

Enhancing Student Motivation and Competencies: Integrating E-Learning, Technological Literacy, and Cultural Alignment

Boumedyen Shannaq^{1*} , Imran Saleem¹, Said AlRawahi¹, Saad Almhlawi¹,
Said AlMaqbali¹

¹ University of Buraimi, Al Buraimi 512, Sultanate of Oman.

Abstract

This study explores the integration of open innovation in education with a focus on technology and cultural aspects, aiming to foster improvements in educational management and policy within Oman learning environments. The research investigates the relationships between technological literacy (TL), cultural compatibility (CC), human face-to-face communication methods (HFtFCM), and student motivation and engagement (SMaE). A survey was conducted among 1,436 Oman students, and the data were analyzed using partial least squares and structural equation modeling to assess the moderating effects of TL and CC on these relationships. Results indicate that incorporating TL and CC as moderators significantly strengthens the mediation framework, enhancing the connection between HFtFCM and student perception of communication effectiveness (SPoCE). Specifically, the p-value decreased from 0.11 to 0.005, highlighting increased statistical significance, and the path from HFtFCM to SPoCE to SMaE improved from -0.051 to 0.071, demonstrating a stronger mediation effect. Conversely, the indirect effect from Technology-Based Communication Methods (TBCM) to SPoCE to SMaE decreased from 0.047 to 0.008. Additionally, notable paths such as TL → SPoCE and CC → SPoCE emerged, illustrating the enhanced explanatory power of these moderators. Conclusion: These findings underscore the potential of TL and CC to elevate student engagement and communication effectiveness, offering valuable insights for educational policy development and leadership programs.

Keywords:

Omani Student Competencies;
Emerging Technology;
Cultural Compatibility;
Technological Literacy;
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1- Introduction

In many ways, the shape of present-day educational systems is profoundly different from the past. Today's educational programs were mostly designed from a western perspective and are now beginning to be adjusted to be specific context. As a result, there are new technological tools and curricula designed to capture, enhance, and relate to the cultural context of our students [1]. However, in the Arabian Gulf and the Middle East region, especially in local universities of Oman, newly added courses, taught fundamentally in the same format as western curricula, have not yet satisfied the needs of our students. Additionally, culturally altered degrees related to regional demand are not widely accepted or acknowledged. We have observed a constant decrease in student motivation to learn new subjects and an increase in academic dishonesty. On the other hand, new cutting-edge industries are on the rise that require specific advanced-level technologies, and there simply is not enough expertise or enough training capabilities in the local area.

Therefore, the problem addressed by this study is increasing the motivation and competencies of our Omani students in substantial technical and engineering areas along with easy and early access to and practice in their future

* **CONTACT:** boumedyen@uob.edu.om

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professional capabilities. The key research question should address the problem within the environment of an evolving education system, social pressures, and producing graduates who are easily employable. The purpose of this research is to create a model to investigate how to enhance the intrinsic motivation and retention rate of Omani students in management, technical and engineering educational programs. Revisiting the culture where these students come from does allow better paths to foster upward mobility of rising professionals. Integrating technological advancements and aligning the local culture of learning will better address the motivational aspects of this study [2-4]. In most Arab countries, technology-based communication methods are the most modern way of teaching, alongside some countries that adopted the e-learning system [5-8]. In the past, high-frequency technology-based communication methods were the only method of teaching, upon which students could rely to ask questions and receive answers from the teacher [9]. The teacher was the only source of information [10]. With the various methods of learning becoming available, such as technology-based communication methods and high levels of technology, did these new methods impact Arab educational environments in terms of student motivation and engagement? If they did, in what manner and to what extent? Many scholars have studied the effect of technology-based communication and e-learning methods on the educational process [11-13]. This study is important to take into account the fact that Oman falls under the classification of developing countries.

1-1-Improving the Focus on Competency Acquisition through E-Learning Enhancement for Oman Vision 2040

The goal of the project role titled “National Mapping for Competence Development to Support Oman Vision 2040” is to build an effective knowledge society and a flexible workforce to meet Oman’s developmental agenda. The study “Enhancing Student Motivation and Competencies: This vision is well supported by a presented article titled “Integrating E-Learning, Technological Literacy, and Cultural Alignment” since it is based on important components that are necessary to maximize competency. Introducing e-learning has given technological improvement for learning as well as skills that are vital to forthcoming occupations. It focuses on incorporating e-learning tools into the educational system to encourage the motivated educational model supported by interactive and flexible learning environments proposed by the study. This is in line with Oman Vision 2040, which aims at producing innovation, critical thinking, and problem-solving in learners. In addition, the study emphasizes cultural relevance when using e-learning to attract the Omani culture and norms. The improvement of culturally appropriate content and the delivery of educational materials will increase the attractiveness of these solutions among the learners, and the latter will facilitate a wider set of applications of contemporary technologies in education. The combination of these factors enhances the determinant factors by improving motivation, technological competency, and cultural relevance to foster the role of higher learning institutions in transformative skills and mentalities for Oman's socio-economic development. This way and that, it is guaranteed that e-learning interventions do not only have academic imperatives; they also help to advance competency needs nationally.

In this way, this work combines cultural values and technologies to support the correlation of the educational reforms with Oman Vision 2040 while presenting a viable pattern for competency promotion for the countries of the Gulf region.

1-2- Research Problem

Importance of charismatic motivational leadership awareness in the learning process is growing among educational professionals globally. However, within the contingency leadership approach, TBCM presents a potential challenge to the conventional personalized leadership style, which is based on the personality dynamics and building human face-to-face relationship. A general move towards modern technology-based teaching in learning and education is increasingly utilizing modern communication technology for student-teacher interaction and for student motivation and engagement facilitation. This research identifies the problems, arguments, and dilemmas to be discussed and debated in the sphere of the identification and operation of TBCM versus HFtFCM and their impact on student motivation and engagement. The primary objective of the research is to develop specific TBCM recommendations for leadership and tools to better manage educational work within the evolving shape of innovative learning approaches and to enhance the validity of practical teaching applications. The interpretation of leadership attitudes related to motivation has been fractured, and no overall concept exists integrating motivation theory and leadership research. The recognized problems deriving from this gap in our understanding are that educational professionals often feel uncertain in their leadership approach and do not understand the influence of TBCM on student motivation.

1-3- Significance of the Study

This study is important as it fills a gap in the literature about the comparative effectiveness of Technology-Based Communication Methods (TBCM) and Human Face-to-Face Communication Methods (HFtFCM) in motivating and

engaging the students. Although prior research has established the former positive impacts of both TBCM and HFtFCM on students' learning, little is known about the possible disparity between these approaches across various educational settings and contexts. Thus, this study enriches the existing knowledge about the communication approach in teaching/learning processes and applies it to an Arab context.

Also, it is the initial method to attempt to assess the general applicability of TBCM and HFtFCM on the students' motivation and engagement level without an emphasis on the individual components of both paradigms. The results should provide an empirical starting point for further investigation for the next similar studies to investigate the potential role of other subcomponents of TBCM and HFtFCM as enablers and barriers to engagement for students. Focusing on whether one or another approach has been found to be more effective when used in specific educational settings, this research will be helpful to educators, policymakers, and scholars interested in improving instructional communication strategies in classrooms to facilitate meaningful engagement of learners.

1-4- Research Questions

- How might Human Face-to-Face Communication Methods be optimized so that students can better gauge the efficiency of communication (SPoCE)?
- How might the Human Face-to-Face Communication Methods (HFtFCM) be optimized to lead to greater same?

1-5- Research Objectives

- To select strategies that can enhance Human Face-to-Face Communication Methods (HFtFCM) for enhancing perception of communication effectiveness among students (SPoCE).
- To identify measures that can be applied in order to improve the practice of Human Face-to-Face Communication Methods (HFtFCM) with a view of increasing same.

1-6- Hypotheses

H₁: Technological Literacy (TL) positively and significantly moderates the relationship between Human Face to Face Communication Methods (HFtFCM) and Students' Perception of Communication Effectiveness (SPoCE).

