International Journal of Advanced and Applied Sciences, 11(2) 2024, Pages: 171-179

Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

Assessing higher education students' perception towards their engagement in pedagogical STEM approach

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ARTICLE INFO

Article history:
Received 3 September 2023
Received in revised form
6 January 2024
Accepted 30 January 2024

Keywords:
Higher education
STEM
Pedagogy
Student

ABSTRACT

This study focuses on evaluating university students' views on their involvement in STEM (science, technology, engineering, and mathematics) teaching methods. The aim was to explore the various factors that affect students' participation in these educational approaches. The research looked at how teaching methods, the use of technology, teamwork, interaction, motivation, and interest all play a role in engaging students with STEM education. Using a descriptive, cross-sectional study design, data were gathered from an online survey completed by 321 senior students from four universities in Mogadishu, selected through a non-random purposive sampling method. The data were analyzed using Smart PLS-4's structural equation modeling (SEM) and SPSS 22.0 software. The results showed significant links between teaching methods, technology use, teamwork, interaction, motivation, interest, and student involvement in STEM education. The study disproved the initial hypotheses (H1, H2, and H3) with p-values of 0.006, 0.000, and 0.000, each below the standard threshold of 0.05. Based on these findings, the researchers suggest improving teaching methods, technology use, teamwork, interaction, motivation, and interest to boost student involvement in STEM education. These results are expected to help shape future STEM education strategies and offer important information for educators and policymakers to improve university settings and teaching methods to further increase student involvement in STEM subjects.

1. Introduction

STEM (science, technology, engineering, and mathematics) education refers to teaching and learning in science, technology, engineering, and mathematics, which usually comprises educational activities across all grade levels, from pre-school to post-doctoral, and in both formal and informal classroom settings (Kennedy and Odell, 2014). STEM education adopts an essential function: To provide students with the required skills and knowledge to meet the rapidly changing requirements of the contemporary workforce (Fairhurst et al., 2023). In this dynamic landscape, it is imperative to understand Somali higher education students' unique challenges and opportunities in their engagement with pedagogical STEM approaches.

To effectively engage students in STEM learning, instructors must employ various pedagogical approaches and teaching strategies that encourage active learning, critical thinking, problem-solving, and collaboration (Fairhurst et al., 2023). However, this becomes even more critical in the context of Somali higher education, given the specific challenges within the region that need to be considered. Some challenges to implementing effectively engaging STEM education include limited access to resources and equipment, inadequate infrastructure, and a shortage of qualified STEM educators. Thus, a pressing need exists to explore how higher education students in Somalia perceive their engagement in pedagogical STEM approaches. This research aims to assess higher education students' perceptions of their engagement in a pedagogical STEM approach, focusing on teaching strategies, technology integration, collaboration, interaction, motivation, and interest in STEM. The researchers proposed three hypotheses.

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https://doi.org/10.21833/ijaas.2024.02.018
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H1: Employing appropriate teaching strategies significantly impacts students' engagement in the pedagogical STEM approach.
H2: Technology integration significantly impacts students' engagement in the pedagogical STEM approach.
H3: Collaboration, interaction, motivation, and interest have a significant impact on students' engagement in the pedagogical STEM approach.

The authors constructed the research model shown in Fig. 1, which illustrates the relationship between the independent variable (teaching strategies, technology integration, collaboration, interaction, motivation, and interest) and the dependent variable (students' engagement in the pedagogical STEM approach).

