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Exploring ICT-based learning adoption in higher education: An extended perspective of the technology acceptance model

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ABSTRACT

This article analyses the self-perception of digital technology learning competence among engineering and science students. The use of information and communication technologies (ICT) is now considered highly essential in higher education. Today's higher education institutions (HEIs) seldom employ traditional methods of instruction; instead, sophisticated ICT is starting to emerge as a feasible paradigm for fundamental change. To this end, Pakistan's Higher Education Commission (HEC) has heavily invested in technology in the education sector and initiated several programs. The ramifications of ICT utilization on the environment, student academic performance, and capabilities remain ambiguous. In delving into how students embrace and utilize ICT systems for learning in HEIs, researchers felt the need to grasp the factors that influence students' acceptance and utilization of ICT skills through the lens of the Extended Technology Acceptance Model (TAM). This study develops an exclusive conceptual model by incorporating TAM with a set of latent variables identified in the available literature: interest, ICT self-efficacy, economic cost, and performance expectancy. The adapted TAM model developed in this study considers the influence of these variables on students' ICT acceptance and its impact on academic performance in emerging countries. As part of this study, reports on the development of instruments and validation in the research field were managed using a cross-sectional survey method and SPSS-22 and Smart PLS-4 software. In addition, association rule mining applied in demographic data. A sample of 69 students was randomly selected from three universities representing engineering, medical, and general HEIs in the Sindh province. Though the sample size was small, it showcases that the reliability of the scales is within an acceptable range and can be used to test the main study hypotheses. A conceptual framework model is introduced to offer a comprehensive framework derived from the amalgamation of various acceptance and usage models of technology. The results demonstrate that the survey items are appropriate and suitable for further research.

1. Introduction

Recent advancements and modernizations in ICT have revolutionized conventional educational approaches. Today, students benefit from engaging learning experiences and easy access to vast amounts of information [1].

Many universities have made significant strides in fully integrating ICT to enhance learning methodologies, training, research, and development. However, the impact of these ICT applications on students' performance and success remains unclear [2].

Emerging ICTs are evolving as sustainable models for transforming education through digitalization. By transitioning from traditional desktop-based to network-based paradigms, these technologies facilitate active learning by enhancing content delivery and comprehension. This study stands out for its utilization of real-time supervising tools, which enable the tracking of students' activities and progress. These tools provide insights into students' usage patterns and their readiness to embrace technology-driven systems [3].

University authorities should prioritize maximizing the potential of ICT to facilitate students' successful adaptation to academic life. By focusing on enhancing students' study skills, universities can significantly boost academic achievement. Additionally, incorporating self-regulated learning skills, motivation, and strategic frameworks will help universities capitalize on their investments in ICT, further enriching the educational experience in higher education institutions [4].

The mere advancement of ICT technology does not guarantee its widespread acceptance among learners in educational settings. Therefore, it is crucial to understand the factors that influence both the rejection and acceptance of such technology. This research aims to explore these dynamics comprehensively [5].

The adoption of technology in educational settings is a critical area of study within Information Systems, particularly concerning how students accept and use technological tools. Academic performance in universities can be significantly influenced by students' acceptance of ICT-based learning. Previous research has indicated a widespread acceptance and utilization of ICT in higher education institutions (HEIs). By extending the TAM, this study seeks to develop a theoretical framework to identify key factors influencing students' perceptions and acceptance of ICT-based learning in HEIs in Sindh, Pakistan. Several studies have investigated the integration and acceptance of technology in educational contexts. The significance of this research lies in its potential to enhance the quality of education in HEIs by effectively implementing ICT, thereby enabling students to become more active and quality-oriented professionals.

Upon a comprehensive review of the literature, it is evident that the ethical application of ICT holds significant promise in enhancing technical and engineering education. Research consistently emphasizes the inclination of engineering students towards ICT tools, underscoring their pivotal role in facilitating learning [1]. The recent surge in eLearning modalities, precipitated by the global pandemic, highlights the urgency for educators and learners to adapt to digital platforms [2][3]. The evolution from rudimentary e-learning 1.0, focused on information transfer, to interactive e-learning 4.0, integrating diverse technologies, signifies a shift towards a more dynamic educational paradigm [4]. The potential of augmented reality (AR) as an ICT tool in engineering education, seeking to evaluate its effectiveness in improving learning outcomes. By developing an AR application for analysing digital current in resistive circuits, the study endeavours to bridge the gap between theoretical concepts and practical understanding. The transformative impact of AR technology has been demonstrated across various disciplines, including mathematics, social sciences, and notably, engineering education. In the realm of engineering, AR applications have proven instrumental in elucidating complex electronic concepts, offering interactive simulations and visualizations to complement traditional learning methods [5][6].

Moreover, amidst the unprecedented challenges posed by the global pandemic, the integration of ICT tools has emerged as a crucial component for continued education [7]. Despite initial apprehensions surrounding the transition to ICT-based systems, the widespread adoption of ICT has facilitated seamless educational delivery, albeit with challenges such as teacher adaptability and resource availability. In engineering education, the integration of ICT encompasses a diverse range of applications, from enriched classroom presentations to the utilization of simulation software and engineering design tools. These tools enable students to conduct virtual experiments, providing valuable insights into real-world applications [8][9].

The multifaceted nature of ICT integration in engineering education extends beyond conventional boundaries, encompassing online resources such as digital content repositories and interactive learning environments. VLEs and Managed Learning Environments (MLEs) serve as conduits for online content delivery, fostering collaboration and engagement among students. Additionally, the proliferation of virtual and remote laboratories underscores the adaptability of engineering education to evolving technological landscapes [7][10].

In conclusion, the judicious integration of ICT in engineering and science education represents a paradigm shift towards a more dynamic and interactive learning environment. By harnessing emerging technologies such as augmented reality and simulation software, educators can cultivate deeper conceptual understanding and empower students to navigate the complexities of the digital age with confidence and proficiency [9].