H₂: Technological Literacy (TL) positively and significantly moderates the relationship between Human Face to Face Communication Methods (HFtFCM) and Student Motivation and Engagement (SMaE).

H₃: Cultural Compatibility (CC) positively and significantly moderates the relationship between Human Face to Face Communication Methods (HFtFCM) and Students' Perception of Communication Effectiveness (SPoCE).

H₄: Cultural Compatibility (CC) positively and significantly moderates the relationship between Human Face to Face Communication Methods (HFtFCM) and Student Motivation and Engagement (SMaE). Based on a review of the literature Figure 1 summarize the available variables and basic framework.

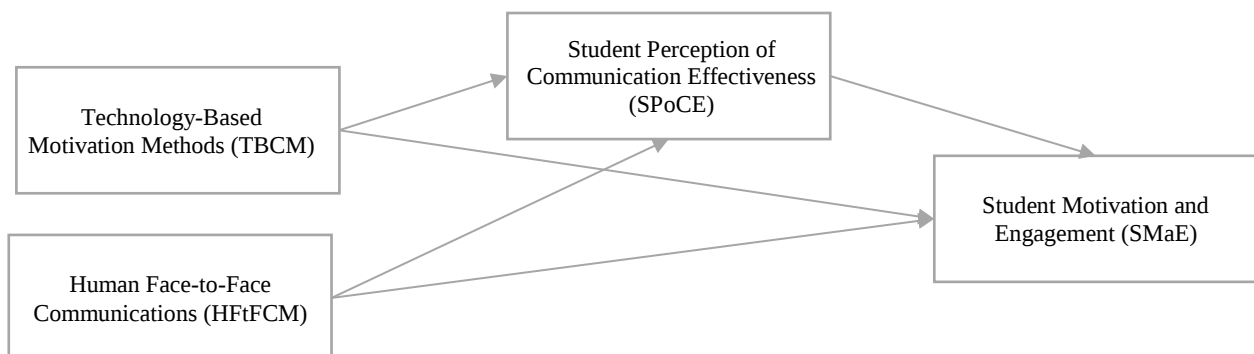


Figure 1. Literature summary of the available variables and basic framework

Many studies in the literature have found that Human Face-to-Face Communication Methods (HFtFCM) negatively impact students' perception of communication effectiveness (SPoCE) and student motivation and engagement (SMaE). To address this, our research introduces two moderators that could positively influence these relationships. As a result, we developed an updated conceptual framework, shown in Figure 2, which includes these two variables as moderators. The aim is to test whether Transformational Leadership (TL) and Cultural Context (CC) significantly and positively moderate the relationship between HFtFCM and both SPoCE and same.

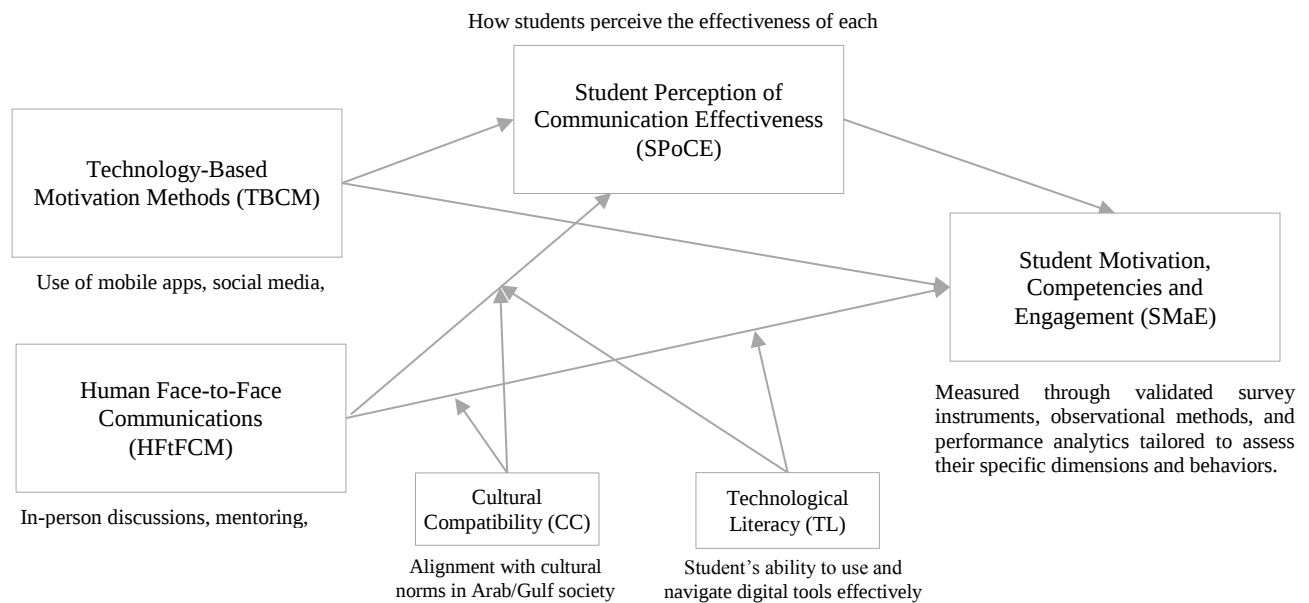


Figure 2. Updated conceptual framework by author

2- Background and Literature Review

While technology is increasing rapidly, educational institutions are obligated to prepare their students for these rapid technological advancements and increase student engagement and motivation [14, 15]. The human face-to-face communication methods, which may increase students' motivation and engagement, have greatly influenced education for many [16] years. On the other hand, there are various technology-based communication methods and virtual environments, which have been used at different academic levels for enhancing student interest [6, 17, 18]. However, few studies provide insight into the effectiveness of combining technology-based communication methods and human face-to-face communication methods in educational environments. According to the analysis of the components of face-to-face communication, socio-interaction can be described as a combination of spoken and gestural signals. Non-verbal communication includes physical movements of the hands and arms as well as facial expressions, pace and pattern of speech (paraverbal), and even posture. Facial and touch, as related to eye contact and skin contact, make people believe in each other, and proxemics, which is about how people manage space, shows their relation, power balance, and cultural background. Their equivalencies include active listening and facial gestures for feedback recognition from both involved individuals. In general, communication is a complex social process that reflects the interdependence of verbal, non-verbal, and cultural means used during an interpersonal exchange with a view to achieving the intended goals. The technological revolution accelerates learning and applies communication to replace traditional education's PROs and CONs. Course content delivery, communication, and student activity tracking are made easier by the course's content delivery systems and tools, such as Moodle, Blackboard, and Canvas. Online conferencing platforms like Zoom and Google Meet are used to replicate in-person instruction, and synchronous and asynchronous discussions like Reddit and Moodle help students participate. Skype and Google Docs: These tools provide access to a flexible learning environment.

Further, these tools offer flexible learning through Mobile Learning Application (Duolingo), Coursera- Students and teachers get the flexibility in learning. VLEs and AI-based feedback (like Turnitin) enhance learners' participation and provide individualized feedback. Whereas support for informal co-operation is provided by social media (Facebook, WhatsApp). In sum, these sophisticated instruments of technology enhance motivation, flexibility, and efficiency in learning processes of the current teaching systems.

