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The Impact of Higher Secondary ICT Education on University STEM Student Performance

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Abstract

This study investigates the significant impact of ICT education from the Higher Secondary Certificate (HSC) on Bangladeshi students' progress in tertiary STEM fields. Through utilizing a comprehensive examination of demographic profiles, proficiency assessments, facility rating systems, and satisfaction measures, this study determines the complex relationships between HSC-level ICT education as well as success in STEM areas at the university level. Data were collected through an online survey from 244 students enrolled in Computer Science and Engineering (CSE), Software Engineering (SWE), and Information Technology Management (ITM) departments. The results highlight how many different factors have significant effects on students' first-semester SGPA. Several variables, including prior ICT knowledge on data handling from college, quality of instruction provided by the college ICT teacher, and HSC-level ICT course grade, have strong relationships with student performance at the university level. This study illustrates the positive impact of improved instructional materials and teacher-led projects on strong skill development, a phenomenon that will increase overall satisfaction among learners. Although geographical location, gender, and college type have been explored, it does not appear that they have significantly affected ICT course grades directly. Instead, instructional components and techniques for improving skills become important factors in determining students' academic performance. The study not only finds significant relationships but also promotes curriculum improvements with a focus towards ICT education technique optimization. With an aim of improving instructional methods and curriculum design, these observations provide governments and other individuals within education with suggestions that are applicable. The study highlights how important it is to effectively utilize ICT education in order to encourage overall STEM development in Bangladesh's educational system.

Keywords:

ICT Education;
Statistical Analysis;
STEM Students;
Students Performance;
Curriculum Development.

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1- Introduction

The rapid expansion of the economy has led people to recognize undeniably that technology plays a crucial role in promoting higher education and economic development [1]. ICT plays a pivotal role in improving education access and awareness in developing nations. They greatly aid in acquiring and sharing knowledge, offering remarkable chances for underprivileged countries to enhance education, policy-making, and economic prospects. Every facet of human existence is being impacted by Information and Communication Technologies (ICT). The adept use of ICT in developed countries

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has already demonstrated a significant role in their economic and societal advancement. The use of information technologies in several sectors—including the education sector, one of the key sectors—determines the economic success of a nation [2]. The Bangladeshi government recognizes the significance of ICT education in the contemporary global context [3]. So, in recent times, the Government of Bangladesh has embraced the integration of ICT within both domestic and international educational institutions, underscoring the significance of this initiative [4]. In this regard, the government introduced ICT education, which was integrated into the curriculum of secondary school certificate (SSC) and higher secondary school certificate (HSC) levels in 2013 [3]. At the HSC level, Bangladesh is currently in the initial phases of embracing ICT adoption with the intention of improving students' understanding and stimulating their interest in this field. This is done to aid students in understanding the significance of ICT in our rapidly transforming world. Students get an opportunity to educate themselves on the fundamentals of computers through this intermediate-level ICT educational program. This includes understanding computer basics and hardware components like input and output devices, processing units, and storage devices. Additionally, students will learn about the operational principles of hardware, the functioning of operating systems, the basics of networking, communication devices, the Internet, programming fundamentals, and more [3]. This study assists students in attaining higher levels of education. It additionally assists them to make career choices; for instance, there has been an enormous rise in choice for the IT sectors at the university level in the past few years.

The impact of prior ICT education at the Higher Secondary Certificate (HSC) level on students' success in STEM (Science, Technology, Engineering, and Mathematics) subjects at universities is enormous. Students' journey into tertiary STEM professions is enhanced by this foundational education, providing them the information and skills they need. Many courses require the use of specialized software, data analysis tools, and programming languages. Higher secondary-level ICT education can provide a head start in understanding these tools, making it easier for students to engage with complex course content. As students make their way into university STEM performance, the benefits of a strong ICT education at the HSC level become visible, giving them a strong basis in technology and problem-solving abilities. This prior education helps students integrate more easily and enables them to have the confidence and adaptability to face the challenges that come along with entering the STEM fields. Higher education has been significant in adopting modern technology and driving innovation in a variety of sectors, including education, knowledge dissemination, instructional delivery, healthcare services, artistic performances, and public administration, among others. This prepares students for university-level studies, where a significant amount of research, coursework, and communication is conducted using digital platforms. Many universities in Bangladesh have successfully integrated ICT into their curricula, employing it in effective and suitable ways to enhance teaching and learning across various academic areas. By efficiently incorporating ICT into their educational programs, these universities have harnessed its potential to significantly elevate the quality of education and benefit a diverse range of academic participants. This shift has enabled students to use online learning platforms, digital libraries, and e-learning resources. They can engage with multimedia content, participate in online discussions, and access a variety of educational materials that enrich their learning experience. Proficiency in ICT allows students to collaborate with peers and professors through digital platforms, facilitating group projects, discussions, and information sharing regardless of physical distances. This prepares them to adapt to different modes of instruction, which is especially important during unforeseen circumstances like the COVID-19 pandemic.

Later research further emphasizes the importance of keeping ICT education within the scope of national development plans. Bangladesh's Vision 2041 and Digital Bangladesh initiatives explicitly emphasize ICT literacy as a basis for economic growth and innovation [5]. However, even as policy plans recognize the importance of ICT, the degree to which initial ICT exposure at the higher secondary level translates to measurable academic success in STEM disciplines has not been thoroughly assessed. Much of the assessment that exists remains descriptive in character, aimed at infrastructure provision or teacher professional development, not at empirical student outcomes. The discrepancy between policy intention and empirical reality underlines the need for studies that undertake diligent analytical scrutiny of the educational effect of HSC-level ICT education and, accordingly, inform curriculum reform and national education policy [6].