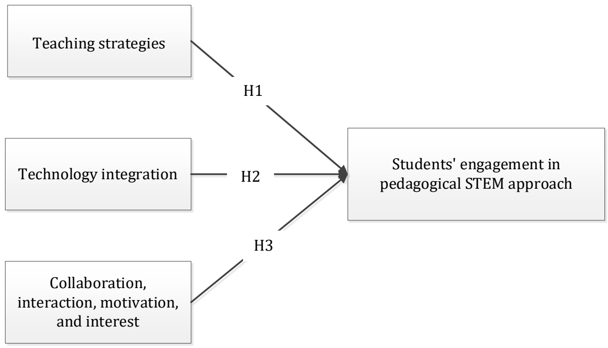

Fig. 1: Proposed research model

2. Literature review

2.1. Teaching strategies in STEM education

Effective teaching strategies are essential for engaging students in STEM education (Fairhurst et al., 2023). Traditional lecture-based teaching has limitations in promoting student engagement and active participation (Alaagib et al., 2019). As a result, educators have implemented inventive approaches such as inquiry-based learning, problem-based learning, project-based learning, and hands-on activities in STEM education (Amerstorfer and Münster-Kistner, 2021; Lin and Tsai, 2021). These strategies inspire students to explore real-world problems, apply scientific principles, and work collaboratively to find solutions.

Inquiry-based learning is an approach that involves posing questions, problems, or scenarios that require students to investigate and explore to find answers (Heindl, 2019). It encourages students to develop critical thinking, problem-solving, and scientific inquiry skills (Attard et al., 2021).

Problem-based learning is another strategy that promotes active engagement in STEM. In this approach, students are presented with authentic, real-world problems or challenges that require them to apply their knowledge and skills to find solutions (Amerstorfer and Münster-Kistner, 2021). By working collaboratively in groups, students deepen their understanding of STEM concepts and develop essential skills such as teamwork, communication, and creativity. Problem-based learning encourages students to think critically, make connections between different STEM disciplines, and develop practical problem-solving abilities (Smith et al., 2022).

Project-based learning is a teaching strategy involving students in extended, hands-on projects integrating multiple STEM disciplines. Students work on open-ended projects that require them to identify problems, propose solutions, and engage in prototype design, construction, and testing (Guo et al., 2020). Project-based learning allows students to apply their knowledge in authentic contexts, develop research and presentation skills, and experience the iterative nature of the engineering and design process (Shekar, 2014). This strategy fosters creativity, innovation, and a deep understanding of STEM concepts.

In addition to these specific strategies, hands-on activities play a crucial role in STEM education. Providing students with opportunities to engage in practical experiments, simulations, and manipulative tasks allows them to explore concepts and develop a concrete understanding of abstract ideas (Lin and Tsai, 2021). Hands-on activities can range from laboratory experiments to building models or conducting fieldwork. These activities promote student engagement, curiosity, and a deeper appreciation for the practical applications of STEM subjects.

Effective teaching strategies in STEM education move away from passive learning and prioritize active engagement, problem-solving, and collaboration.

2.2. Technology integration in STEM education

Technology is essential in enhancing STEM education by providing tools and resources that facilitate interactive and immersive learning experiences (Yang and Baldwin, 2020). Integration of technology, such as virtual simulations, computer modeling, data analysis software, and educational apps, can help students visualize abstract concepts, conduct virtual experiments, and engage in authentic scientific practices (Ali et al., 2022). Technology in STEM classrooms also fosters digital literacy and prepares students for the digital-age workforce (Baterna et al., 2020).

One significant advantage of integrating technology into STEM education is its ability to enable visualization of abstract concepts. Many STEM subjects involve complex and abstract ideas that can be challenging for students to comprehend solely through traditional teaching methods. However, technology offers visual representations, simulations, and interactive models to help students grasp these concepts more easily (Baterna et al., 2020). Another valuable aspect of technology integration in STEM is its capacity to facilitate virtual experiments and data analysis. Students can use computer modeling and simulation software to conduct experiments that might otherwise be impractical or unsafe in a traditional laboratory setting. These virtual experiments enable students to apply scientific methods, test hypotheses, and analyze data hands-on and risk-freely (Ali et al., 2022). By engaging in these virtual experiments, students can develop their scientific inquiry skills, learn how to collect and interpret data, and better understand the scientific process (Hamed and Aljanazrah, 2020). In conclusion, integrating technology in STEM education provides numerous advantages for students and educators.