Massive open online courses (MOOCs) face high dropout rates. This review examines how gamification, using elements like badges and leaderboards, improves student motivation and engagement and reduces dropout rates, based on 16 studies from 2014 to 2021 [19]. This study explores student engagement with educational technologies through a systematic review of 33 articles (2018–2022), focusing on gamification, online learning, and technology. It provides insights and highlights future research directions [11]. E-learning's rise due to the pandemic and technological advancements demands understanding factors that impact student success. This study examines how extrinsic (content, support) and intrinsic (innovativeness, self-efficacy) factors influence e-learning use, improving student learning and performance [20]. Some of the last studies examine the integration of problem-based learning (PBL) within the e-learning ecosystem, enhancing interaction and collaboration through ICT. Findings indicate improved learning outcomes and critical thinking, with 70% of students reaching Bloom's cognitive taxonomy Level C4 and above, supported by self-reflection processes [21]. The COVID-19 pandemic accelerated the shift to e-learning, emphasizing innovative teaching and sustainable learning. This study explores how academic motivation, e-learning tools, and

teaching practices enhance students' mental well-being. Findings show that higher motivation, better academic performance, and improved mental health among Chinese university students offer policy insights [22]. Mechanical concepts and formulas often challenge the students. We propose a method of combining modeling, numerical computation, and e-learning software to boost learning enthusiasm. Using automotive axles as a case, we developed visual materials and e-learning tools, significantly improving concept understanding and engagement, with over 85% acceptance rates [23]. This chapter explores persuasive technologies in education to boost learner participation, focusing on increasing interest through e-learning, mobile apps, and games. It highlights positive effects and challenges through case studies and practical approaches [24]. The pandemic spurred rapid growth in online learning platforms, yet 48.4% of students didn't complete their courses. Lack of interaction (36.7%) was the main barrier, though 37.1% completed their courses successfully [25].

This study examines challenges faced by Saudi and non-Saudi women in higher education, shaped by Vision 2030 and public sector growth. Barriers include social norms, nationality, and geography, highlighting women's resilience in navigating patriarchal systems and career advancement [26]. This Ph.D. study explores gender inclusivity in STEM higher education in Italy and China. Through expert interviews and policy analysis, it reveals inconsistencies in promoting gender equality, highlighting the need for enhanced focus, teaching methods, and long-term action frameworks [27]. This study develops and validates an ICT unethical behavior scale for undergraduates in Oman, showing strong measurement invariance across gender. Results suggest that minor gender differences, with females reporting higher ethical behavior than males [28]. This research creates and validates an ICT unethical behavior scale for Omani undergraduates, demonstrating strong measurement invariance by gender, revealing minor differences, with females exhibiting higher ethical behavior than males [29]. Distance education in Saudi Arabia is increasing female student enrollments, as e-learning offers equal opportunities. This study explores female perceptions of online courses with male instructors, highlighting the support for the challenges faced by them. The recommendations include faculty training for culturally specific contexts [30]. This study investigates challenges in implementing Computer-Assisted Language Learning (CALL) in Iran, identifying factors like computer knowledge, cultural background, and institutional support that hinder successful integration. Recommendations for policymakers and educators are discussed [31].

This study investigates biometric analytics and machine learning in online education, finding that CNN models effectively interpret cognitive states through eye-tracking and EEG data, enhancing student engagement and personalized learning experiences [32]. This paper utilizes UTAUT2 to analyze factors influencing student acceptance of online communication services during COVID-19, finding social influence, facilitating conditions, hedonic motivation, and habit positively impact behavioral intention [33]. Despite being key stakeholders, students' voices are often overlooked in education policymaking, leading to misalignment. This study examines Omani students' experiences with emergency remote teaching during COVID-19 for future planning [34]. This study investigates the role of companions during childbirth in Oman, highlighting their impact on the quality of care for pregnant women. Conducted at Sultan Qaboos University Hospital, findings reveal that companions, primarily mothers and husbands, provided vital emotional support, enhancing the laboring women's experiences and fostering a calmer atmosphere [35]. Before oil discovery, Oman was primarily rural, relying on agriculture. At Sultan Qaboos University, the Agricultural Mechanization department evolved into Agricultural Engineering, reflecting curriculum reforms, changing perceptions, and fluctuating student enrollments amid ongoing challenges in public image and program viability [36]. This chapter examines faculty perceptions of e-learning challenges during the COVID-19 pandemic at Middle East College, revealing barriers that hinder successful implementation and offering recommendations for overcoming these obstacles [37]. In general, the literature mentioned critical issues for the improvement of e-learning and other educational practices, namely, the issue of students' engagement, the application of new technologies into learning, and cultural factors. These findings are in rapport with the objective of the suggested study, which is to compare the effect of various means of communication on students' motivational and learning interests, which may provide additional information on teaching approaches.

3- Research Methods

To accomplish the above-stated research questions and to show the verification of the formed hypotheses, structural equation modeling through partial least square will be utilized. This type of sampling technique will enable this work to achieve a good fit and model for analyzing interactions between the independent communication methods, the dependent student motivation and engagement, and the moderating and mediating variables of cultural compatibility, technological literacy, and student perception of communication effectiveness. Figure 3 demonstrates the steps of the proposed Research Methods and Materials.

- **Problem Analysis:** The quantitative research starts with an analysis of the identified problem with a view to coming up with the issues of concern in the study context.
- **Literature Review:** Motivated by the research questions, a systematic literature search was done to aggregate theory, prior empirical evidence, and identified lacunae in the field of study.

- **Research Questions and Objectives:** Hence, according to the outlined literature, the following research questions and objectives are developed to direct the study.
- **Hypothesis Development:** The hypotheses are expected to represent the relationship of the variables in the conceptual framework spotlighted.
- **Conceptual Framework Design:** Conceptual model is constructed to depict the proposed flow of relations between variables that is based on theoretical literature and previous studies.
- **Implementation Using SmartPLS:** The conceptual framework is analyzed by applying the SmartPLS software for implementing the Partial Least Squares Structural Equation Modeling (PLS-SEM), which is appropriate for testing hypotheses based on the Fornell-Larcker test in this analysis when examining the complex relationships between constructs.
- **Measurement Model Application:** The measurement model is utilized to analyze the reliability and validity of each of the construct by Cronbach alpha, composite reliability, and average variance extracted.
- **Structural Model Application:** Using the structural model, the hypotheses are tested by researching the paths between the constructs and comparing the models fit with SEM indicators.

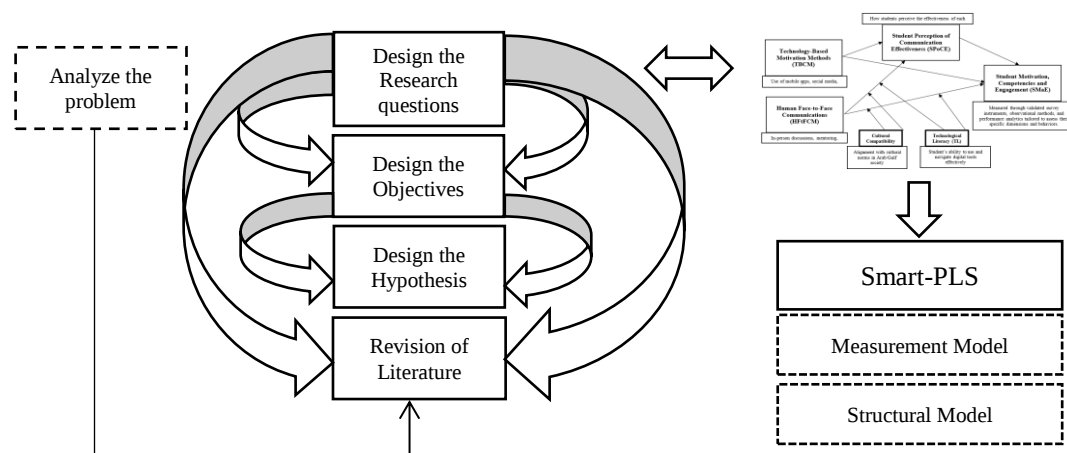


Figure 3. Research Methodology

3-1- Data Collection

For this study, a simple sample survey was chosen to facilitate the collection of reliable data (Appendix I). Students have been targeted with responses of 1436 participants thus ensuring that the collected sample covers those with disparate level of usage of E-Learning tools and extraverted cultural backgrounds.

3-2- Data Analysis

The data were further analyzed through SEM-PLS to check the impact strength and moderation tests.

3-3- Comparison of Communication Methods

The impact of HFtFCM and TBCM have been compared in relation to its impact to students' motivation/ engagement level with reference to the moderator, perception of communication effectiveness.