The study aims to investigate how ICT education affects university-level studies. Determine the students' comprehension level following their Higher Secondary-level ICT course, assess how ICT education affects their choice of university department and career plans, and identify areas in the ICT sector that require improvement. Overall, our study seeks to advance knowledge of the impact of Higher Secondary ICT education on universities in Bangladesh, based on the following factors.

The remainder of this paper follows the following structure: Section 2 briefs the relevant literature and situates the study within existing research. Section 3 describes the research design, data gathering, and data analysis employed. Section 4 presents the results of the statistical tests, and then Section 5 provides an in-depth discussion interpreting the findings in relation to existing studies and policy implications. Lastly, Section 6 concludes the paper by presenting main findings, mentioning limitations, and presenting directions for future research.

2- Related Work

ICT Digital technology has played a pivotal role in the economic development of societies by significantly influencing higher education and its modernization [1]. ICT contributes significantly to the economic, political, social, and cultural advancement of emerging countries [7]. Development allocates significant investment to education [8]. & education plays a pivotal role in the development of a nation [9]; both are connected. Rahman et al. [2] Over the past twenty years, numerous nations have made substantial investments in the comprehensive development of information and communication technology (ICT). The Bangladeshi government has undertaken various initiatives to incorporate information and communication technology (ICT) in education. The government has initiated the "ICT for Education" project, aiming to integrate ICT tools in schools and colleges by supplying computers, internet access, and digital content to enhance interactive and modern learning. This education empowers students to embrace technology-driven career paths, aligning with Bangladesh's vision of a digital economy.

The World Bank, the UN, and other donor organizations are implementing large-scale projects or programs in developing countries that cost millions of dollars and are supported either directly or indirectly by information and communication technologies (ICT) [10]. ICT has the power to substantially change lifestyles, prepare students for careers, improve educational systems, and completely transform how we access and use information [8]. Amid the tech revolution, education must integrate ICT for enriched experiences, especially in universities [9]. Worldwide, educational institutions have embraced ICT for teaching and providing academic programs focused on ICT [11]. Several educational institutions in Bangladesh have used ICT in their strategies of teaching [11]. Almost all public and private universities offer study in ICT-related subjects such as Computer Science & Engineering (CSE), and some provide Software Engineering (SWE) as well. The field of information and communication technology (ICT) focuses on using software and computers, and CSE concentrates on fundamental ideas about the building blocks of computers and networks (hardware), as well as fundamental ideas about programming (formal languages, programming, and software development) [12]. While the relationship between ICT uses and student achievement in higher education is yet unknown [11]. However, Higher Secondary ICT provides ideas and influences students towards IT-centered subjects in university.

Current research also emphasizes the evolving role of ICT in supporting STEM education worldwide. Sun et al. [13] illustrated how technology-infused STEM education makes more use of computational tools, inquiry learning, and game pedagogies to gain 21st-century skills in students. In the same vein, Hertweck & Lehner [14] showed that ICT skills strongly influence STEM career choice, especially among female students, and that improved ICT foundations in secondary school can help address gender gaps. Torres & Inga [15] highlighted that school-level programming and robotics integration increase student motivation and build critical thinking capabilities, establishing a stronger basis for future STEM education. Within Africa, Nsabayezu et al. [16] pinpointed that multimedia-supported flipped classrooms improved engagement and motivation in secondary-level chemistry, but with rural learners being disadvantaged by the lack of ICT infrastructure. All these recent initiatives underscore the imperative need for strengthening ICT education at the secondary level, upon which other areas of equity, infrastructure, and gender participation must be addressed—also gaps that remain very relevant for Bangladesh and which form the purview of the present study.

2-1- Comparative Analysis and Summary

According to Rahman et al. [1], it shows that digital technology (internet users) and GDP stimulate higher education, with a 3.26% increase for a 1% rise in digital technology and an 18.93% increase for a 1% rise in GDP. This research underscores the importance of effectively integrating digital technology in higher education for sustainable economic growth in Bangladesh, emphasizing collaboration among educators, institutions, and policymakers. Huda et al. [9] Approximately 35% of private universities in Bangladesh utilize ICT to a significant degree for teaching purposes. The utilization of ICT in education, particularly in Bangladesh, Nepal, and Sri Lanka, was examined by the Asian Development Bank (ADB) [17]. This study offers comprehensive insights into ICT in education initiatives in Bangladesh, along with an assessment of their strengths, weaknesses, opportunities, and threats [17]. Roughly 1,367,377 students were registered for higher secondary examinations in Bangladesh in the year 2020 [3]; most of them are from rural areas. The majority of trained teachers work in urban areas with advanced facilities [3]. A wide range of teachers struggle to provide adequate guidance, and there is a shortage of laboratory facilities in rural areas in contrast to urban areas [3].