2.3. Collaboration, interaction, motivation, and interest in STEM education

Collaboration and interaction among students are crucial aspects of STEM education. Collaborative learning environments promote teamwork, communication, and the exchange of ideas (Wang et al., 2022). When students work together on STEM projects, they develop problem-solving and critical-thinking skills, learn from each other's perspectives, and experience the social aspect of scientific inquiry (Chen et al., 2019). Moreover, fostering students' motivation and interest in STEM subjects is vital to sustain their engagement and encourage long-term learning. Collaboration promotes teamwork skills, which are essential in STEM fields. By engaging in collaborative STEM projects, students learn how to communicate effectively, delegate tasks, and leverage the strengths of their peers to achieve common goals (Hamed and Aljanazrah, 2020). These experiences cultivate crucial teamwork and collaboration skills to serve them well in their future STEM careers.

In addition to collaboration and interaction, fostering students' motivation and interest in STEM subjects is essential to sustain their engagement and encourage long-term learning (Bayanova et al., 2023). Educators can enhance students' motivation and interest in STEM by incorporating various strategies, and one approach is to make connections between STEM subjects and real-world applications (Roberts et al., 2018).

In conclusion, collaboration, interaction, motivation, and interest are crucial components of effective STEM education. By promoting collaborative learning environments, educators can cultivate teamwork, communication, and critical-thinking skills in students.

2.4. Student engagement in the pedagogical STEM approach

Engagement refers to students' involvement, interest, and active participation in the learning process (Bayanova et al., 2023). In STEM education, student engagement encompasses their willingness to explore STEM topics, interest in pursuing STEM careers, and overall enthusiasm for STEM teaching (Struyf et al., 2019).

Educators can employ various pedagogical approaches to foster student engagement in STEM (Holmes et al., 2021). Creating hands-on and inquiry-based learning opportunities allows students to actively explore STEM concepts and engage in problem-solving activities (Yang and Baldwin, 2020). Additionally, incorporating technology, multimedia, and interactive tools in STEM instruction can increase students' engagement by making the learning experience more interactive and dynamic (Kärkkäinen and Vincent-Lancrin, 2013).

Furthermore, promoting a supportive and inclusive learning environment is crucial for student engagement in STEM (Fairhurst et al., 2023). Encouraging collaboration, peer interaction, and open discussions allows students to learn from each other, share their perspectives, develop a sense of belonging, and enhance their active engagement in STEM subjects (Kärkkäinen and Vincent-Lancrin, 2013). High levels of engagement in STEM are associated with improved academic performance, increased retention rates, and enhanced problem-solving abilities (Kazu and Kurtoglu Yalcin, 2021).

Engaged students in STEM demonstrate a willingness to explore and investigate STEM topics. They actively seek opportunities to learn and discover new knowledge in these fields. They are curious about the world and intrinsically motivated to understand how things work. This curiosity-driven approach encourages students to ask questions, conduct research, and engage in hands-on activities, fostering a deeper understanding of STEM concepts and principles (Borg Preca et al., 2023). Moreover, high levels of engagement in STEM education are closely linked to students' interest in pursuing STEM careers (Rivera and Li, 2020). By examining the impact of teaching strategies, technology integration, collaboration, interaction, motivation, and interest on students' engagement, this study seeks to identify effective practices and recommendations for promoting meaningful STEM learning experiences.

3. Research method

3.1. Participants and sample

In Mogadishu, Somalia, a survey was conducted involving both private and public universities using a pre-tested questionnaire. This investigation utilized a non-probability sampling technique known as purposive sampling, as outlined by Creswell and Creswell (2017). The study targeted senior students from a range of faculties at various universities in Mogadishu who voluntarily consented to participate. A total of 321 questionnaires were distributed to four prestigious universities in Mogadishu, and all 321 questionnaires were completed appropriately.