In this way, by implementing the technology supported communication means suitable for Omani cultural context, this study is to provide a viable strategy on how to enhance student interest and motivation, develop leadership abilities, competencies, and pave the way towards Omani students' future entrepreneurship rather than limiting them to public sector jobs.

4- Data Analysis and Results

4-1- Measurement Model: Validity and Reliability

The validity and reliability of the gathered data were evaluated using both Cronbach's Alpha and Composite Reliability (CR). The dataset initially included items with factor loadings less than 0.700, including all. Following that, all items below 0.700 were taken out of the dataset. Figures 4 and 5 show the procedure before and after removal, respectively. After a thorough testing process utilizing the Heterotrait-Monotrait Ratio (HTMT) and Average Variance

Extracted (AVE), the analysis resulted in the computation of Cronbach's Alpha and Composite Reliability. With their corresponding factor loadings, Table 1 displays the validity and reliability of the remaining items. There is a high degree of reliability evident in all alpha values and CR scores, which are above the suggested cutoff of 0.700. There was evidence of convergent validity since the AVE and CR values were both equal to or greater than 0.500 and 0.700, respectively. Because each item's factor loadings were higher than the corresponding cross-loadings, discriminant validity was established.

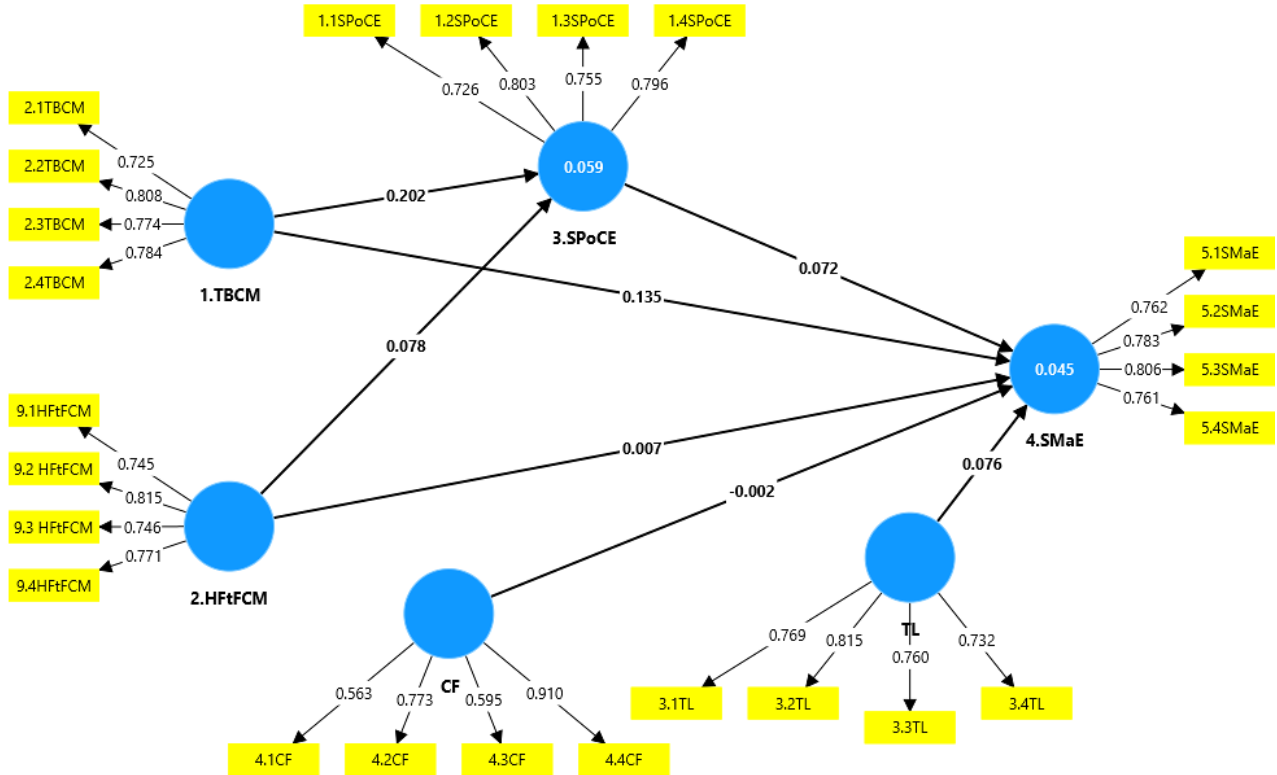


Figure 4. Factor loading (primary data)

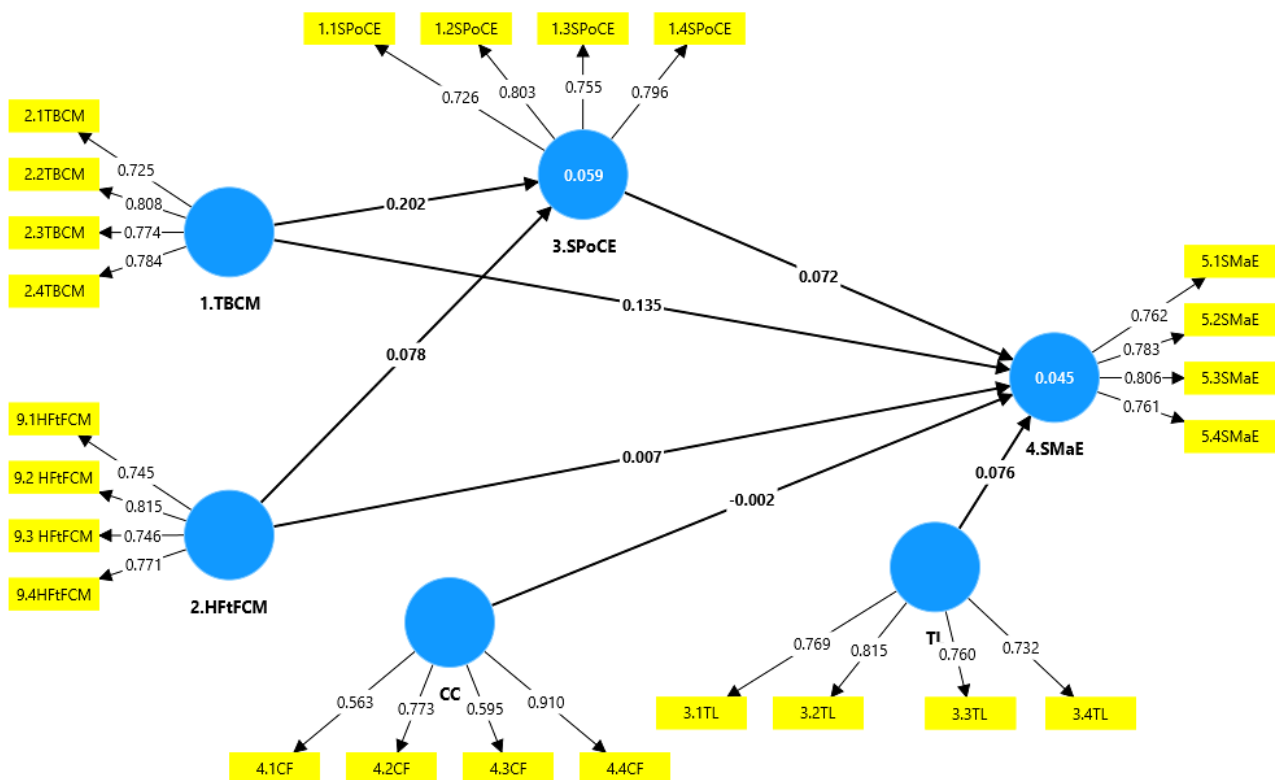


Figure 5. Factor loading (After removal: items < 0.07)