The main findings of Rahman et al. [2] include infrastructural problems in using ICT, higher student interest in ICT integration, and recommendations for providing ICT facilities in classrooms and developing an ICT-based service system. The study also emphasized the importance of teachers and focused on ICT training for them. Limitations of the study include the lack of ICT equipment, manpower, and training in institutions, as well as the need for further development and practice of ICT facilities. The study also suggests further research on the development and practice of ICT facilities [2]. Chowdhury et al. [18] The study highlights ineffective ICT integration in higher education, citing obstacles like teachers' limited skills, inadequate equipment, and lack of technical support. Addressing these challenges is crucial for improving ICT utilization in higher education teaching-learning. The study's limitations include teachers' insufficient knowledge and skills, limited time, inadequate equipment, and a lack of technical support. Notably, the absence of self-reported issues and specific suggestions for further research is a noteworthy limitation. Additionally, there is a crucial need for comprehensive teacher training in ICT integration [18].

Al-Rahmi et al. [19] underscores the significant impact of PEU, PU, and ACU on students' ICT intentions and satisfaction, affirming the TAM model's robustness. It emphasizes the importance of systematic research for model validation in education sustainability. However, limitations, such as the unexplored CSE-PU relationship, call for future studies using interview techniques, cross-cultural validation, and consideration of cultural dimensions [19]. Islam et al. [11] The study reveals minimal impact of ICT on academic performance, as most students are unaware of its potential for academic enhancement, viewing ICT access primarily as a source of recreation. Limitations include a small sample size, potential bias from self-reported data, and limited generalizability to other academic programs, alongside a lack of detailed analysis on specific ICT tools. Suggestions for improvement lack empirical testing, necessitating careful interpretation and validation through further research [11]. Youssef et al. [20] explored the link between ICT use and student performance in higher education, noting conflicting literature results. It emphasizes that strategic implementation of digital technologies can significantly impact students' attitudes and academic achievements. Haque et al. [21] paper's key findings highlight subpar education quality in non-government universities, factors shaping perceptions of higher education quality, and recommendations for improving its quality. Study limitations encompass a small sample size, restricted generalizability, potential data collection bias, absence of external validation, and a narrow scope of variables [21]. The main findings of the paper by Punie et al. [22] included the potential impacts of ICT on education, such as improved student outcomes, closing the gender gap, assisting students with special needs, and enhancing teacher and classroom outcomes.

3- Material and Methods

This diagram illustrates the comprehensive data collection process and methodology employed for the analysis in this survey, encapsulating the research approach for the thesis.

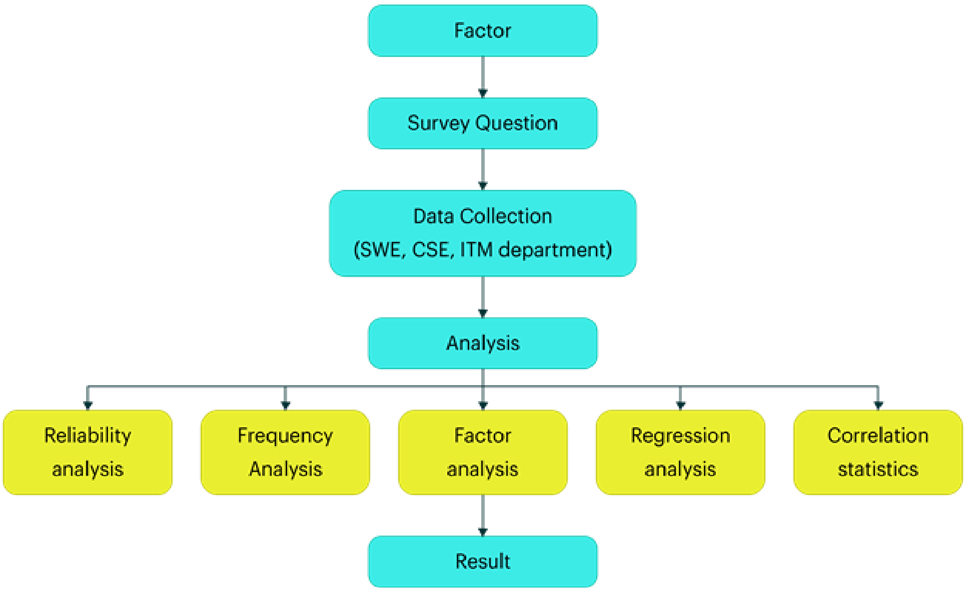

Figure 1. Methodology Diagram

3-1- Data Sources

The overall thesis strategy applied in this study is shown in Figures 1 and 2. Initially factors were identified, and then survey questions were created based on the standards that were identified. Then data collection started with students in the departments of Information Technology Management (ITM), Software Engineering (SWE), and Computer Science and Engineering (CSE). Using a Google Form, a semi-structured questionnaire with 38 questions that was based on specified requirements was created and sent. A total of 244 responses, including a range of opinions, were gathered from students enrolled at several Bangladeshi universities. After the data was collected, the SPSS program was used to conduct a detailed analysis that included regression, correlation, factor, reliability, and frequency analyses. This systematic technique made sure that the research objectives had been extensively investigated and made it easier to identify them.