2. Determination of Pilot Study

The core of pilot study is pre-test data in small scale; before the main research is conducted; the main aim is to decide whether an approach that is planned for a larger-scale study is reasonable [11]. A pilot study is important, while questionnaire survey method utilized. Sekaran (2003), it is always done before main study in order to make sure and validate instrument/questionnaire. The determination of pilot study was to elude participants' confusions and misconceptions as well as to identify and detect any errors and uncertainties.

The main goal of this pilot study was to refine and assess a questionnaire before implementing it in a larger research endeavour, ensuring the effectiveness of our methods. By examining how participants responded to the questionnaire, we were able to validate the instrument and gauge their understanding of each aspect within the construct. This study significantly contributes to the existing academic literature on the topic. The insights gained from the pilot study will help researchers refine their data collection strategies, aligning them with relevant practices and content. Conducting a pilot study with a smaller sample size is crucial to laying a solid foundation for the success of future, more extensive investigations.

This study aimed to gauge students' perceptions of ICT acceptance and its impact on learning across various disciplines. The pilot study was conducted with the following objectives:

- To develop a questionnaire that explores key constructs
- To assess the reliability and validity of the developed instrument

3. Literature Review

Understanding the potential benefits of ICT efforts may offer for educational organizations are utmost significance in the recent knowledge era. Now usage of ICT is part of our daily lives for all. Thus, in order to improve learning and teaching in the twenty-first century, it is crucial to raise knowledge of the use of ICT among students and teachers [12].

Internet of Things (IoT) is being extended to new heights by software engineering, and in turn, IoT is changing the way people learn [13] .

Over the past decade, numerous HEIs have worked to improve students' academic performance by implementing cutting-edge technology that could lead to creative methods for delivering and developing new settings for university education. For many stakeholders, including students, teachers, and academic institutions, predicting students' performance when using ICT for learning or over an entire course is a significant responsibility [14]. ICT infrastructure that is insufficient or non-existent appears to be a major obstacle to student ICT usage. Although some studies have used students' views as major variables to analyses ICT usage, this only applies when there is an appropriate ICT facility accessible [15].

ICT usage has greatly promoted in earlier literature as a means of improving student achievement. Such an attitude stems from the fact that various studies have found a correlation between the use of ICT and students' performance [15]. Whereas few recent research highlights ICT usage have an adverse impact on students' performance and identified no correlation between ICT use and student performance. [16]. Moreover, a few studies have found the detrimental impact of ICT on student achievement. These researchers draw attention to the way that students using social media and gaming during class or lab. These studies also indicate those students were observed paying more attention to their virtual world, so it is challenging to assess the direct effect of ICT on students' performance in such conditions [15].

In light of this background academic researcher and education specialists have engaged in a number of discussions about how ICT impact students' academic achievement [17]. This is particularly surprising that digital literacy is thought to be a requirement for the efficient application of ICT in education and the adoption of safe operating embraces are additional conditions for the efficient use of ICT [18]. In shed of this, educational policymakers have prioritized the development of digital skills and give recommendations to universities on how to change their teaching methods in order to make greater use of ICT. IoT acceptance by students for learning in HEIs [19].

In this study author indicates ICT can be used for a variety of objectives, students rarely utilize ICT for academic purposes [20] and specific recommendation should adapt to enhance the learning experience for the students. Today's technology has made it simpler to update educational materials and applications. [21].

Because of the ability of Internet-enabled devices to connect students and teachers globally, it is possible for students to communicate with one another and exchange important knowledge and learning experiences[22]. Some studies provided evidence that digital technology is crucial in present learning environments and that technology being freely available in many countries [23].

There is inadequate empirical evidence about the impact and effectiveness of ICT on students' academic achievement at the university level in both developed and poor nations. [24].

The research conducted which does not clearly depict the ICT pure impact on students' academic performance, this is necessitates synchronization and regularity. Hence, extended technology acceptance models integrate many models were employed in this study to achieve the study's objectives, contrary to past studies that used various individual acceptance models. In result a comprehensive model is created and used to compare the available literature. Similarly, enough work has been done using the acceptance model in developed regions, but little work has been published in developing regions, and cultural norms vary from one region to the next. Therefore, there is a great need to investigate various influencing factors that have an impact on performance depending on our circumstances.

4. Problem Statement

Almost all government higher educational institutions in Sindh, Pakistan, have integrated digital (ICT) infrastructure, funded through significant grants from the HEC. However, there is a dearth of literature on the adoption of ICT in these institutions, particularly regarding its impact on students' academic performance. Consequently, there is a pressing need for comprehensive research, detailed data analysis, and identification of core factors that enhance academic performance in Sindh's HEIs. Nearly all government HEIs in Sindh, Pakistan, have embraced ICT infrastructure, thanks to substantial grants from the HEC. Yet, there's a noticeable gap in literature concerning the integration of ICT in these establishments, especially in terms of its impact on students' academic achievements. Hence, there's an immediate need for in-depth research, meticulous data analysis, and the identification of pivotal factors that bolster academic success in HEIs across Sindh.

To address this gap, an extensive realistic study is required to assess ICT acceptance in HEIs and identify both the success components and hedges that influence its impact on learned performance. This study aims to explore the factors that affect ICT acceptance and the application of ICT skills in educational settings within HEIs. It seeks to determine whether ICT-based learning is cost-effective, accessible, and an efficient educational approach in Sindh. Furthermore, the study will identify the prerequisites for students to effectively implement ICT-based education. It will also examine the features and strategies necessary to support a sustainable ICT-based learning environment, ultimately aiming to improve students' academic performance.

5. Proposed Model

Numerous concepts and models, such as TPB, TRA, DOI, TAM, and UTAUT, evaluate the acceptance of innovative technology. The Technology Acceptance Model (TAM) is particularly suitable for interpreting internal beliefs and user perceptions regarding the acceptance of innovative technology due to its simplicity and user-centered approach [15]. The primary elements defined in TAM, Perceived Ease of Use (PEOU) and Perceived Usefulness (PU), significantly influence user acceptance of a specific technology[32].