Table 1. Item loading, Reliability, and Validity

	Factor Loading	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Technology-Based Communication Methods (TBCM)		0.783	0.797	0.856	0.598
2.1TBCM $\leftarrow$ 1.TBCM	0.725				
2.2TBCM $\leftarrow$ 1.TBCM	0.808				
2.3TBCM $\leftarrow$ 1.TBCM	0.774				
2.4TBCM $\leftarrow$ 1.TBCM	0.784				
Human Face-to-Face Communication Methods (HFtFCM)		0.775	0.791	0.853	0.593
9.1HFtFCM $\leftarrow$ 2.HFtFCM	0.745				
9.2 HFtFCM $\leftarrow$ 2.HFtFCM	0.815				
9.3 HFtFCM $\leftarrow$ 2.HFtFCM	0.746				
9.4HFtFCM $\leftarrow$ 2.HFtFCM	0.771				
Student Perception of Communication Effectiveness (SPoCE)		0.779	0.799	0.854	0.594
1.1SPoCE $\leftarrow$ 3.SPoCE	0.726				
1.2SPoCE $\leftarrow$ 3.SPoCE	0.803				
1.3SPoCE $\leftarrow$ 3.SPoCE	0.755				
1.4SPoCE $\leftarrow$ 3.SPoCE	0.796				
Cultural Compatibility (CC)		0.78	0.801	0.809	0.524
4.1CC $\leftarrow$ CC	0.563				
4.2CC $\leftarrow$ CC	0.773				
4.3CC $\leftarrow$ CC	0.595				
4.4CC $\leftarrow$ CC	0.91				
Technological Literacy (TL)		0.774	0.795	0.853	0.592
3.1TL $\leftarrow$ TL	0.769				
3.2TL $\leftarrow$ TL	0.815				
3.3TL $\leftarrow$ TL	0.76				
3.4TL $\leftarrow$ TL	0.732				
Student Motivation and Engagement (SMaE)		0.785	0.795	0.86	0.606
5.1SMaE $\leftarrow$ 4.SMaE	0.762				
5.2SMaE $\leftarrow$ 4.SMaE	0.783				
5.3SMaE $\leftarrow$ 4.SMaE	0.806				
5.4SMaE $\leftarrow$ 4.SMaE	0.761				

Figure 6 shows that 4.1 CF (0.563) and 4.3 CF (0.595) are among the items in the construct factor (CF) that have factor loadings less than 0.700. Because of the items Variance Inflation Factor (VIF) values < 5 , demonstrated in Table 2. We did not however decide to exclude them. In addition, the factor loadings were changed to surpass the 0.700 threshold when we changed the direct link to the moderator.

Table 2. Collinearity statistics (VIF)-Inner model

	VIF
1.TBCM $\rightarrow$ 3.SPoCE	1.182
1.TBCM $\rightarrow$ 4.SMaE	1.382
2.HFtFCM $\rightarrow$ 3.SPoCE	1.182
2.HFtFCM $\rightarrow$ 4.SMaE	1.191
3.SPoCE $\rightarrow$ 4.SMaE	1.198
CF $\rightarrow$ 4.SMaE	1.137
TL $\rightarrow$ 4.SMaE	1.216

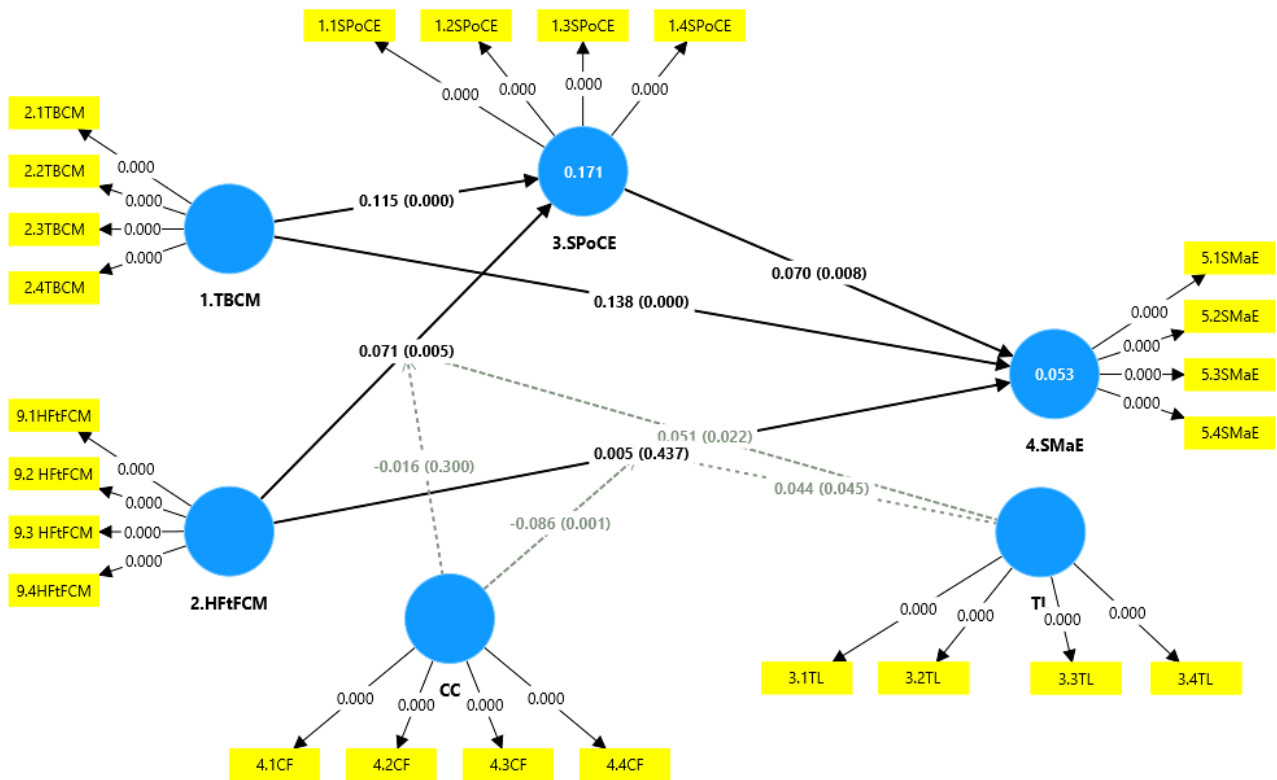


Figure 6. Bootstrapping implementation

Justification for Acceptance: These values were approved because the VIF shows that multi-collinearity is not a major issue, and the modifications made during the modeling phase imply that these elements can make a substantial contribution to the overall construct. Including them in the study upholds our criteria for assessing the validity of the model and increases the strength of our conclusions.

4-2- Validity Predictive

Table 3 presents the Fornell and Larcker criteria and Table 4 shows the Heterotrait-Monotrait ratio (HTMT) for discriminant validity. Consequently, discriminant validity gained more support and predictive validity was reaffirmed.

Table 3. Heterotrait-Monotrait ratio (HTMT)

	1.TBCM	2.HFtFCM	3.SPoCE	4.SMaE	CF	TL
1.TBCM						
2.HFtFCM	0.49					
3.SPoCE	0.258	0.185				
4.SMaE	0.22	0.1	0.144			
CF	0.126	0.091	0.428	0.051		
TL	0.477	0.15	0.293	0.174	0.202	

Table 4. Fornell & Larcker

	1.TBCM	2.HFtFCM	3.SPoCE	4.SMaE	CF	TL
1.TBCM	0.773					
2.HFtFCM	0.392	0.77				
3.SPoCE	0.232	0.157	0.771			
4.SMaE	0.184	0.081	0.122	0.778		
CF	0.133	0.074	0.331	0.055	0.724	
TL	0.38	0.122	0.239	0.146	0.18	0.769

Explanation of Table 3: Heterotrait-Monotrait Ratio (HTMT). The HTMT ratio scrutinises the discriminant validity in Structural Equation Modeling (SEM) to confirm that the constructs are unique. All HTMT values in Table 3 are below 0.85, providing support for discriminant validity. Key Observations: TBCM (Technology-Based Communication Methods): TBCM is correlated moderate with TL ($r=0.477$) and low with HFtFCM ($r=0.49$) and SPoCE($r=0.258$). HFtFCM (Human Face-to-Face Communication Methods): The correlation is low, yet negative with SPoCE ($r= 0.185$) and TL ($r = 0.15$). SPoCE (Student Perception of Communication Effectiveness): Moderately correlated with CF = 0.428 and weak correlation with TL = 0.293. SMaE (Student Motivation and Engagement): Least associated with all constructs, most with TL = 0.174. CF (Cultural Compatibility): Low interactions with TBCM and HFtFCM as shown by 0.126 and 0.091 respectively. Consequently, the given results endorse TL and CF's contributions to engagement to achieve the study's objectives.