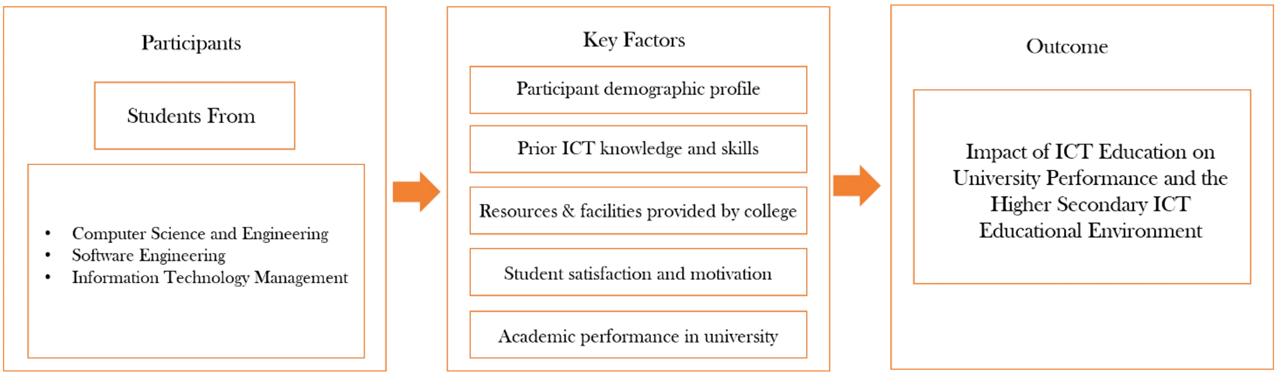

Figure 2. Data Collection Process

3-2- Reliability Test

We have analyzed our dataset, considering several parameters, to determine the condition of Higher Secondary ICT education in university STEM performance & Higher Secondary Educational Environment in Bangladesh. Starting with the Cronbach's alpha reliability testing in SPSS, it is used to ensure that survey questions are reliable internally. Cronbach's alpha (α) measures the dependability and consistency of a scale's items. It is determined using the variance of the individual items and the total score.

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2}\right) \tag{1}$$

Cronbach's alpha reliability testing uses k as the number of variables in the scale. The calculation relies heavily on the variance of individual items (σ_i^2) and total scores (σ_t^2). A high Cronbach's alpha value (preferably more than 0.7) signifies a strong correlation between the elements, showing the reliability and consistency of the collected data. This analysis is essential in ensuring that the survey accurately represents the desired fundamentals or variables, which increases reliance on the final conclusions.

3-3- Frequency Analysis

Frequency analysis is one of the statistical methods I used for categorical data in my survey. It shows the distribution or occurrence of various categories or principles, which helps to discover patterns or frequencies within certain variables and provides understanding of data structure and frequency. The percentages for each category are calculated using the following formula:

$$Percentage\ of\ Category = \frac{Count\ of\ Category}{Total\ Valid\ Cases} \times 100 \tag{2}$$

This approach consists of collecting a series of certain categories within a variable, known as the "Count of Category," and determining the overall number of non-missing values for that variable, known as the "Total Valid Cases." A simple formula is then used to calculate the proportion of cases allocated to each category, shown as a percentage of the total valid cases. SPSS finally provides these frequencies and percentages in a tabular style, allowing for simple analysis. This analytical approach is essential for identifying the distribution of values within a dataset, providing valuable understanding into regularities and frequency.

3-4- Factor Analysis

Factor analysis is a statistical technique used to find structural connections between observed variables, with the goal of reducing them into a smaller collection of unseen variables called factors. This method reveals the implicit structure of datasets, explaining connections and patterns among variables, simplifying difficult data and making it easier to understand relationships between many variables. The identification of factor loadings is essential to this study, and it frequently requires using methods such as principal component analysis (PCA) or maximum likelihood estimation (MLE). The formula for computing factor loadings is written as:

$$x = \lambda F + \varepsilon \tag{3}$$

The relationship between observed variables (x) and underlying factors (F) is defined in terms of strength and orientation. The factor loading (λ) indicates how closely the observed variable is related to the underlying element. The phrase denotes the error term, which captures variation that is not accounted for with the underlying variables.

3-5- Linear Regression Analysis

Significantly applying a linear equation to observed data, linear regression analysis in SPSS aims to explain the connection between a dependent variable and one or more independent variables. One independent variable is incorporated in the simple linear regression equation, which is as follows:

$$Y = \beta_0 + \beta_1 X + \varepsilon \tag{4}$$

The independent variable (X) is the predictor, while the dependent variable (Y) determines what is being predicted or explained. When $Y = X = 0$, the constant term that indicates Y's value is the y-intercept ($Y = \beta_0$). For a one-unit change in X, the slope coefficient (β_1) indicates the rate of change in Y. The variation in Y as the regression equation fails to explain is corrected for the error term (ε).

For multiple linear regression, this includes multiple independent variables; the equation extends to include for each variable:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon \tag{5}$$

3-6- Correlation Analysis

Correlation analysis is a tool used in SPSS to evaluate the direction and strength of a relationship between two continuous variables. The amount that changes in one variable are related to changes in another is measured by the correlation coefficient, which is commonly represented by the symbol r. The following is the formula to find the Pearson correlation coefficient (r):

$$r = \frac{\sum(X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum(X - \bar{X})^2 . \sum(Y - \bar{Y})^2}} \tag{6}$$

Correlation analysis investigates the connection between two continuous variables, represented as X and Y. The correlation coefficient (r), which is a number between -1 and 1, is computed to express the significance and orientation of this connection. A complete positive correlation, or one in which both variables establish as one does, is denoted by a correlation coefficient of 1. A perfect negative correlation, on the other hand, is represented by a coefficient of -1, meaning that as one variable rises, the other falls. There may not be a linear relationship between the variables if the correlation coefficient is 0.