This study employs TAM as the foundational model to explore the usage of ICT in learning. The hypothetical model will be tested and analyzed as illustrated in Fig. 1. In this model, eight student-related factors are examined to understand their behavioral intentions towards ICT. This research aims to extend TAM and investigate the impact of ICT-based learning on students' academic performance and the likelihood of ICT acceptance in an emerging country, specifically Pakistan.

6. Pilot Study

To pre-test a specific research instrument, the scale development approach uses a pilot study. This study involved the survey instrument as the principal technique for collecting data for the pilot study [25]. A self-administered instrument was developed grounded on prior literature. As this study is exploring ICT acceptance impact on student performance. For generalizability and increase response rate this study targeted three universities one engineering, one medical and other is general Universities. The questionnaire sent via postal services. The researcher identified universities that are appropriate as well as cover large population to conduct this research. A survey was composed on a random sample of 100 students from three Universities from various department almost targeted to the department where ICT course in exist syllabus. Out of the 69 surveys collected, 31 were omitted either because some students showed that they were unfamiliar with use of ICT or other find out inappropriate response. The remaining 69 instruments were used in reliability analysis. The following table 1. represents data for pilot study.

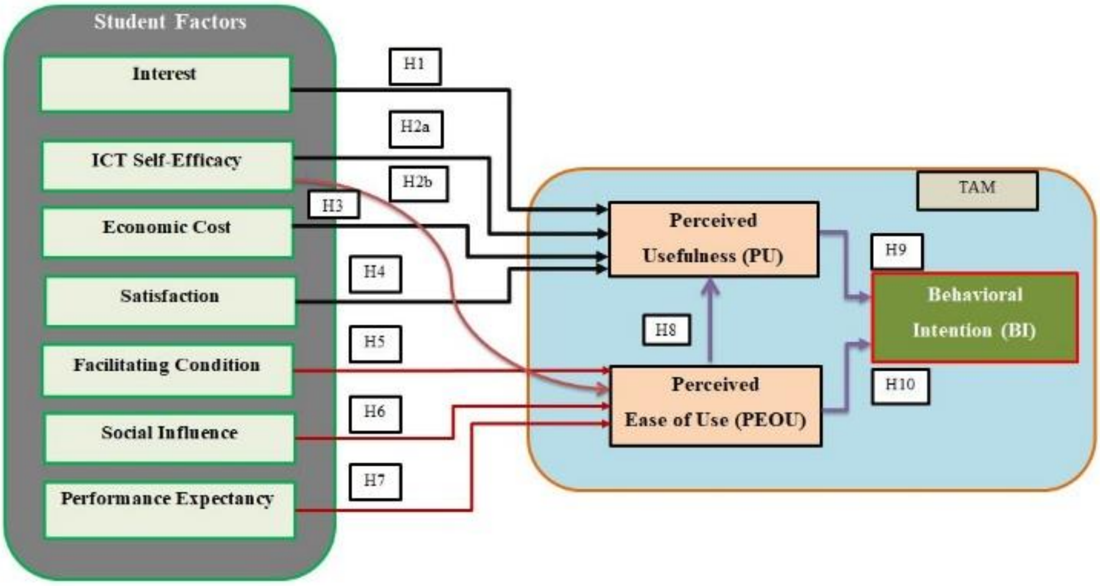

Fig. 1. The Proposed Model of This Research

Table 1

Sample selected for pilot study

S.no	Name of Universities	Distributed	Received	%
1	University of Sindh	50	32	64%
2	Mehran University of Engineering and Technology Jamshoro	25	20	80%
3	LUHMS, Jamshoro	25	17	68%
	Total	100	69	69%

7. Methodology

For this study, we utilized a cross-sectional survey research design to collect data. A pilot study questionnaire was distributed to 100 students across three public sector universities, representing various disciplines. The selection of participants was carried out using simple random sampling, as advocated by Krejcie and Morgan (1970), ensuring that each respondent had an equal opportunity to be included. This sampling method was deemed most appropriate to ensure unbiased data collection and representation across the participant pool [26]. In this study manual survey method carried out questionnaire and Self-administered survey questionnaires are considered for data collection. Self-administered survey questionnaires have two sections, the open-ended section which collects personal demographic data and the closed ended section. The closed ended section contains the major portion of the questionnaire, while the open ended mostly contains the demographic questions. Fig. 2. shown conceptual framework model.