Explanation of Table 4: Fornell & Larcker Criterion Discriminant validity with respect to structural equation modeling is evaluated by Fornell & Larcker criterion by using the comparison of the square root of the Average Variance Extracted (AVE) for each construct with the correlation of the construct with other constructs. Diagonal values in the Table 4 are the square root of AVE and other entries in the matrix represent correlations. Key Observations: Diagonal values (e.g., TBCM= 0.773 and SPoCE = 0.771) are higher than the other values in their respective row and column the discriminant validity. TBCM was established to be moderately correlated with TL, $r = 0.38$ but weak correlation with other constructs necessary to avoid redundancy. SPoCE is greatly correlated with CF at 0.331, thus proving its usefulness in concern to cultural compatibility. Similarly, small coefficients between other constructs like SMaE and HFtFCM (0.081) strengthen the construct clearness. Thus, the findings substantiate the proposition that the model's constructs are sufficiently distinct from one another to support the reliability and validity of the study.

4-3- The Structural Model is the Assessment Model

We examined the structural models in order to assess the proposed hypotheses in the following stage of this investigation (Tables 5 and 6). To show the update and the contribution of this work we test the hypothesis related to the literature as shown in Figure 1, then implemented bootstrapping in smart-Pls as shown in Figure 6.

Table 5. Path coefficient

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
1.TBCM → 3.SPoCE	0.245	0.249	0.035	6.975	0
1.TBCM → 4.SMaE	0.177	0.179	0.039	4.493	0
2.HFtFCM → 3.SPoCE	-0.051	-0.053	0.042	1.227	0.11
2.HFtFCM → 4.SMaE	0.056	0.06	0.049	1.156	0.124
3.SPoCE → 4.SMaE	0.192	0.195	0.043	4.502	0

Table 6. Specific indirect effect

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
1.TBCM → 3.SPoCE → 4.SMaE	0.047	0.049	0.013	3.737	0.000
2.HFtFCM → 3.SPoCE → 4.SMaE	-0.01	-0.01	0.009	1.125	0.130

According to the Table 5 HFtFCM has both weakly negative and weakly positive effects on SPoCE and SMaE however, the p-values indicate that these effects are not significant.

The mediation study presented in Table 6 indicates that there is no statistically significant relationship between HFtFCM and SMaE through SPoCE and the effect of HFtFCM on SMaE is negligible.

To enhance the direct interaction between HFtFCM and SMaE as well as the mediation that takes place through the use of SPoCE this study adds two moderators TL and CC into the framework. Figure 6 provides an additional illustration of this task by demonstrating the bootstrapping process used to carry out the modified implementation.

Table 7 demonstrates the results of testing of hypothesis. The choice was made to run a one-tailed test with a 95 percent significance level and a t-value of +1 point 645. The information shown in Table 7 which showed noteworthy results for the hypothesis H_1 guided this decision. The findings validated hypothesis H_1 by showing a significant impact of H_1 : Technological Literacy (TL) positively and significantly moderate the relationship between Human Face to Face Communication Methods (HFtFCM) and Students' Perception of Communication Effectiveness (SPoCE). ($B=0.051$, $t=2.022$, $p=0.022$). Thereby supporting hypothesis H_1 . Also Technological Literacy (TL) positively and significantly moderates the relationship between Human Face to Face Communication Methods (HFtFCM) and Student Motivation and Engagement (SMaE) ($B=0.044$, $t=1.696$, $p=0.045$). Thereby supporting hypothesis H_2 . However, the Cultural Compatibility (CC) negatively and insignificantly moderate the relationship between Human Face to Face Communication Methods (HFtFCM) and Students' Perception of Communication Effectiveness (SPoCE) ($B=-0.016$,

$t=0.525$, $p=0.300$). Thereby rejecting hypothesis H_3 . Cultural Compatibility (CC) negatively and significantly moderate the relationship between Human Face to Face Communication Methods (HFtFCM) and Student Motivation and Engagement (SMaE) ($B=-0.086$, $t=3.175$, $p=0.001$). thereby rejecting hypothesis H_4 .

Table 7. Testing Hypothesis with moderators

	Original sample (O)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
1.TBCM → 3.SPoCE	0.115	0.028	4.08	0
1.TBCM → 4.SMaE	0.138	0.031	4.448	0
2.HFtFCM → 3.SPoCE	0.071	0.028	2.585	0.005
2.HFtFCM → 4.SMaE	0.005	0.03	0.158	0.437
3.SPoCE → 4.SMaE	0.07	0.029	2.392	0.008
CC → 3.SPoCE	0.296	0.028	10.674	0
CC → 4.SMaE	-0.019	0.028	0.673	0.251
TL → 3.SPoCE	0.14	0.026	5.455	0
TL → 4.SMaE	0.082	0.03	2.687	0.004
CC x 2.HFtFCM → 3.SPoCE	-0.016	0.031	0.525	0.3
CC x 2.HFtFCM → 4.SMaE	-0.086	0.027	3.175	0.001
TL x 2.HFtFCM → 3.SPoCE	0.051	0.025	2.022	0.022
TL x 2.HFtFCM → 4.SMaE	0.044	0.026	1.696	0.045

Table 8 demonstrates the update in the mediation analysis after we integrate the proposed 2 moderators TL and CC

Table 8. Specific indirect effect with moderator's integration

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
1.TBCM → 3.SPoCE → 4.SMaE	0.008	0.008	0.004	2.011	0.022
2.HFtFCM → 3.SPoCE → 4.SMaE	0.005	0.005	0.003	1.711	0.044
CC → 3.SPoCE → 4.SMaE	0.021	0.021	0.009	2.316	0.01
TL → 3.SPoCE → 4.SMaE	0.01	0.01	0.005	2.113	0.017
CC x 2.HFtFCM → 3.SPoCE → 4.SMaE	-0.001	-0.001	0.002	0.467	0.32
TL x 2.HFtFCM → 3.SPoCE → 4.SMaE	0.004	0.004	0.003	1.421	0.078

4-4- Comparison Results between Literature Finding and the Proposed Work

The results of the previous work and the present work are compared in Table 9 which also shows the gains made possible by the addition of the moderators CC and TL.

Table 9. Comparison results with moderators

Path	Without Moderators (Original Sample O)	With Moderators (Original Sample O)	Improvement	P-value Comparison
1.TBCM → 3.SPoCE	0.245	0.115	Decrease	$p = 0.00$ (unchanged)
1.TBCM → 4.SMaE	0.177	0.138	Increase	$p = 0.00$ (unchanged)
2.HFtFCM → 3.SPoCE	-0.051	0.071	Positive Shift	$p = 0.11 \rightarrow p = 0.005$
2.HFtFCM → 4.SMaE	0.056	0.005	Decrease	$p = 0.124 \rightarrow p = 0.437$
3.SPoCE → 4.SMaE	0.192	0.070	Decrease	$p = 0.00 \rightarrow p = 0.008$
CC → 3.SPoCE	-	0.296	New Path	$p = 0.00$
CC → 4.SMaE	-	-0.019	New Path	$p = 0.251$
TL → 3.SPoCE	-	0.140	New Path	$p = 0.00$
TL → 4.SMaE	-	0.082	New Path	$p = 0.004$
CC x 2.HFtFCM → 3.SPoCE	-	-0.016	New Interaction	$p = 0.30$
CC x 2.HFtFCM → 4.SMaE	-	-0.086	New Interaction	$p = 0.001$
TL x 2.HFtFCM → 3.SPoCE	-	0.051	New Interaction	$p = 0.022$
TL x 2.HFtFCM → 4.SMaE	-	0.044	New Interaction	$p = 0.045$