4- Result Analysis

4-1- Demographic Profile of Participants

Table 1 shows that the survey included 244 people from the departments of Computer Science and Engineering (CSE), Software Engineering (SWE), and Information Technology Management (ITM); most of them were men (82.4%) with a small percentage of females (17.6%). Their educational backgrounds differed according to the type of college they attended: 34.4% were associated with government-affiliated colleges, 22.5% were enrolled in semi-government schools, and 43.0% attended colleges that were private. Geographically, most of the respondents (84.4%) were from urban areas, followed by those from semi-urban areas (23.4%) and rural areas (8.2%). About 51% passed HSC in 2019, whereas 24.4% and 24.2% passed before 2018 and in 2018.

The 244 participants were drawn from several universities offering CSE, SWE, and ITM programs, including both public and private institutions. However, as the demographic data show, the majority (84.4%) came from urban universities, with smaller representation from semi-urban (23.4%) and rural (8.2%) contexts. While this provides some variation, the sample is more reflective of students in urban institutions with relatively better ICT access. Broader representation across elite and rural universities would improve generalizability, and this is acknowledged as a limitation.

Table 1. Demographic profile

Variable	Categories	Frequency	Percent
Gender	Male	201	82.4
	Female	43	17.6
College category	Private	105	43.0
	Semi-Government	55	22.5
	Government	84	34.4
College location	Urban	167	84.4
	Semi-Urban	57	23.4
	Rural	20	8.2
HSC passing year	Before 2018	60	24.4
	2018	59	24.2
	2019	125	51.2

4-2- ICT Proficiency Levels Received from HSC Studying and Facilities Available During HSC

Table 2 presents students' perceptions of their achieved ICT proficiency levels during college. Students attained proficiency during HSC in areas such as computer hardware, computer software, networking, internet use, data handling, programming, use of multimedia, internet access, and up-to-date laboratory practices. Based on students' perceptions, only proficiency in internet access scored above 4. Among the skills, students demonstrated lower proficiency in data handling (3.28), up-to-date lab experiments (3.44), and networking (3.48).

Table 2. ICT proficiency levels achieved during college

Criteria	Not at all (%)	Rarely (%)	Neutral (%)	Moderate (%)	Very Strong (%)	Average score	Rank*
Computer Hardware	8 (3.3)	18 (7.4)	74 (30.3)	99 (40.6)	45 (18.4)	3.64	4
Computer Software	9 (3.7)	20 (8.2)	71 (29.1)	95 (38.9)	49 (20.1)	3.64	4
Networking	7 (2.9)	30 (12.3)	86 (35.2)	80 (32.8)	41 (16.8)	3.48	7
Internet using	3 (1.2)	3 (1.2)	40 (16.4)	96 (39.3)	102 (41.8)	4.19	1
Data handling	21 (8.6)	36 (14.8)	81 (33.2)	65 (26.6)	41 (16.8)	3.28	9
Programming Language	9 (3.7)	17 (7.0)	66 (27.0)	112 (45.9)	40 (16.4)	3.64	3
Use of Multimedia	4 (1.6)	36 (14.8)	45 (18.4)	108 (44.3)	51 (20.9)	3.68	2
Internet access	6 (2.5)	37 (15.2)	64 (26.2)	94 (38.5)	43 (17.6)	3.54	6
Upto date lab experiment	10 (4.1)	39 (16.0)	71 (29.1)	81 (33.2)	43 (17.6)	3.44	8

* Lowest rank (rank 1) indicates highest perception about achieving proficiency.

4-3- Student Satisfaction Levels in Higher Secondary College

The collected dataset is sufficient and consistent for performing factor analysis, as the KMO measure is greater than 0.6 and the P-value of Bartlett's Test of Sphericity is less than 0.01 (Table 3). It is also found that there is only one component used to measure satisfaction with ICT education at the HSC level (SICT Education) among Bangladeshi students. The equation for satisfaction with ICT education at the HSC level is:

$$S_{ICT\ Education} = 0.793 \times X_1 + 0.768 \times X_2 + 0.744 \times X_3 + 0.734 \times X_4 + 0.726 \times X_5 + 0.724 \times X_6 + 0.690 \times X_7 + 0.678 \times X_8 \quad (1)$$

Table 3. Component detection from factor analysis

Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy	Bartlett's Test of Sphericity			Component matrix	
	Chi-Square	df	P value	Items	Loading
0.882	812.7	28	<0.01	Quality ICT Teaching Methods in HSC (x_1)	0.793
				Sufficient ICT Facilities in College (x_2)	0.768
				Quality ICT Curriculum (x_3)	0.744
				Quality Instruction ICT Teacher (x_4)	0.734
				Support Instructors Peers ICT Studies (x_5)	0.726
				Computer Labs Availability College (x_6)	0.724
				Alignment ICT Curriculum Interests Needs (x_7)	0.690
				Effective Assessment Methods (x_8)	0.678

4-4- Effects of ICT Education During HSC on SGPA in First Semester

Table 4 and Figure 3 present the results indicating that ICT grade and prior knowledge about dealing with data and quality of ICT teachers at college are significantly influencing factors, as indicated by the p-value less than 0.05, on SGPA in the first semester at university. This points out that strong performance in structured ICT courses and high quality of teaching during HSC increases academic success at a tertiary level. On the other hand, variables like prior ICT skills and college teachers' general effort do not have a significant impact on SGPA. These findings emphasize the importance of focused ICT education and effective teaching in preparing students for university studies.