3.2. Data analysis

The collected data were subjected to quantitative analysis utilizing SmartPLS-4 for Structural Equation Modeling (SEM) and SPSS 22.0. Construct validity was employed as a means of validating the instrument. To assess the research model as depicted in Fig. 1, data analysis was performed using the Partial Least Squares (PLS) method, with the analysis conducted using the Smart PLS 4.0 software package for this specific purpose. This software can manage non-normal data and provide a complete solution for models (Hair et al., 2020). This was also influenced by the small sample size, which can affect the activity aspects of SEM. For example, when employing PLS-SEM to model estimation, the sample size is typically much smaller, regardless of whether the model is complex (Bagozzi and Yi, 2012). To analyze data and evaluate the research model, Smart PLS software application V3.2.7 was utilized. In this study, the measurement and structural models were estimated based on the validation and verification of the research model. Construct validity (convergent and discriminant validity) was examined to evaluate the measurement model. Convergent validity was used to evaluate three standard conditions of validity, namely internal consistency (Composite Reliability CR), indicator reliability (indicator factor loadings), and convergent validity (AVE) (Bagozzi and Yi, 2012). According to recommendations, indicator loadings should exceed 0.5, CR should exceed the minimum of 0.7 (Henseler et al., 2016), and the AVE of each construct should account for more than 50 percent of the variance (Fornell and Larcker, 1981). Due to the low value of their scales, a few items were omitted from this validation procedure when validating the Composite Reliability's values or when the factor loadings were weak, with loadings of less than 0.5. The reliability analysis is complete when the CR exceeds the minimum of 0.70 (Hair et al., 2011).

4. Results and discussion

4.1. Demographics of respondents

The respondents' characteristics are listed in Table 1. Males (71.1 %) were marginally higher than females (29.9 %), reflecting the gender ratio of students in Somali higher education institutions. The majority of respondents (48.6%) were aged 24 to 26. This is because, over the past few years, many secondary school students have enrolled in colleges and universities. Approximately 81.3% of students major in science.

Table 1: Demographics of respondents

Variable	Response category	Frequency	Percent (%)
Gender	Female	96	29.9
	Male	225	71.1
Age	21-23 years	90	28.0
	24-26 years	156	48.6
	27+ years	75	23.4
Specialization	Arts	60	18.7
	Science	261	81.3
Institution	SIMAD University	117	36.4
	Somalia International University	45	14
	University Somalia	51	15.9
	Zamzam University	108	33.6

4.2. Assessment of measurement model

The measurement model was subjected to analyses of convergent and discriminant validity. Based on the outcome of the data analysis, convergent validity was attained, as evidenced by the factor loadings of the items, which displayed loadings greater than 0.60. Cronbach's Alpha and Composite Reliability were used to assess Construct Reliability. Each study construct's Cronbach's Alpha exceeded the minimum threshold of 0.70 (Henseler et al., 2016). Composite reliabilities ranged between 0.850 and 0.890, exceeding the 0.70 threshold (Henseler et al., 2016).

Consequently, construct reliability was established for each study construct. Using the Average Variance extracted, the convergence validity of scale items was estimated as the average variance-extracted values exceeded the 0.50 threshold (Fornell and Larcker, 1981). Therefore, the scales utilized in this investigation possess the necessary convergent validity. Table 2 and Fig. 2 provide an overview of the results of the analyses.

According to Hair et al. (2011), discriminant validity is the degree to which a construct is empirically distinct from other constructs (Table 3). The authors highlighted three techniques for assessing discriminant validity: (1) The Fornell and Larcker (1981) criterion, (2) Cross-Loadings, and (3) the Heterotrait-Monotrait Ratio (HTMT), which serves as a new criterion for assessing discriminant validity, according to Hair et al. (2014) HTMT was able to identify the possibility of discriminants among the correlations (values) of indicators across constructs. There is a concern with the discriminant validity if values for HTMT are close to 1. Some investigations suggested a threshold of 0.868 (Hair et al., 2014), whereas other authors proposed a value of 0.90 (Gold et al., 2001).