4-5- An Overview of the Improvements

Overall Improvement: The initial sample values were altered as a result of the moderators (CC and TL) integration especially for 2. The HFtFCM - 3. A substantial improvement in this relationship was indicated by SPoCE which displayed a positive shift from -0.051 to 0.071. Additionally, from 0.11 to 0.005 the p-value dropped indicating increased statistical significance. Even so some initial sample values—like 2—remain low or negative after being adjusted for negative values. HFtFCM -4. Significantly positive relationships in other paths as well as SMaE and interactions between CC and TL demonstrate that the moderators have had a positive impact on the framework. Important Routes with Moderators: New important routes (e. g. CC and TL) were made possible by the introduction of CC and TL. G. CC -3. TL -3 and SPoCE. SPoCE) indicating the additional explanatory power of these moderators in the model which were absent from the original table. In conclusion, Adding TL and CC as moderators has significantly improved the relationships in the model especially for 2. HFtFCM = 3. SPoCE resulting in enhanced statistical significance and the introduction of novel significant pathways that were not present in the original analysis. An overview of the main conclusions. Relationship Gains: The inclusion of moderators resulted in notable modifications to several pathways most notably the improvement in 2. The HFtFCM - SPoCE. New Significant Paths: By introducing new significant relationships moderators CC and TL improved the overall efficacy of the model. Statistical Significance: The addition of CC and TL had a positive effect on the mediation framework as evidenced by the fact that several paths that were non-significant or had negative values without moderators became significant.

4-6- Mediation with Integration of CC and TL

The mediation outcomes from the previous work and the present work, before and after the moderators CC and TL were integrated are shown in Table 10.

Table 10. Mediation comparison with moderator's integration

Path	Before Moderators (Original Sample O)	After Moderators (Original Sample O)	Change	P-value Comparison
1.TBCM → 3.SPoCE → 4.SMaE	0.047	0.008	Decrease	p = 0.00 → p = 0.022
2.HFtFCM → 3.SPoCE → 4.SMaE	-0.010	0.005	Positive Shift	p = 0.13 → p = 0.044
CC → 3.SPoCE → 4.SMaE	-	0.021	New Path	p = -
TL → 3.SPoCE → 4.SMaE	-	0.010	New Path	p = -
CC x 2.HFtFCM → 3.SPoCE → 4.SMaE	-	-0.001	New Interaction	p = -

Explanation of Table 10: Mediation Comparison with Moderator's Integration Table 10 displays the mediation analysis path before and after adding the moderators (CC and TL). Key observations include: TBCM → SPoCE → SMaE MTX effect decreases from 0.047 to 0.008 while the p-value reduces from 0.00 to 0.022. HFtFCM → SPoCE → SMaE: From -0.010 to 0.005, delta changed significantly (p-value 0.13 to 0.044). New paths I find as significant are CC → SPoCE → SMaE (0.021) and TL → SPoCE → SMaE (0.010). The interaction terms for CC x HFtFCM and TL x HFtFCM are significantly small, which means that the effects are negligible. It is necessary to consider these results as they demonstrate how moderators affect mediation tendencies.

5- Discussion

5-1- Comparison in Detail of Particular Indirect Effects

The particular off-target consequence for 1. TBCM - 3. Space - 4. Following the addition of the moderators SMaE dramatically dropped from 0. 047 to 0. 008 indicating a diminished mediation effect. As an alternative 2. FCM HFt - 3. SpoCE - 4. A positive 0.005 was observed in SMaE indicating an improvement in the mediation effect following the integration of CC and TL from a negative value of -0.010. The New Paths of Mediation. New mediation paths (CC - 3) were introduced with the addition of moderators CC and TL. Space - 4. Both SMaE and TL - 3. Space - 4. With p-values of 0. 01 and 0. 017 respectively both SMaE) exhibit significant effects.

5-2- Relationships with Current Paths

The interplay effects (CC x 2). HFtFCM = 3. Space - 4. TLx 2 and SMaE. HFtFCM = 3. Space - 4. P-values of 0. 32 and 0. 078 which indicate little influence from the moderators on these particular interactions indicate that SMaE) did not demonstrate significant impacts on mediation. Overall, the incorporation of CC and TL led to the increasing significance of certain pathways and a decrease in the overall strength of others indicating a more intricate interaction within the mediation framework.

The results of this research offer important new understandings of the interactions among technological literacy (TL) cultural compatibility (CC) and human face-to-face communication methods (HFtFCM) as well as how these interactions affect student's perceptions of communication effectiveness (SPoCE) and motivation and engagement (SMaE). According to the validation of hypothesis H₁ TL significantly and positively modifies the relationship between HFtFCM and SPoCE (B = 0.051 t = 2.022 p = 0.022). The first research question about how to optimize HFtFCM for improved

communication effectiveness is answered by this finding. It highlights the need for instructional strategies that incorporate technology into communication practices by suggesting that raising students' technological literacy can improve their perception of the efficacy of face-to-face communication. Likewise, the data supporting hypothesis H₂ shows that TL ($B = 0.044$ $t = 1.696$ $p = 0.045$) also positively moderates the relationship between HFtFCM and SMaE. In terms of how to best utilize HFtFCM to increase student motivation and engagement this bolsters the second research question. This research emphasizes how crucial it is to give students the technological know-how they need to increase their motivation and level of engagement in in-person interactions. The findings for CC, however, paint a picture of a situation that is more nuanced. As CC did not significantly moderate the relationship between HFtFCM and SPoCE ($B = -0.016$ $t = 0.525$ $p = 0.300$) hypothesis H₃ was rejected. This suggests that cultural compatibility may not have the same impact on communication effectiveness as first thought. The relationship between HFtFCM and SMaE is significantly negatively moderated by CC as indicated by the rejection of hypothesis H₄ ($B = -0.086$ $t = 3.175$ $p = 0.001$). This implies that using HFtFCM may result in a drop in student motivation and engagement when CC is increased underscoring the importance of carefully taking cultural aspects into account when developing communication strategies.

5-3- Summary of Finding

The findings ($B = -0.086$; $t = 3.175$; $p = 0.001$) that show Cultural Compatibility (CC) negatively and significantly moderates the relationship between Human Face-to-Face Communication Methods (HFtFCM) and Student Motivation and Engagement (SMaE) have significant implications for comprehending the dynamics of communication methods and student engagement in educational settings. An explanation of the findings. Negative Moderation: The negative coefficient ($B = -0.086$) indicates that HFtFCMs ability to increase student motivation and engagement declines as cultural compatibility rises. Thus, higher CC levels could lessen the beneficial effects of in-person interactions on student engagement. Significance for Statistics: The result is statistically significant indicating that the likelihood that this relationship is the result of random chance is very low as indicated by the t-value of 3.175% and the p-value of 0.001. There is reason to pay attention to the strong negative moderation effect. Rejecting hypothesis H₄ suggests that CC did not have the anticipated positive moderating effect on the relationship between HFtFCM and SMaE. This result points to a more intricate interaction in which CC does not improve HFtFCMs efficacy as first thought. Justification: Excellent or Poor Outcomes? Comprehending Contextual Factors: The findings are positive in that they offer insightful information about the complex influence of cultural context on educational communication. It implies that to improve student engagement the cultural context must be carefully taken into account and matched with communication strategies simply implementing HFtFCM is not enough. Consequences for Educational Practice: From a practical standpoint the negative moderation suggests that educational approaches should consider cultural compatibility in addition to enhancing face-to-face communication. Participation may be hampered rather than encouraged if the communication strategies employed do not reflect the cultural diversity of the student body. Possibilities for Improvement: Although the outcome initially appears unfavourable it points to a place for improvement. Academic institutions could examine cultural elements that lead to this detrimental moderation and modify their communication tactics accordingly. This research suggests that teachers adopt more culturally sensitive teaching strategies that connect with their student bodies. In conclusion even though the negative moderation might not seem desirable at first it provides important information about how communication strategies and student engagement relate to one another which in turn helps to improve instructional strategies.