Table 4. Impact of ICT education during HSC on SGPA in first semester

Criteria	Coefficient	P Value	95.0% Confidence Interval for B		Collinearity Statistics	
			Lower Bound	Upper Bound	Tolerance	VIF
ICT grade	0.106	0.008	0.184	0.028	0.990	1.011
Prior knowledge on dealing with data	0.010	0.026	0.007	0.102	0.490	2.040
Quality of ICT Teacher at college	0.016	0.044	0.002	0.124	0.455	2.195
Prior ICT Skills	-0.041	0.218	-0.106	0.024	0.214	4.667
College teachers' effort	0.012	0.495	-0.023	0.048	0.403	2.480

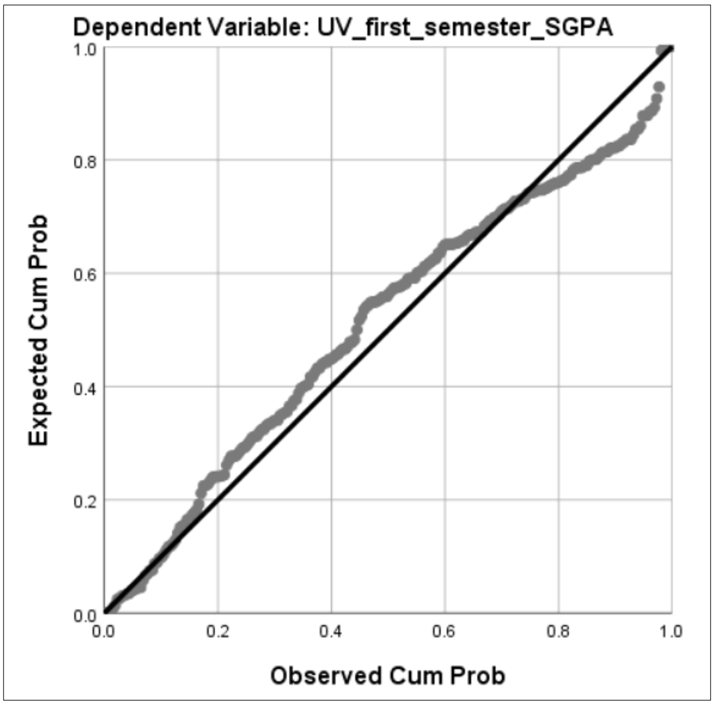

Figure 3. Regression analysis chart on SGPA

4-5- Impact of College Facilities on Student Skills

It is revealed that providing hands-on training, availability of computer resources, and access to the internet have a significant impact on achieving ICT skills among HSC-level students, as the P-values of these variables are less than 0.05 (Table 5). Although the study includes the availability of facilities for practical exercises, the use of multimedia, and up-to-date laboratories as college facilities, these factors are not significant in developing students' ICT skills. An increase of one unit in hands-on training facilities leads to an increase of 0.874 units in students' ICT skills.

Table 5. Impact of Facilities in College on ICT Skills of the Students

Criteria	Coefficient	P Value	95.0% Confidence Interval for B		Collinearity Statistics	
			Lower Bound	Upper Bound	Tolerance	VIF
Practice Exercise	0.124	0.515	-0.251	0.500	.749	1.335
Hand on training	0.874	<0.01	0.469	1.278	.697	1.434
Multimedia	0.390	0.056	-0.010	-0.010	.627	1.594
Computer Resources	0.248	<0.01	-0.193	0.689	.615	1.625
Internet access	0.043	0.036	-0.361	0.448	.599	1.670
Labs-upto-date	0.114	0.611	-0.326	0.553	.459	2.180
Lab functional	0.097	0.685	-0.376	0.570	.450	2.225

4-6- Impact of ICT Course Facilities on Students' Satisfaction Regarding ICT Education

Table 6 shows the impact of laboratory and content facilities of ICT courses in colleges on students' satisfaction with ICT education. The inclusion of Programming Language as part of the ICT course content increases students' satisfaction with ICT education at the HSC level, at a 1% level of significance, as the P-value is <0.01. Among the facilities in ICT courses, the use of multimedia resources, computer availability in college, internet access availability, up-to-date computer software, and hands-on training in ICT are significantly impactful in promoting ICT education at the HSC level, as these factors have a significant effect on students' satisfaction (P-value <0.05).