The structural model is estimated using partial least squares (PLS) V3. The structural model is the second step of SEM, which covers the model's predictive capabilities through R2, which values the goodness of fit model and helps in knowing the relationships among hypothetical constructs. If the outer model (measurement model) is reliable, a valid assessment permits an evaluation of the inner path model's (structural model) estimates. The bootstrapping procedure was used to examine the path coefficients, T-statistics, and significance values by employing 5000 subsamples (Hair et al., 2017). When the absolute value of t is more significant than 1.96, the significance level should be 0.05. Table 4 presents the results of the research hypothesis tested.

Table 2: Results of the measurement model

Construct	Item	Factor loading	Cronbach's alpha (α)	Composite reliability (CR)	The average variance extracted (AVE)
Teaching strategies	TS1	0.826	0.882	0.890	0.914
	TS2	0.868			
	TS3	0.857			
	TS4	0.841			
	TS5	0.728			
Technology integration	TI1	0.820	0.863	0.867	0.907
	TI2	0.819			
	TI3	0.858			
	TI4	0.869			
Collaboration, interaction, motivation, and interest	CIMI1	0.810	0.845	0.850	0.890
	CIMI2	0.780			
	CIMI3	0.741			
	CIMI4	0.787			
	CIMI5	0.808			
Students of engagement in pedagogical STEM	SEPS1	0.817	0.863	0.867	0.907
	SEPS2	0.737			
	SEPS3	0.723			
	SEPS4	0.792			
	SEPS5	0.772			

TS: Teaching strategy; TI: Technology integration; CIMI: Collaboration, interaction, motivation, and interest; SEPS: Students' engagement in pedagogical STEM