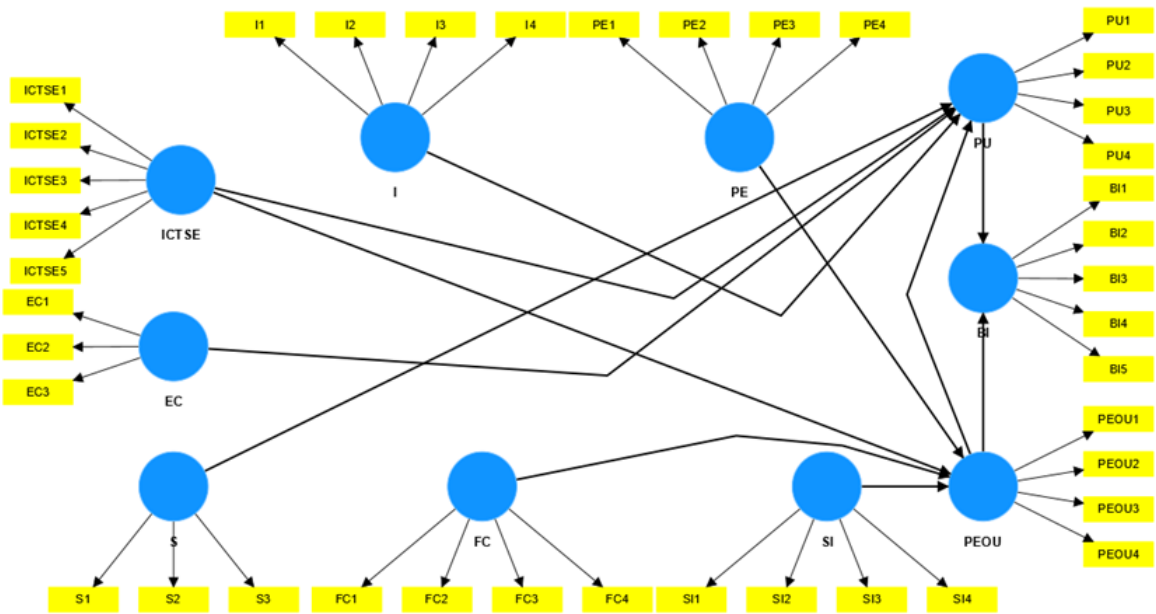

Fig. 2. Conceptual Model

8. Result Reliability of Instrument

Reliability, define as “extent to which a variable or collection of variables is stable in what it is meant to assess" is used to describe reliability. In this work, the reliability of the scale was evaluated using Cronbach's alpha [27]. Content validity of instrument applied by various experts [28],[29].

The outcomes in Table 2. The outcomes of the statistical analysis demonstrate satisfactory reliabilities, from 0.7 to 0.9 for entire scales.

Table 2

Overall Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha of Items	N	N of Items	Mean
.954	.957	69	40	5.236

Construct	Mean	Std.Deviation	Cronbach's Alpha	No of items
BI1	5.5072	1.83610	.844	5
BI2	5.6377	1.48493		
BI3	5.5507	1.69373		
BI4	5.6377	1.59014		
BI5	5.8406	1.64158		
EC1	4.7391	1.92241	.838	3
EC3	4.5217	1.91441		
EC2	4.6957	1.87322		
FC1	4.7681	2.04468	.766	4
FC2	4.6812	1.86684		
FC3	3.5797	2.03936		
FC4	3.9130	1.97588		
I1	5.3913	1.44728	.786	4
I2	5.1159	1.54859		
I3	5.2899	1.60056		
I4	5.5072	1.48149		
ICTSE1	5.0725	1.60256	.863	5
ICTSE2	5.4203	1.38698		
ICTSE3	5.5507	1.56747		
ICTSE4	5.6812	1.34485		
ICTSE5	5.5072	1.50121		
PE1	5.6377	1.44478	.815	4
PE2	5.7391	1.54969		
PE3	5.7246	1.69674		
PE4	5.6812	1.40893		
PEOU1	5.1884	1.56502	.748	4
PEOU2	5.6522	1.54183		
PEOU3	5.3623	1.39296		
PEOU4	5.4348	1.53851		
PU1	5.5797	1.57560	.776	4
PU2	5.5217	1.68565		
PU3	5.5507	1.58612		
PU4	4.9420	1.87777		
S1	5.4058	1.46848	.743	3
S2	5.2754	1.41301		
S3	5.1739	1.63560		
SI1	4.5507	1.53906	.760	4
SI2	5.0145	1.56706		
SI3	5.0725	1.66556		
SI4	5.3333	1.57804		

Fig. 3. Represents Individual Reliability of Construct

9. Convergent Validity

Convergent validity evaluates the degree of correlation among various indicators of the same underlying construct. In this study, the convergent validity was assessed using the "average variance extracted (AVE)", "composite reliability (CR)", and "Cronbach's Alpha". A minimum AVE value greater than 0.5 and a CR value exceeding 0.7 were considered indicative of good convergent validity, as recommended [30]. Furthermore, for Cronbach's Alpha, values ranging between 0.7 to 0.9 were deemed acceptable for assessing convergent validity. Table 3 presents the results of the convergent validity analysis.

Table 2

Result of Convergent Validity

Latent Construct	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
BI	0.848	0.892	0.625
EC	0.839	0.885	0.723
FC	0.768	0.817	0.544
I	0.786	0.861	0.609
ICTSE	0.866	0.903	0.652
PE	0.812	0.877	0.650
PEOU	0.748	0.841	0.570
PU	0.787	0.865	0.625
S	0.749	0.857	0.669
SI	0.761	0.846	0.580

10. Discriminant Validity

Discriminant validity pertains to the distinction between constructs. It measures the degree to which one construct differs from others, gauged by the level of correlation with alternative constructs. This study adopts two methods to establish discriminant validity: the "Fornell & Larcker" criterion and cross-loading values [30]. According to the Fornell & Larcker criterion, discriminant validity is confirmed when diagonal values surpass off-diagonal ones. As depicted in Table 4, the square root of AVE for each latent variable exceeds the inter-construct correlations, aligning with the Fornell & Larcker criterion. Furthermore, cross-loading analysis reveals that component loadings of indicators within their assigned constructs are higher than those of alternative constructs, providing an alternative measure for discriminant validity. Bold scores in the diagonal row of Table 4 denote the square roots of the average variance extracted, corroborating the established discriminant validity.

Table 3

Discriminant validity

	BI	EC	FC	I	ICTSE	PE	PEOU	PU	S	SI
BI	0.790									
EC	0.334	0.850								
FC	0.527	0.243	0.738							

I	0.695	0.263	0.484	0.780						
ICTSE	0.725	0.272	0.598	0.778	0.808					
PE	0.788	0.294	0.598	0.686	0.741	0.806				
PEOU	0.703	0.158	0.647	0.653	0.705	0.767	0.755			
PU	0.765	0.352	0.492	0.722	0.609	0.675	0.600	0.790		
S	0.480	0.287	0.501	0.625	0.592	0.586	0.489	0.542	0.818	
SI	0.450	0.421	0.612	0.520	0.618	0.638	0.485	0.488	0.605	0.762

