

Kacmaz, G., & Dubé, A. K. (2022, February). Examining pedagogical approaches and types of mathematics knowledge in educational games: A meta-analysis and critical review. *Educational Research Review, 35*, 100428. https://doi.org/https://doi.org/10.1016/j.edurev.2021.100428

Kaiser, G., & Sriraman, B. (2006). A global survey of international perspectives on modelling in mathematics education. *ZDM: the international journal on mathematics education, 38*(3), 302-310. https://doi.org/10.1007/BF02652813

Kanandjebo, L. N. (2024). Mathematics as a driver for sustainable development: Pre-service teachers' perspectives on awareness, challenges, and implications for teacher training . *Interdisciplinary Journal of Education Research, 6*(26), 1-17. https://doi.org/10.38140/ijer-2024

Kuznetsova, E., & Matytcina, M. (2018). A multidimensional approach to training mathematics students at a university: Improving the efficiency through the unity of social, psychological and pedagogical aspects. *International Journal of Mathematical Education in Science and Technology, 49*(3), 401–416. https://doi.org/10.1080/0020739X.2017.1363421

Li, H. C., & Tsai, T. L. (2021). Education for sustainable development in mathematics education: What could it look like? *International Journal of Mathematical Education in Science and Technology, 53*(9), 2532-2542. https://doi.org/10.1080/0020739X.2021.1941361

Li, H.-C. (2025). STEM education and sustainability: What role can mathematics education play in the era of climate change? *Research in Mathematics Education*, 1-23. https://doi.org/https://doi.org/10.1080/14794802.2025.2499813

Makar, K., Bakker, A., & Ben-Zvi, D. (2011). The reasoning behind informal statistical inference. *Mathematical Thinking and Learning, 13*, 152-173. https://doi.org/10.1080/10986065.2011.538301

Makramalla, M., Coles, A., Roux, K. l., & Wagner, D. (2025). Mathematics education for sustainable futures: A strengths-based survey of the field to invite further research action. *Educational Studies in Mathematics*. https://doi.org/https://doi.org/10.1007/s10649-025-10389-x

Manandhar, D. C., & Chhetri, R. (2023). Homegrown school meal is an integrated and sustainable day-meal program: A case of bagamati province in nepal. *A Journal of Provincial Development, 3*(1), 17. https://doi.org/10.13140/RG.2.2.30543.87204

Mohammed Tohit, N. F., & Haque, M. (2024). Empowering futures: Intersecting comprehensive sexual education for children and adolescents with sustainable development goals. *Cureus, 16*(7), e65078. https://doi.org/10.7759/cureus.65078

Nguyen, L. T., Cleveland, D., Nguyen, C. T., & Joyce, C. (2024). Problem-based learning and the integration of sustainable development goals. *Journal of Work-Applied Management*, 218-234. https://doi.org/https://doi.org/10.1108/JWAM-12-2023-0142

Nuringsih, K., & MN, N. (2021). The role of green entrepreneurship in understanding indonesia economy development sustainability among young adults. *Studies of Applied Economics, 39*(12), 1-13. https://doi.org/10.25115/eea.v39i12.6021

Nussbaum, M. C. (2000). *Women and human development.* Cambridge University Press.

OECD. (2018). *The future of education and skills education 2030.* OECD.

OECD. (2021). *Education at a Glance 2021: OECD Indicators.* OECD Publishing,. https://doi.org/10.1787/b35a14e5-en

Ogamba, I. K. (2019). Millennials empowerment: Youth entrepreneurship for sustainable development. *World Journal of Entrepreneurship, Management and Sustainable Development, 15*(3), 267-278. https://doi.org/10.1108/WJEMSD-05-2018-0048.

Rojas, D. G., Rangel, Y. N., & Mora, D. M. (2025). Implementing design thinking in stem education: A systematic review of trends and challenges. *International Journal of Instruction, 18*(4), 111-130. https://doi.org/10.29333/iji.2025.1847a

Sebhatu, S. P., & Enquist, B. (2022). Values and multi-stakeholder dialog for business transformation in light of the UN sustainable development goals. *Journal of Business Ethics, 180*, 1059-1074. https://doi.org/https://doi.org/10.1007/s10551-022-05195-x

Sen, A. (1999). *Development as freedom.* Oxford University Press.

Skovsmose, O. (1994). Towards a critical mathematics education. *Educational Studies in Mathematics, 27*, 35-57.

Steen, L. A. (2001). Mathematics and democracy: The case for quantitative literacy. The National Council on Education and the Disciplines.

Su, C. S., Díaz-Levicoy, D., Vásquez, C., & Hsu, C. C. (2023). Sustainable development education for training and service teachers teaching mathematics: A systematic review. *Sustainability, 15*(10), 1-20. https://doi.org/10.1007/978-3-319-45989-9_8

TEEB. (2020). *The economics of ecosystems and biodiversity: mainstreaming the economics of nature: A synthesis of the approach, conclusions and recommendations of TEEB.*

Thakuri, R. R. (2023). Fostering engaged pedagogical innovation for meaningful learning: A literature review. *Pragyaratna, 5*(1), 63-73. Retrieved July 5, 2025, from file:///C:/Users/Dell/Downloads/63-73+RamRaja%20(1).pdf

Thapa, B. K. (2025). Financial literacy and digital payment system in nepal. *Nepalese Journal of Management Research, 5*, 64-72. http://balkumaricollege.edu.np/journal

Tiwari, D. D. (2023). Factors affecting the achievement of students in mathematics. *Mathematics Education Forum, 8*(1), 11-23. https://doi.org/10.3126/mefc.v8i1.60473

Ulhoi, J. P., & Madsen, H. (1999). Sustainable development and sustainable growth: Conceptual plain or points on a conceptual plain? *Proceedings of the 17th International Conference of the System Dynamics Society "Systems thinking for the next millennium"*. Wellington.

UNESCO. (2017). *Education for sustainable development goals: Learning objectives.* UNESCO Publishing.

UNESCO. (2020). *Education for sustainable development: A roadmap.* UNESCO Publishing.

United Nations. (2015). *Transforming our world: The 2030 ajenda for sustainable development.* UN Publishing.

Vásquez, C., Alsina, Á., José Seckel, M., & García-Alonso, I. (2023). Integrating sustainability in mathematics education and statistics education: A systematic review. *Eurasia Journal of Mathematics, Science and Technology Education, 19*(11), 1-16. https://doi.org/https://doi.org/10.29333/ejmste/13809

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.

Widiati, I., & Juandi, D. (2019). Philosophy of mathematics education for sustainable development. *Journal of Physics: Conference Series, 1157*(2). https://doi.org/10.1088/1742-6596/1157/2/022128

Zaharrudin, N. Z., & Zakaria, A. (2021). Media and funding: A qualitative study of malaysian social welfare ngo's. *Environment-Behaviour Proceedings Journa, 6*(18), 11-17. https://doi.org/10.21834/ebpj.v7i19.3240

Zhao, S., & Abdullah, A. H. (2025). Enhancing Undergraduates' Creative Thinking through Mathematics Courses: A Systematic Literature Review.

Zimmerman, M. A. (2000). *Empowerment Theory: Psychological, Organizational and Community Levels of Analysis.* Boston: Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-4193-6_2