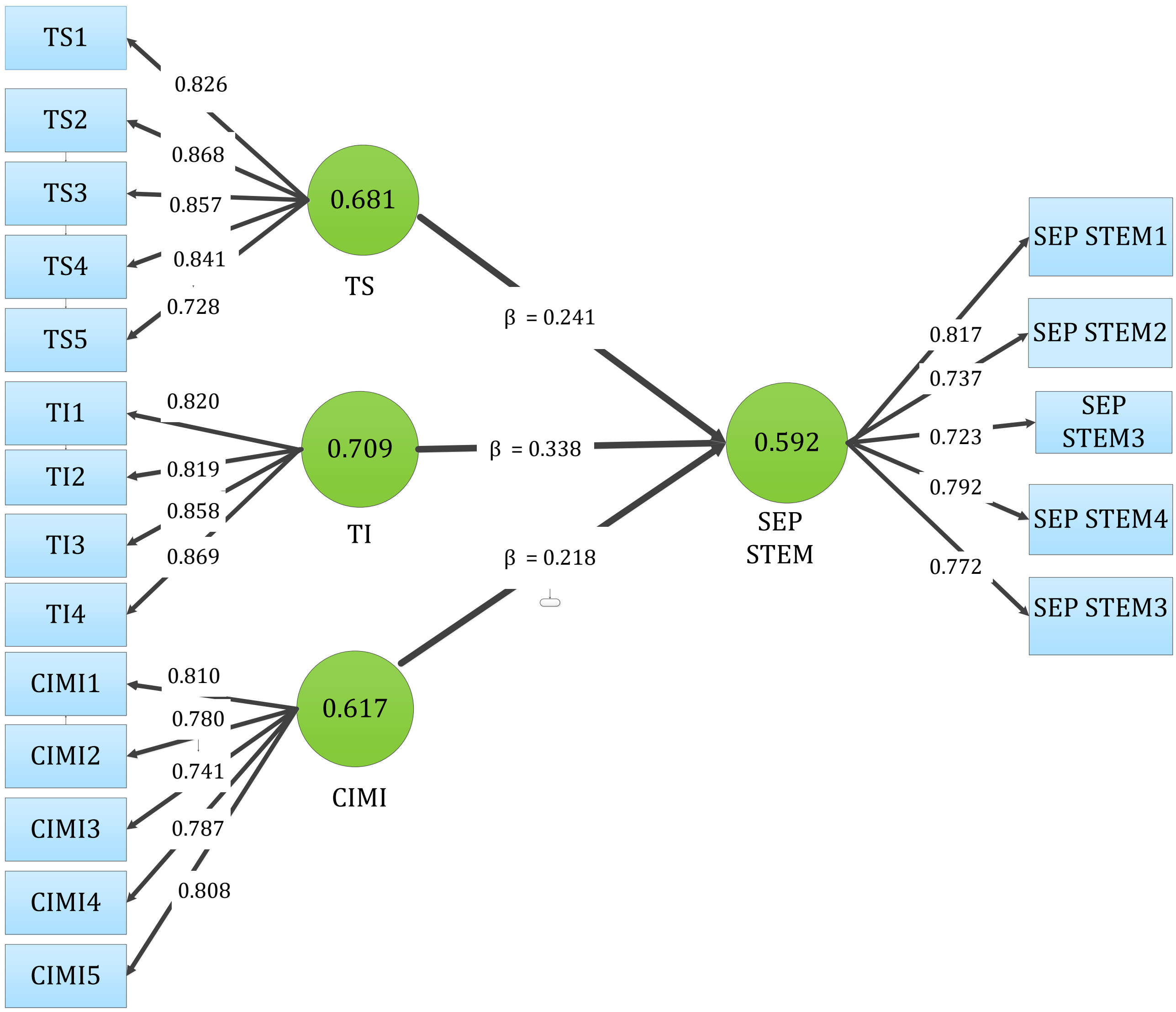

Fig. 2: Results of path analysis

Table 3: Discriminant validity using Heterotrait-Monotrait ratio (HTMT)

	CIMI	SEPS	TI	TS
CIMI				
SEPS	0.612			
TI	0.619	0.734		
TS	0.591	0.699	0.868	

TS: Teaching strategy; TI: Technology integration; CIMI: Collaboration, interaction, motivation, and interest; SEPS: Students' engagement in pedagogical STEM

4.3. Hypothesis test

As the significance threshold, researchers used p=0.05. The three hypotheses have been confirmed based on the values of the standardized path coefficients presented in Table 4 and Fig. 3. Using the bootstrap procedure, the output of a structural model was obtained. The path coefficient in PLS-SEM serves as a standardized regression coefficient (beta) to evaluate the structural model and hypothesis. It emphasizes the direct relationship between an independent variable and a dependent variable. The bootstrapping method was applied to 5000 subsamples to determine the applicability of path coefficients. Significant relationships satisfy the path-coefficient condition and have a p-value less than 0.05.

Table 4: Summary of hypothesis testing

Hypothesis	Path	(β)	T-V	P-V	Results
H1	TS -> SEPS	0.241	2.724	0.006	Supported
H2	TI -> SEPS	0.338	3.675	0.000	Supported
H3	CIMI -> SEPS	0.218	2.751	0.006	Supported

TS: Teaching strategy; TI: Technology integration; CIMI: Collaboration, interaction, motivation, and interest; SEPS: Students' engagement in pedagogical STEM