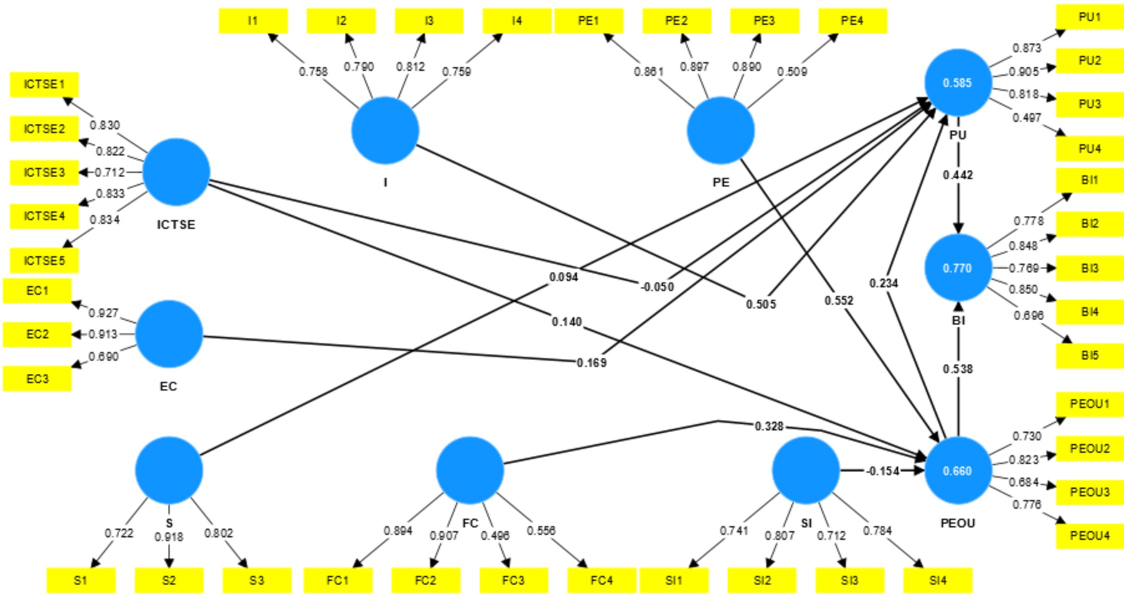

Fig. 3. Result After Execution Data

11. Collinearity Assessment

The Collinearity arises when two predicators (independent construct) are highly correlated. The collinearity among latent constructs are assessed through variance inflated factor. [31].The threshold value Variance Inflation Factor (VIF), range 1 to 5 are considered moderate which indicate a significant collinearity. VIF was applied in this work to find multicollinearities.

Table 4

VIF Score

Constructs	VIF
EC -> PU	1.117
FC -> PEOU	1.856
I -> PU	2.957
ICTSE -> PEOU	3.648
ICTSE -> PU	3.220
PE -> PEOU	3.757
PEOU -> BI	1.552
PU -> BI	2.149
S -> PU	1.552
SI -> PEOU	1.763

12. Data Mining Approach

In this study, we used Association Rule Mining, a popular data mining technique, to uncover valuable insights from transaction data. We specifically applied the Apriori and Éclat algorithms using Python. While these algorithms produce a large number of rules, identifying the most relevant ones can be challenging. Therefore, we adjusted the support and confidence levels to pinpoint the most significant and interesting rules. After cautiously filtering the rules with confidence value and 10 quality rules were generated. Shown in table 5 below. In addition, frequency of items exhibited in table 6, Fig. 6 exhibited matrix plot of 10 rules and pseudocode of algorithm shown in appendix (a).

1) If a person is male or female, attends University A, is an expert in computer literacy, and uses ICT at university, then they are likely to face challenges in technical support in ICT.

2) If a person is male, an expert in computer literacy, has access to most ICT facilities, and uses the internet for general ICT purposes,

then they are likely to engage in common ICT research activities.

3) If a person is male or female, faces challenges in ICT technical support, has access to most ICT facilities, uses the internet for general ICT purposes, and attends University B, then they are likely to engage in common ICT research activities and be an expert in computer literacy.

4) If a person is male or female, faces challenges in ICT technical support, is an expert in computer literacy, and engages in common ICT research activities, then they are likely to use ICT at university.

5) If a person is male or female, faces challenges in ICT technical support, is an expert in computer literacy, and uses ICT at university, then they are likely to engage in common ICT research activities.

6) If a person has access to most ICT facilities, uses the internet for general ICT purposes, is male, attends University A, and is an expert in computer literacy, then they are likely to face challenges in ICT technical support and engage in common ICT research activities.

7) If a person is male, faces challenges in ICT technical support, and is an expert in computer literacy, then they are likely to engage in common ICT research activities and use ICT at university.

8) If a person has access to most ICT facilities, uses the internet for general ICT purposes, is male, engages in common ICT research activities, and is an expert in computer literacy, then they are likely to face challenges in ICT technical support and attend University A.

9) If a person attends University B, faces challenges in ICT technical support, has access to most ICT facilities, and uses the internet for general ICT purposes, then they are likely to be an expert in computer literacy.

10) If a person faces challenges in ICT technical support, is an expert in computer literacy, has access to most ICT facilities, and uses the internet for general ICT purposes, then they are likely to attend University C.

These rules provide insights into the relationships between different factors related to ICT use, gender, expertise in computer literacy, access to ICT facilities, internet usage, university attended, and engagement in common ICT research activities or facing challenges in ICT technical support.