Table 6. Impact of Lab and Content Facilities of ICT course in College on Students' Satisfaction regarding ICT Education

Criteria	Coefficient	P Value	95.0% Confidence Interval for B		Collinearity Statistics	
			Lower Bound	Upper Bound	Tolerance	VIF
Data handling	0.137	0.549	-0.311	0.585	0.582	1.719
Programming Language	1.544	<0.01	1.027	2.06	0.644	1.554
Database Management	0.375	0.415	-0.529	1.279	0.811	1.232
Web Development	0.072	0.873	-0.806	0.95	0.851	1.175
Networking	-0.208	0.656	-1.129	0.713	0.758	1.319
Cybersecurity	-0.986	0.096	-2.147	0.175	0.871	1.148
Artificial Intelligence	-1.051	0.092	-2.274	0.173	0.739	1.353
Digital Device Logic Gate	0.482	0.290	-0.414	1.379	0.79	1.266
Use of Multimedia Resources	0.529	0.007	0.146	0.912	0.627	1.594
Computer Availability in College	1.064	<0.01	0.642	1.486	0.615	1.625
Internet Access Availability in College	0.632	0.001	0.245	1.02	0.599	1.670
Upto Date Computer Software	0.724	0.001	0.303	1.144	0.459	2.180
Upto Date Hardware in computer	0.361	0.192	-0.183	0.905	0.564	1.773
Hands on training	1.671	<0.01	1.164	2.178	0.677	1.477

4-7- Impact of Cognitive Ability on Satisfaction of ICT Education and ICT Skill

Table 7 presents the impact of students' cognitive ability on satisfaction with ICT education and proficiency in ICT skills. Both variables—Creative Problem Solving and Critical Thinking—have a significant positive impact on satisfaction and proficiency in software-related skills, as the P-value is <0.01. However, only Critical Thinking shows a significant positive impact on proficiency in hardware/network-related ICT skills.

Table 7. Impact of Cognitive ability on ICT Skill and ICT course satisfaction

		Model I		Model II		Model III	
		Creative Problem Solving	Critical Thinking	Creative Problem Solving	Critical Thinking	Creative Problem Solving	Critical Thinking
Coefficient		1.445	1.755	0.273	0.848	0.472	0.33
P Value		<0.01	<0.01	0.220	<0.01	<0.01	0.001
95.0% CI	Lower	0.971	1.257	-0.164	0.389	0.291	0.139
	Upper	1.918	2.254	0.709	1.308	0.654	0.521

Note: Dependent variable of Mode I: Satifaction of ICT education, Model II: Proficiency of hardware/ network related skills of ICT and Model III: Proficiency of software related skills of ICT.

5- Discussion

This study examines the perceptions of students regarding their ICT proficiency levels gained during Higher Secondary Certificate (HSC) education and the subsequent impact on their academic performance and satisfaction in higher education. Several key insights emerge from the analysis, particularly in terms of students' proficiency in various ICT skills, the quality of ICT education they received, and the effect of these factors on their early university outcomes. The results from Table 2 show a wide range of ICT proficiency levels achieved by students during their HSC studies, with notable differences across various ICT domains. Students reported the highest proficiency in internet usage (average score: 4.19), followed by the use of multimedia (3.68) and programming languages (3.64). However, students indicated relatively lower proficiency in data handling (3.28), up-to-date lab experiments (3.44), and networking (3.48). These findings suggest that while students are becoming proficient in basic ICT skills such as internet usage and multimedia, more advanced and practical skills, such as data management and lab-based learning, require further improvement [23, 24]. The lower scores in areas such as data handling and up-to-date lab experiments reflect gaps in practical, hands-on ICT education. This may be attributed to inadequate lab facilities or a lack of emphasis on applied learning in the curriculum [25].

To bridge this gap, schools and colleges must focus on enhancing lab infrastructure and providing more opportunities for hands-on experience with data management and networking [26]. The factor analysis results shown in Table 3 highlight key factors influencing student satisfaction with ICT education during HSC. It was found that quality teaching methods, sufficient ICT facilities, and alignment of the curriculum with student interests were the most critical factors. The overall high Kaiser-Meyer-Olkin (KMO) value (0.882) indicates that the variables used in the analysis were appropriate for understanding satisfaction with ICT education [27]. The significant loading of items such as "Quality ICT Teaching Methods" (0.793) and "Sufficient ICT Facilities in College" (0.768) reinforces the importance of both teaching quality and facility availability in driving student satisfaction. This aligns with prior literature, where the quality of instruction and the adequacy of ICT resources are identified as crucial components for effective ICT education [28]. It is clear that improving both the quality of teaching and access to adequate resources can substantially enhance students' satisfaction and overall learning experiences. The study also explored the effects of ICT education during HSC on students' first-semester performance at university (Table 4). The results indicate that ICT grades, prior knowledge in data handling, and the quality of ICT teachers significantly impacted students' Semester Grade Point Average (SGPA) at university. Among these, the ICT grade had the strongest effect ($p = 0.008$), suggesting that students who performed better in their ICT coursework in HSC were more likely to succeed academically in their first semester of university [29]. Interestingly, prior ICT skills and the college teachers' effort did not have a significant impact on SGPA. This could imply that general ICT skills gained before HSC or teachers' additional support may not be as critical as specific, formal instruction and the final grade in ICT. The focus should, therefore, be on ensuring that students perform well in structured ICT courses during HSC, as this directly correlates with their university success [30].

Table 5 shows that hands-on training, computer resources, and internet access significantly impacted students' ICT skills during HSC. Hands-on training had the strongest effect (coefficient = 0.874, $p < 0.01$), highlighting the importance of practical learning opportunities. Access to modern computer resources and reliable internet also played vital roles in helping students acquire ICT skills [31]. Factors like multimedia use, up-to-date labs, and lab functionality were not significant. This may suggest that while these resources are essential, they are not utilized effectively, or the existing infrastructure is insufficiently modern to meet students' learning needs. Therefore, increasing the availability of practical training and ensuring that computer labs are up-to-date could further improve students' ICT proficiency [32].