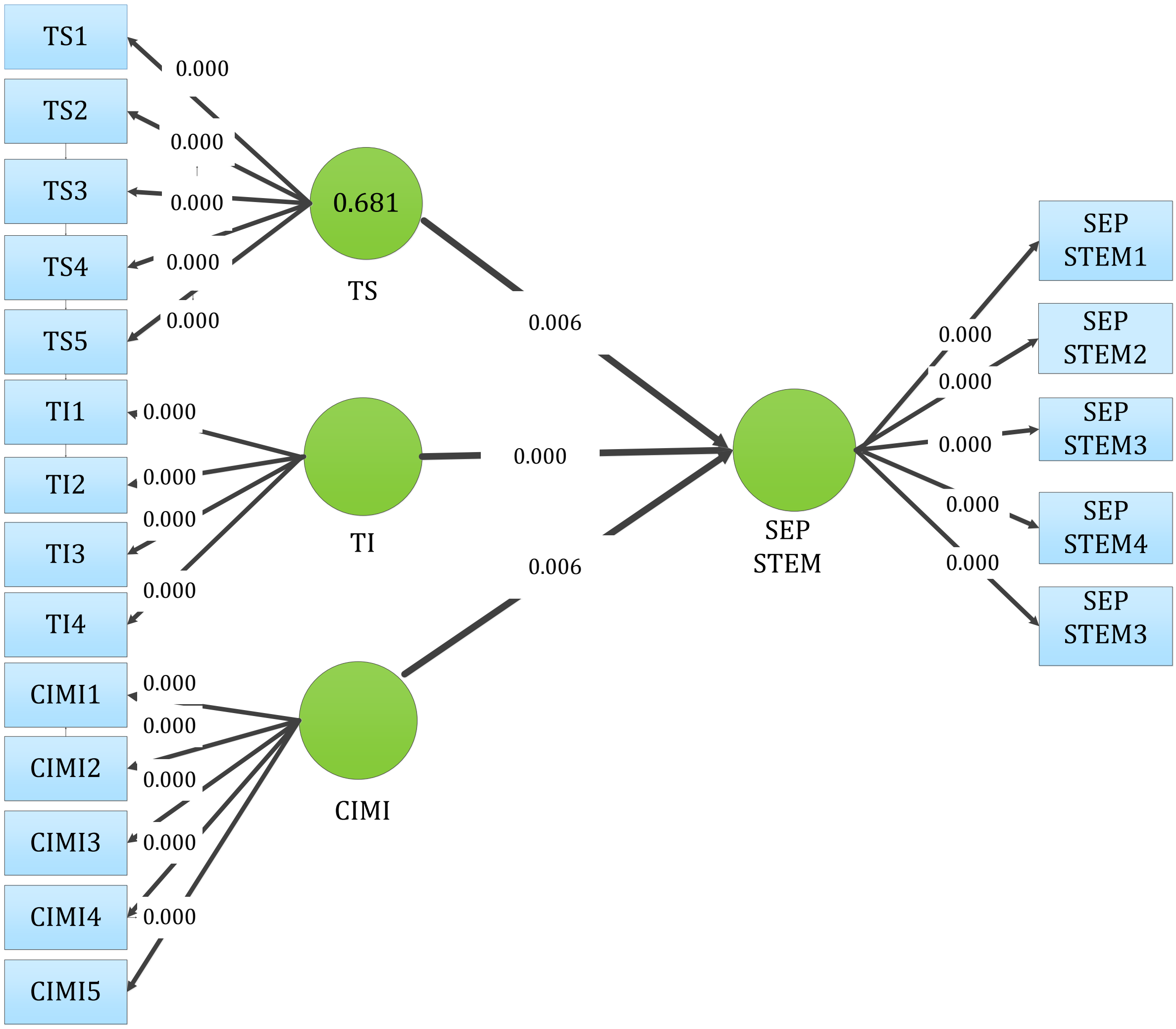

Fig. 3: Test of path analysis

The interpretation of p-value, t-statistics, path coefficient, and 5% significance level are shown in Table 4 and Fig. 3. This study provided general support for three hypotheses. The finding that the TS of Employing an appropriate teaching strategy substantially affects students' engagement in pedagogical STEM approach SEPS supports Hypothesis 1 (β=0.241, t-statistic=2.724, p=0.006). In this case, TI significantly impacts students' engagement in the pedagogical STEM approach. SEPS supports Hypothesis 2. TI (β=0.338, t-statistic=3.675, p=0.000) and Hypothesis 3 are supported by the finding that the CIMI of Collaboration, interaction, motivation, and interest has a substantial impact on students' engagement in pedagogical STEM approach SEPS (β=0.241, t-statistic=2.724, p=0.006). As all p-values are less than 0.05, the H1, H2, and H3 hypotheses are deemed valid.