Table 5

Shown association of various variables

No.	Lhs	Rhs	Support	Confidence	Lift	Count
1.	{'Gender_Male_female', 'Univesity_A', 'Computer_Literacy_Expert', 'Location_of_use_ICT_At University'}	{'Challenge_in_ICT_Technical Support'}	0.127	1.000	4.647	8.734
2	{'Gender_Male_female', 'Computer_Literacy_Expert', 'Available_ICT_facilities_Most of the resources', 'General_ICT_Internet'}	{'Common_Use_of_ICT_Research'}	0.089	1.000	3.950	6.114
3	{'Gender_Male_female', 'Challenge_in_ICT_Technical Support', 'Available_ICT_facilities_Most of the resources', 'General_ICT_Internet'}	{'Common_Use_of_ICT_Research', 'Computer_Literacy_Expert', University_B'}	0.089	1.000	6.583	6.113
4	{'Gender_Male_female', 'Challenge_in_ICT_Technical Support', 'Computer_Literacy_Expert', 'Common_Use_of_ICT_Research'}	{'Location_of_use_ICT_At University'}	0.127	1.000	1.519	8.734

5	{'Gender_Male_female', 'Challenge_in_ICT_Technical Support', 'Computer_Literacy_Expert', 'Location_of_use_ICT_At University'}	{'Common_Use_of_ICT_Research'}	0.127	1.000	3.950	8.734
6	{'Available_ICT_facilities_Most of the resources', 'General_ICT_Internet', 'Gender_Male', ' University_A", 'Computer_Literacy_Expert'}	{'Challenge_in_ICT_Technical Support', 'Common_Use_of_ICT_Research'}	0.089	1.000	5.643	6.113
7	{'Gender_Male_female', 'Challenge_in_ICT_Technical Support', 'Computer_Literacy_Expert'	{'Common_Use_of_ICT_Research', 'Location_of_use_ICT_At University'}	0.127	1.000	4.389	8.734
8	{'Available_ICT_facilities_Most of the resources', 'General_ICT_Internet', 'Gender_Male', 'Common_Use_of_ICT_Research', 'Computer_Literacy_Expert'}	{'Challenge_in_ICT_Technical Support', ' University_A"}	0.089	1.000	5.643	6.113
9	{' University_B', 'Challenge_in_ICT_Technical Support', 'Available_ICT_facilities_Most of the resources', 'General_ICT_Internet'}	{'Computer_Literacy_Expert'}	0.101	1.000	4.000	6.977
10	{'Challenge_in_ICT_Technical Support', 'Computer_Literacy_Expert', 'Available_ICT_facilities_Most of the resources', 'General_ICT_Internet'}	{' University_C"}	0.101	1.000	3.950	6.987

Table 6

Shown most frequent items

No	Items	Frequency_No (%)	Frequency_Yes (%)
1	Gender_Male	0.164557	0.835443
2	University_A	0.265823	0.734177
3	Location_of_use_ICT_At University	0.341772	0.658228
4	Available_ICT_facilities_Most of the resources	0.569620	0.430380
5	Computer_Literacy_Average	0.594937	0.405063
6	Common_Use_of_ICT_Learning	0.658228	0.341772
7	Available_ICT_facilities_All available resources	0.708861	0.291139
8	Common_Use_of_ICT_Research	0.746835	0.253165
9	General_ICT_Internet	0.772152	0.227848