5-4- Comparing Findings with Other Studies

This paper sought to extend the work in Shannaq et al. [1], and examine the cross relationship of TL, CC, HFtFCM and SMaE in Oman's learning institutions. The result shows that there seems to be a moderate increase in the mediation framework when TL and CC were invoked as the means. More importantly, the level of statistical significance of the association between HFtFCM and SPoCE increased from $p = 0.11$ to $p = 0.005$ as did the strength and positive direction of the SPoCE from -0.051 to 0.071.

These findings are consistent with previous research stressing's the necessity to consider cultural contexts and technological affordance in educational contexts. For instance, Hossain [38] and El-Sabagh [39] found that cultural aspects in the e-learning context improve students' interaction revealing that there should be cultural adaptation for better learning. In like manner, other work established that technological literacy directly affects students' motivation while arguing that improvement of TL can result in bettering of students' performance.

Furthermore, a direct correlation between the HFtFCM and the SPoCE stresses on the continued importance of face-to-face communication in today's technology savvy world. In support of this argument, Miller [40] posited that social interaction is inextricable from cognitive processes This means that there is no specific area of development that is not in some way impacted by social interaction, including that which results in the acquisition of academic knowledge. The enhanced signalled attitude regarding the communication efficiency implies that, indeed, technology is instrumental in learning, but humans are significant in keeping motivation going.

This work's advancement of TL and CC as moderating factors offers a more dynamic approach to understanding how educational systems in Oman can be further developed. Such insights not only add to the body of knowledge but also provide immediate use to principals, teachers, and policymakers who practice or are interested in culturally and technologically mediated engagement with students.

6- Conclusion

This paper aims to explore the relationship between technological literacy (TL), cultural compatibility (CC), human face-to-face communication methods (HFtFCM), and student motivation and engagement (SMaE). The study examines TL and CC as moderating factors that strengthen the mediation framework. The results indicate a significant statistical difference in the p-value, which decreases from 0.11 to 0.005, signifying a stronger statistical significance in the proposed relationships. Additionally, a positive shift is observed from a -0.051 path to SPoCE from HFtFCM, reaching 0.071. This suggests that the integration of TL and CC significantly enhances the impact of communication methods.

The findings emphasize the importance of technological competency in increasing student interest and improving the effectiveness of human face-to-face communication. These factors contribute to higher academic achievement, while modern teaching approaches, such as the use of information technology, enhance students' communication skills in educational institutions, ultimately boosting student participation. However, the study also reveals a negative impact of cultural compatibility on student motivation and engagement, suggesting that ineffective communication strategies may hinder student involvement. Therefore, educational institutions are encouraged to align communication methods with students' cultural perspectives to foster better interaction. These findings support the inclusion of technological and cultural considerations in communication strategies to improve student engagement. Future research should further investigate the relationship between technological literacy and cultural factors to develop optimal communication models for various educational systems.

6-1- Recommendations

- **Boost Technological Literacy:** Universities/Colleges should put in place training programs designed to help students become more proficient with technology so they can communicate in person more successfully.
- **Communication that is Culturally Responsive:** Plans should be created to make sure that communication techniques are considerate of other people's cultures and appropriate for the varied backgrounds of students.
- **Integrate Technology into Communication:** Programs that combine technology with conventional communication techniques can improve student's competency, motivation engagement and impressions of the efficacy of communication.
- **Additional Research:** To evaluate the long-term impacts of enhanced technological literacy and cultural compatibility on student competency, engagement and communication effectiveness conduct longitudinal studies.

6-2- Future Work and Limitations

This research has several shortcomings. First of all, the studies exclusive focus on Omani students may have limited the findings applicability in other cultural contexts. To confirm these results in various educational contexts future studies should take a more varied sample into account. Second bias may be introduced by using self-reported measures using mixed methods could strengthen the validity of the results. Prospective research endeavours may additionally investigate the distinct cultural elements that give rise to the detrimental moderation of CC and the ways in which communication tactics can effectively tackle these factors.

7- Declarations

7-1- Author Contributions

Conceptualization, B.S. and I.S.; methodology, B.S.; software, S.A¹; validation, S.A², S.A³, and I.S.; formal analysis, B.S.; investigation, I.S.; resources, I.S.; data curation, B.S.; writing—original draft preparation, B.S.; writing—review and editing, I.S., S.A¹, S.A², and S.A³; visualization, S.A¹; supervision, I.S.; project administration, I.S.; funding acquisition, I.S. All authors have read and agreed to the published version of the manuscript.

7-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7-3- Funding and Acknowledgments

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7-4- Institutional Review Board Statement

Not applicable.

7-5- Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

7-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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Appendix I: Questionnaire

Survey Questions: Available online: <https://docs.google.com/forms/d/1oyO09vxEnPJky9nKbj5PCUd6AQL5tbUVEX1mlWOzGFI/prefill> (accessed on January 2025).

Variable	Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Technology-Based Motivation Methods	I feel more motivated to study when using mobile apps or online resources.	☐	☐	☐	☐	☐
	Social media platforms help me stay engaged with my studies.	☐	☐	☐	☐	☐
	I prefer receiving academic updates and communication via email.	☐	☐	☐	☐	☐
	Technology-based tools (e.g., apps, emails) keep me organized and motivated.	☐	☐	☐	☐	☐
	I feel more motivated when interacting with my instructors and peers through digital platforms.	☐	☐	☐	☐	☐
Human Face-to-Face Motivation Methods	Personal interaction with teachers motivates me more than digital communication.	☐	☐	☐	☐	☐
	I feel more engaged in my studies when my instructor discusses the material face-to-face.	☐	☐	☐	☐	☐
	Face-to-face mentoring is more effective for my academic growth than using technology.	☐	☐	☐	☐	☐
	I learn better in a classroom setting with direct contact with instructors and peers.	☐	☐	☐	☐	☐
	My motivation increases when I can ask questions and get answers in person.	☐	☐	☐	☐	☐
Student Motivation and Engagement	I am highly motivated to engage in my studies.	☐	☐	☐	☐	☐
	My participation in academic activities has improved this semester.	☐	☐	☐	☐	☐
	I feel actively involved in classroom discussions and projects.	☐	☐	☐	☐	☐
	My academic performance reflects my level of motivation.	☐	☐	☐	☐	☐
	I consistently attend lectures and stay committed to my studies.	☐	☐	☐	☐	☐
Student Perception of Effectiveness	I believe technology-based tools help me succeed academically.	☐	☐	☐	☐	☐
	I perceive face-to-face interaction as essential to my learning success.	☐	☐	☐	☐	☐
	Technology helps me achieve better academic results.	☐	☐	☐	☐	☐
	Face-to-face discussions are more effective than digital interactions for complex topics.	☐	☐	☐	☐	☐
	Overall, I find that in-person motivation is more beneficial for my long-term success.	☐	☐	☐	☐	☐
Cultural Compatibility	Face-to-face interaction aligns with cultural expectations in the Gulf region.	☐	☐	☐	☐	☐
	Technology-based methods of communication fit well with Arab cultural values.	☐	☐	☐	☐	☐
	I feel more comfortable in face-to-face academic settings due to cultural norms.	☐	☐	☐	☐	☐
	Digital tools for learning are culturally appropriate in the Gulf region.	☐	☐	☐	☐	☐
	The traditional approach to teaching is more culturally accepted than technology-driven methods.	☐	☐	☐	☐	☐
Technological Literacy	I feel comfortable using online learning platforms and apps for my studies.	☐	☐	☐	☐	☐
	My technological skills help me navigate educational tools effectively.	☐	☐	☐	☐	☐
	I need more training to feel confident using technology in my academic work.	☐	☐	☐	☐	☐
	I prefer technology-based solutions because I am proficient in using	☐	☐	☐	☐	☐