4.4. Discussion

This study aimed to determine the primary factors influencing higher education students' perceptions of their engagement in pedagogical STEM approaches in Mogadishu, Somalia. As mentioned, the presented hypotheses were examined using SEM analysis. As depicted in Fig. 2, the results of this study confirmed and demonstrated the significance of three hypotheses: Teaching Strategy (TS) (H1), Technology Integration (TI) (H2), and Collaboration, interaction, motivation, and Interest (CIMI) (H3). The findings confirmed all hypotheses.

According to the statistical calculation summarized in Table 4, employing appropriate teaching strategies in higher education significantly positively affects student engagement in STEM pedagogy. The T-statistics value of 2.724 and the P-values value of 0.006 indicate that the significance level is less than 0.05. This indicates that the first hypothesis (H1) is accepted, as this case is consistent with prior research findings (Bhargava and Pathy, 2014). Therefore, teaching strategies in higher education have a significant positive effect on student engagement in STEM pedagogy. Based on the statistical calculation summarized in Table 4, it is possible to conclude that Technology integration expectations are significant predictors of student engagement in STEM pedagogical approaches. The T-Statistics value of 3.675 and the P-Values value of 0.000, which is less than 0.05, demonstrate this. The second hypothesis (H2) is therefore adopted. This study's conclusion corroborates the findings of the previous investigation by Kazi and Akhlaq (2017) and Shohel and Banks (2012). The expectations for technology integration are significant predictors of student engagement in STEM pedagogical approaches. Based on the statistical calculation summarized in Table 4, it can be concluded that collaboration, interaction, motivation, and interest expectations are strong predictors of student engagement in STEM pedagogical approaches. The T-Statistics value of 2.75 and the P-Values value of 0.006, which is less than 0.05, demonstrate this.

Consequently, the third hypothesis (H3) is adopted. This study's conclusion corroborates the findings of the previous investigation by Kazi and Akhlaq (2017) and Shohel and Banks (2012). Collaboration, interaction, motivation, and interest expectations significantly predict students' STEM pedagogical engagement.

This study has notable implications for advancing STEM education, underscoring the pivotal roles played by teaching strategies, technology integration, and collaborative motivational elements in enhancing student engagement in STEM pedagogy. These findings stress the significance of tailoring educational approaches to foster active participation in STEM subjects, thus contributing to the overall quality of STEM education.

The study's limitation lies in its regional specificity, focusing only on the students of higher education institutions in Mogadishu. Future research should encompass various regions within the country to mitigate this limitation and gain a more comprehensive understanding of students' perceptions towards their engagement in the pedagogical STEM approach.

5. Conclusions

The purpose of the present study was to investigate the effect of teaching strategies, technology integration, collaboration, interaction, motivation, and interest on students' engagement in STEM pedagogical approaches. The results indicated that the teaching strategies of Higher Education, Technology integration and Collaboration, interaction, motivation, and interest are essential predictors of attitudes regarding the influence of the STEM pedagogical approach on students' engagement. The results are consistent with prior research indicating that these three dimensions are the most important predictors of student engagement in STEM pedagogical approaches. Consequently, the relational model generated and supported by PLS analysis is amenable to further investigation utilizing other constructs. The research is conducted exclusively at Mogadishu higher education, limiting our findings' generalizability. Different regions may yield different results, so further research in diverse settings is warranted to validate the robustness of our conclusions. Additionally, our study focused on a specific set of factors, as well as other variables or contextual elements that may influence student engagement in STEM pedagogical approaches. Future research should consider a broader range of factors and settings.

To enhance student engagement in pedagogical STEM, we recommend diversifying teaching methods, incorporating technology, promoting collaboration, motivating students through tailored curricula, improving educational facilities, and focusing on teacher training and development. When taken together by educators and policymakers, these actions can strengthen STEM education, leading to increased student engagement and success in these critical fields.

Acknowledgment

The authors thank the Center of Research and Development of SIMAD University for funding this study under the Research Grant Scheme (Revitalizing stem education in post-conflict Somalia: the role of higher education in developing hands-on and experiential learning opportunities) with Grant No: SU-STEM-2023-005. The authors also thank all the respondents of this research.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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