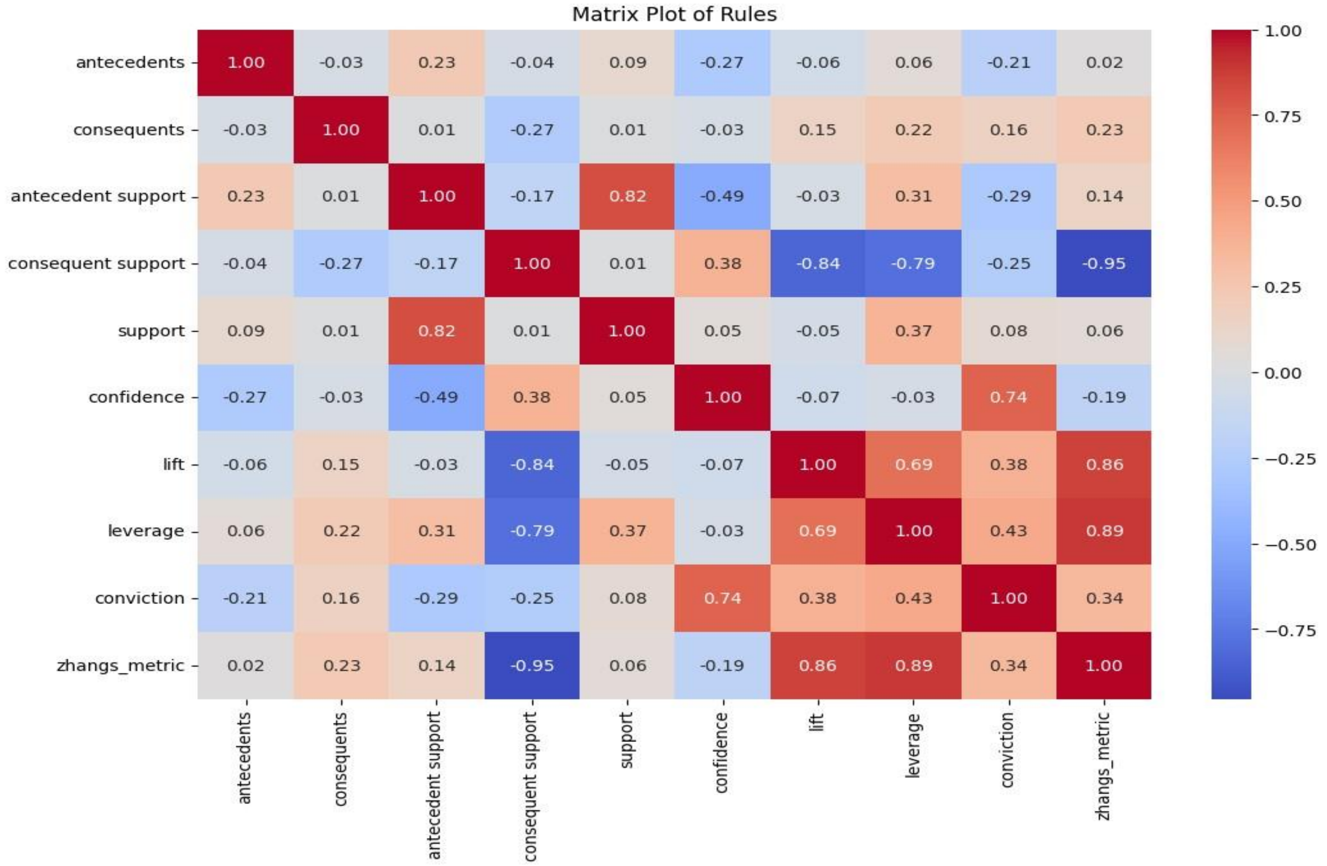

Fig. 4. Matrix Plot of Rules

13. Conclusion

A comparatively small number of sample size examined in this study in the context of ICT acceptance impact on academic performance, despite the fact that much of the research on ICT acceptance's impact on students' academic performance is focused on developing nations. The main goal of this study is to close this gap by a conceptual framework for ICT adoption in education. The paper also discussed the creation and validation of the survey instrument as part of a wider research project through field testing of a pilot survey. Despite the limited sample size, the study confirmed the reliability of the instrument scales, allowing for the evaluation of the research model hypotheses discussed herein. Future research will aim to test and validate the proposed model with a larger population to enhance its reliability and applicability.

14. Appendix

```
# Import necessary libraries
from mlxtend.frequent_patterns import apriori,
association_rules
import pandas as pd
# Load transaction data from CSV file
transaction_data =
pd.read_csv("C:/Users/PMLS/Desktop/jn/asifdata
.csv")
```

```
# Preprocess the data: Convert non-boolean
columns to boolean
transaction_data =
pd.get_dummies(transaction_data)
# Set minimum support threshold for frequent
itemsets
min_support = 0.05
# Apply Apriori algorithm to find frequent itemsets
frequent_itemsets = apriori(transaction_data,
min_support=min_support, use_colnames=True)
# Set minimum confidence threshold for
association rules
min_confidence = 0.5
# Generate association rules
rules=association_rules(frequent_itemsets,metric=
"confidence", min_threshold=min_confidence)
# Filter rules based on desired support and
confidence levels
min_support_filtered = 0.1  # Update to a smaller
value for more stringent filtering
min_confidence_filtered = 0.9  # Update to a
higher value for more stringent filtering
filtered_rules = rules[(rules['support'] >=
min_support_filtered) & (rules['confidence']
 >= min_confidence_filtered)]
```

```
# Limit the number of association rules to 50
filtered_rules = filtered_rules.head(50)
# Summarize the results
total_rules_initial = len(rules)
total_rules_filtered = len(filtered_rules)
# Print summary
print("Total rules generated initially:", total_rules_initial)
print("Total rules after filtering (support >= 0.1 and confidence >= 0.9), limited to 50 rules:", total_rules_filtered)
# Proceed with further analysis as needed
```

15. References

[1] J. A. Kumar, B. Muniandy, W. Ahmad, and J. Wan, "Exploring the perception and acceptance of information technology and communication technology (ICT) in the classroom for polytechnic students", Journal of teaching and Education, vol. 03, no. 03, pp. 175–185, 2014.

[2] S. Khan, R. Umer, N. Uddin, J. Muhammad, and N. Ahmed, "Identifying the factors affecting individuals' trust to use social media for e-government services: a conceptual model", Mehran University Research Journal of Engineering and Technology, vol. 42, no. 1, p. 109, 2023, doi: 10.22581/muet1982.2301.11.

[3] F. Kanwal, M. Rehman, and M. A. Malik, "E-learning adoption and acceptance in Pakistan: the moderating effect of gender and experience," Mehran University Research Journal of Engineering and Technology, vol. 39, no. 2, pp. 324–341, 2020, doi: 10.22581/muet1982.2002.09.

[4] T. Teo, W. S. Luan, T. Thammetar, and W. Chattiwat, "Assessing e-learning acceptance by university students in Thailand," Australasian Journal of Educational Technology, vol. 27, no. 8, pp. 1356–1368, 2011, doi: 10.14742/ajet.898.

[5] T. Lucke, P. K. Dunn, and M. Christie, "Activating learning in engineering education using ICT and the concept of 'Flipping the classroom,'" European Journal of Engineering Education, vol. 42, no. 1, pp. 45–57, 2017, doi: 10.1080/03043797.2016.1201460.

[6] A. Álvarez-Marín, J. Á. Velázquez-Iturbide, and M. Castillo-Vergara, "The acceptance of augmented reality in engineering education: the role of technology optimism and technology innovativeness," Interactive Learning Environments, vol. 31, no. 6, pp. 3409–3421, 2023, doi: 10.1080/10494820.2021.1928710.

[7] O. S. Shaghaghi and E. İşçioğlu, "A study on the application of the information and communication technology tools in the learning process of a mechanical engineering undergraduate program," vol. 06, no. July, pp. 28–33, 2020.

[8] S. Ali, A. Qamar, O. F. Derindag, M. Habes, and E. Youssef, "The mediating role of gender in ICT acceptance and its impacts on students' academic performance during Covid-19," International Journal of Advanced Trends in Computer Science and Engineering, vol. 10, no. 2, pp. 505–514, 2021, doi: 10.30534/ijatcse/2021/081022021.

[9] C. Gupta, V. Gupta, and A. Stachowiak, "Adoption of ICT-based teaching in engineering: An extended technology acceptance model perspective," IEEE Access, vol. 9, pp. 58652–58666, 2021, doi: 10.1109/ACCESS.2021.3072580.

[10] N. Tvenge and K. Martinsen, "Selection of ICT-tools for manufacturing education," Procedia CIRP, vol. 41, pp. 1096–1100, 2016, doi: 10.1016/j.procir.2015.10.008.

[11] M. A. Hasim, J. Jabar, A. Sufian, and N. F. Ibrahim, "Validating the component of E-learning antecedents, digital readiness, and usage behaviour towards E-learning performance: A pilot study," International Journal of Learning, Teaching and Educational Research, vol. 21, no. 10, pp. 178–194, 2022, doi: 10.26803/ijlter.21.10.9.