As shown in Table 6, programming languages, multimedia resources, computer availability, and internet access were key determinants of student satisfaction with ICT education. Programming languages had a particularly strong impact on satisfaction ($p < 0.01$), suggesting that students find the mastery of coding languages critical to their overall educational experience in ICT [33]. Multimedia resources and up-to-date software also had significant positive impacts on satisfaction, which aligns with the trend of increasing reliance on multimedia in both teaching and learning environments. The findings emphasize the need for institutions to provide modern and relevant content, as well as ensure that students have access to cutting-edge technologies [34].

Table 7 highlights the significant positive impact of creative problem-solving and critical thinking on both satisfaction with ICT education and ICT skill proficiency. Both cognitive abilities were crucial for the development of software-related ICT skills, with creative problem-solving playing a slightly larger role. Moreover, critical thinking was the only significant predictor of proficiency in hardware and network-related ICT skills ($p < 0.01$) [35]. These findings underscore the importance of developing higher-order thinking skills alongside technical ICT education. Critical thinking and creative problem-solving enable students to apply their ICT knowledge in more innovative and effective ways, which can lead to both higher satisfaction and greater proficiency in a broad range of ICT competencies [36]. These findings signal the critical gaps in students' ICT skills and have useful implications for education policy and practice. In light of these findings, it is recommended that the education system at the university level invest in modern computer laboratories with access to reliable internet services and hands-on training that can help students attain high-order skills, such as handling data and networking, which will enable them to be globally competent in academic and professional life. Moreover, the enhancement of ICT teaching methods and the harmonization of curricula with the emerging technological requirements will better equip students for the challenges of higher education and the STEM workforce. This evidence-based approach provides actionable insights for policymakers in bridging skill gaps and a robust digital education framework.

The study's results suggest three priorities: (a) integrating mandatory programming and data science modules at the HSC level to strengthen technical skills, (b) enhancing teacher ICT training to ensure quality instruction, and (c) updating curricula to include applied, project-based learning aligned with university and industry needs. These reforms would bridge current gaps in data handling, networking, and critical thinking. The limitation of this study is that the low proportion of female respondents reflects broader enrollment disparities in Bangladeshi STEM fields. This imbalance may have influenced results on ICT proficiency and satisfaction, potentially underestimating gender-specific challenges. Cultural norms, systemic barriers, and limited encouragement for female participation in ICT-related fields likely contributed to the skewed ratio. Future studies should deliberately oversample female students to explore how gender mediates ICT proficiency and satisfaction. A longitudinal design would allow researchers to assess how the influence of HSC ICT evolves across multiple university semesters and into professional careers. Mixed-methods approaches, such as interviews or case studies, would provide richer insights into the lived experiences of students, teachers, and administrators. These methods could uncover contextual factors (e.g., motivation, institutional support, cultural barriers) that survey-based quantitative analysis alone cannot capture.

6- Conclusion

The research provides several valuable findings into the state of ICT education at the level of Higher Secondary Certificate (HSC) and its impact on student performance at higher levels of education. While the students demonstrated sufficient proficiency in basic ICT skills such as internet use and elementary programming, there are still significant gaps in sophisticated topics such as data handling, networking, and lab-based learning. Statistical examination also revealed that ICT course grades, characteristics of ICT pedagogy, and introductory exposure to data handling were predictor factors for first-semester STEM performance at the tertiary level. Additionally, practical training, computer laboratories with advanced features, and internet accessibility were crucial enablers of ICT skills acquisition, while programming languages and multimedia facilities significantly influenced student satisfaction. Critical thinking and creative problem-solving cognitive skills also played a determining role in enhancing both ICT competence and satisfaction. As a whole, these results support the fact that effective ICT learning at the HSC level not only confers technical proficiency but also provides resilience and confidence as students embark on university STEM studies. The study also carries enormous curriculum and policy implications. To optimize ICT learning benefits, the quality of teaching, access to updated labs, and equitable resource allocation between urban and rural universities have to increase. Teacher training improvement and expansion can enhance ICT skills gaps, thereby enhancing national competency for STEM development. These proposals harmonize with recent international studies emphasizing gender equity, technology incorporation, and motivational factors in STEM education supported by ICT. Future studies will have to extend the effort of this work with longitudinal studies on ICT skill development in professions, cross-country/region comparative studies, and supplementing quantitative data with qualitative data such as interviews and case studies to interpret quantitative data. By connecting HSC ICT curricula to the needs of higher education and the employment market, Bangladesh can better equip its students for academic success and draw nearer to its overall goal of creating a digitally literate and globally competitive workforce.

7- Declarations

7-1- Author Contributions

Conceptualization, K.B.B.B. and M.A.H.; methodology, K.B.B.B., M.A.H., M.E.H., and A.K.B.; formal analysis, A.K.B. and M.N.S.; investigation, K.B.B.B. and M.E.H.; data collection, M.N.S.; writing—original draft preparation, A.K.B.; writing—review and editing, S.N.S.H., M.E.H., and K.B.B.B.; supervision, M.A.H. and S.N.S.H. 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

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7-4- Acknowledgements

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7-5- Institutional Review Board Statement

Not applicable.

7-6- Informed Consent Statement

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

7-7- Conflicts of Interest

The authors declare that there is no conflict of interests 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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