[12] H. G. M. Merma, "The academic performance related to the proper use of the mobile of the students of engineering of private university in Arequipa 2017 [El rendimiento académico relacionado con el uso adecuado del móvil de los estudiantes de ingeniería de universidad priv", RISTI - Revista Iberica de Sistemas e Tecnologias de Informacao, vol. 2019, no. E21, pp. 70–80, 2019.

[13] M. J. Khan, W. Khan, R. A. Khan, A. Khan, and I. ullah, "Web services composition in UML: An empirical study", Mehran University Research Journal of Engineering and Technology, vol. 41, no. 3, pp. 120–131, 2022, doi: 10.22581/muet1982.2203.12.

[14] M. Pardo-Cueva, L. M. Chamba-Rueda, J. Rios-Zaruma, and A. H. Gómez, "Information and communication technologies and their relationship with academic performance in higher education", 2019 14th Iberian Conference on Information Systems and Technologies (CISTI), Jun. 2019, pp. 1–6. doi: 10.23919/CISTI.2019.8760718.

[15] M. S. Islam et al., "From ICT adoption to ICT addiction: The mediating factors between the use of ICT and learning performance", International Journal of Electronic Commerce Studies, vol. 9, no. 2, pp. 133–159, 2018, doi: 10.7903/ijecs.1561.

[16] M. A. Ullah, M. M. Alam, A. Shan-A-Alahi, M. M. Rahman, A. K. M. Masum, and N. Akter, "Impact of ICT on students' Academic performance: Applying association rule mining and structured equation modelling", International Journal of Advanced Computer Science and Applications, vol. 10, no. 8, pp. 387–393, 2019, doi: 10.14569/ijacsa.2019.0100852.

[17] P. Hai-tao et al., "Predicting academic performance of students in Chinese-foreign cooperation in running schools with graph convolutional network", Neural Comput Appl, vol. 33, no. 2, pp. 637–645, 2021, doi: 10.1007/s00521-020-05045-9.

[18] K. Liang, J. Liu, and Y. Zhang, "The effects of non-directional online behaviour on students' learning performance: A user profile-based analysis method", Future Internet, vol. 13, no. 8, 2021, doi: 10.3390/fi13080199.

[19] A. Muhammad, S. Chandio, and M. Maree, "Acceptance of IoT by students in universities of Sindh, Pakistan: A Proposed Framework", vol. 2, pp. 83–99, 2023.

[20] G. Faimau, K. Tlhowe, and O. Tlhaolang, "Smartphone use, experience of learning environment, and academic performance among university students: A descriptive appraisal", Advances in Human-Computer Interaction, vol. 2022, 2022, doi: 10.1155/2022/2617596.

[21] L. Mutanu and P. Machoka, "Enhancing computer students' academic performance through predictive modelling - A proactive approach", 2019 14th International Conference on Computer Science & Education (ICCSE), Aug. 2019, pp. 97–102. doi: 10.1109/ICCSE.2019.8845452.

[22] M. Jia, "The influence of distance learning during COVID-19 pandemic on student's self-regulated learning in higher education: a qualitative study", 5th International Conference on Digital Technology in Education, in ICDTE '21. New York, NY, USA: Association for Computing Machinery, 2022, pp. 47–52. doi: 10.1145/3488466.3488492.

[23] Y. Otsuka, "Evaluation of the effect of ICT in education on the academic literacy of high school students", 2021 Ninth International Symposium on Computing and Networking Workshops (CANDARW), Nov. 2021, pp. 305–308. doi: 10.1109/CANDARW53999.2021.00058.

[24] W. Villegas-Ch, S. Jácome-Vásconez, J. García-Ortiz, J. Calvache-Sánchez, and S. Sánchez-Viteri, "Proposal of a model for the analysis of the state of the use of ICT in education applied to technological institutes of higher education", Computers, vol. 11, no. 7, 2022, doi: 10.3390/computers11070112.

[25] M. Kipli and A. Z. Khairani, "Content validity index: An application of validating cipp instrument for programme evaluation", Int Multidiscip Res J, vol. 2, no. 4, pp. 31–40, 2020, doi: 10.54476/iimrj313.

[26] Uma. Sekaran and Roger. Bougie, Research methods for business: a skill-building approach. Wiley, 2013.

[27] J. C. Zavaleta, R. Y. Alva, S. V Vargas, E. F. Medina, Y. P. Somoza, and L. Andrade-Arenas, "Relationship between stress and academic performance: An analysis in virtual mode", International Journal of Advanced Computer Science and Applications, vol. 12, no. 12, pp. 823–833, 2021, doi: 10.14569/IJACSA.2021.01212100.

[28] A. A. Jamali, K. Ur, R. Khoumbhati, A. A. Shah, and A. Bhutto, "Validating of survey instrument in the perspective of computer technology-based learning", vol. 3, no. 1, 2023.

[29] A. Muhammad, S. Chandio, and R. Maree, “Investigating the content validity of an IOT-acceptance survey instrument in higher education: a study in the context of Sindh,” vol. 3, no. 2, pp. 172–189, 2024.

[30] M. Shamout, R. Ben-Abdallah, M. Alshurideh, H. Alzoubi, B. Al Kurdi, and S. Hamadneh, “A conceptual model for the adoption of autonomous robots in supply chain and logistics industry,” Uncertain Supply Chain Management, vol. 10, no. 2, pp. 577–592, 2022, doi: 10.5267/j.uscm.2021.11.006.

[31] Rayhab Anwar Master, “Framework for the implementation of knowledge sharing behavior in global software development organizations”, M.S. thesis, Faculty of Information and Communication Technology, Universiti Tunku Abdul Rahman, June 2019.

[32] A. A. Jamali, K. Ur, R. Khoumbhati, A. M. Jamali, A. Bhutto, and A. A. Shah, “A conceptual framework of ICT impact on students’ academic performance : higher education institutes (HEIs) ”, vol. 21, no. 4, pp. 16–28, 2023.