

The Role of Cloud Computing in Enhancing University Education: Benefits and Challenges

Taposhi Tamanna¹ and Sk. Mamun Mostofa^{2*}

¹Research Student, Department of Information Science and Library Management,
University of Dhaka, Bangladesh

²Associate Professor, Department of Information Science and Library Management,
University of Dhaka, Bangladesh

¹taposhi-2020418517@islm.du.ac.bd, ²mostofa@du.ac.bd

Abstract

This research aims to assess the University of Dhaka's cloud computing readiness, identify challenges in implementing cloud computing, and examine the benefits and limitations of cloud computing as perceived by stakeholders. The research methodology employed in this study is quantitative research. Data were obtained from randomly selected students at Dhaka University through a structured data collection form that includes both closed- and open-ended questions. Inferential statistics, including correlation and regression analysis, are conducted using IBM SPSS. The results show a moderate level of awareness and a positive attitude towards cloud computing. The most important factors in the adoption of cloud computing were found to be security, scalability, and cost-effectiveness. The most important barriers were found to be a lack of technical knowledge, cost factors, and infrastructure. There is a statistically significant relationship between benefit perception and cloud adoption. The purpose of this research is to conduct the first empirical study on cloud computing readiness at Dhaka University and to shed light on this topic, which will have important implications for policymakers and administrative authorities of universities interested in the process of digital transformation in higher education in Bangladesh. The results show that the University of Dhaka is conceptually ready to implement cloud computing, but in terms of infrastructure and human resources (ability), they are facing serious challenges.

Keywords: Cloud computing, Higher education in Bangladesh, Adoption, Challenges, Digital transformation

1. Introduction

The digital revolution has not only made things faster but also enabled different ways of working together through cloud computing. In education, this change is quite apparent, as technology is reshaping how students learn and complete academic tasks. Cloud computing enables a new wave of information technology and consumer services to be delivered over the internet quickly and at reasonable prices, without compromising performance or security [1]. As a result, it supports the creation of modern learning environments that address the limitations of traditional education systems [2].

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*corresponding author

At the University of Dhaka, one of the leading public universities in Bangladesh, students are increasingly relying on cloud-based platforms for greater flexibility, improved productivity, and collaboration. Tools, including Google Drive, OneDrive, Zoom, Moodle, and other Learning Management Systems (LMSs), enable users to build, store, and share academic materials in real time. These platforms also support collaborative work, allowing multiple users to contribute simultaneously to documents, presentations, and research activities [3][4].

The increasing use of cloud computing in Higher Education Institutions (HEIs) is attributed to its key features, such as scalability, flexibility, resource efficiency, and accessibility [5][6][7]. Cloud-based applications support a wide range of academic activities, including online learning, group projects, assignment submission, and document management. Furthermore, they increase the availability of learning resources and enable more interactive and student-centered learning experiences [3][4].

However, despite these advantages, the integration of cloud computing in education also poses some challenges. Students with limited access to digital skills or technology might struggle to adapt to cloud-based learning environments. There are many issues with successful use, including internet connectivity reliability, data security, and technological complexity [8]. These challenges highlight the need for a focused, context-specific investigation into how students in Bangladeshi higher education actually use cloud computing.

This research is being conducted at the University of Dhaka to analyze students' context-specific approach to accepting and using cloud computing in their academic activities. Unlike general studies on ICT and e-learning, this study specifically examines the role of cloud technologies in enhancing learning experiences at a single institution. It focuses on identifying the benefits, challenges, and overall impact of cloud-based tools on students' academic performance, collaboration, and organization.

The importance of this research lies in its contribution to understanding cloud computing in the context of higher education in Bangladesh. The results are expected to help policymakers, educators, and university administrators make informed decisions regarding technology integration. Additionally, the study will serve as a basis for future research at other universities and in developing countries facing similar problems.

This study aims to examine how students at the University of Dhaka use cloud computing tools in their academic activities. It specifically investigates perceived benefits, potential barriers, and the overall impact of these technologies on learning, collaboration, and academic management.

2. Literature review

Cloud computing has emerged as a significant technology in higher education, offering institutions an opportunity to deliver academic services more efficiently while reducing infrastructure costs [3]. It enables us to access computing resources on demand and provides better flexibility, collaboration, and management of such resources [2]. Over time, researchers have studied cloud computing taxonomies and motivations for adoption, highlighting its strategic significance for universities [9]. As a result, many universities are moving to cloud-based systems managed by external providers [5], reducing the local infrastructure required at great cost.

Cloud computing allows access to computing services from anywhere with an internet connection. According to L. Singh, a consumer can now use computing services immediately

without needing to talk to any provider. Despite global growth in cloud computing adoption, adoption in Bangladeshi higher education, especially at the University of Dhaka, remains limited. Existing research primarily focuses on general factors related to adoption [10], with little empirical evidence provided on student use and academic impact. This is the gap in connecting the Technology Adoption Model (TAM) to Innovation Diffusion (DOI) in local contexts.

Therefore, this literature review aims to examine the adoption of cloud computing in higher education, identify key benefits and challenges, and analyze the relationships among familiarity, usage, and perceived benefits, as well as their impact on educational outcomes, within a TAM and DOI framework.

2.1. Conceptual framework for cloud computing adoption in higher education

This section reviews relevant theoretical models and prior research that explain the adoption of Cloud Computing (CC) in Higher Education Institutions (HEIs) in developing countries. Numerous studies have explored the adoption of cloud technology across various sectors. Amron M. T. et al. [11] identified common factors affecting adoption, including technology readiness, human readiness, organizational support, environmental conditions, and security and privacy concerns. Similarly, Arpaci I [12] concluded that adopting the Cloud in HEIs enhances knowledge management and improves user performance.

At the organizational level, the Technology-Organization-Environment (TOE) framework and the Diffusion of Innovation (DOI) theory are widely used. These models describe adoption in terms of factors such as relative advantage, compatibility, complexity, and external pressures [13][14][15]. However, most of these studies focus on institutional decision-making processes and often ignore individual user behavior, which is crucial in educational contexts.

At the individual level, Fred Davis's Technology Acceptance Model (TAM) has been widely used to explain students' adoption of cloud technologies. Prior research identifies the critical variables such as perceived usefulness, ease of use, trust, risk, behavioral intention, and actual usage [11][12][16]. For instance, Almazroi A. A. et al. [17] noted that the subjective factors of usefulness and ease of use have a significant impact on students' intention to adopt cloud services.

Other models, such as the Unified Theory of Acceptance and Use of Technology (UTAUT), also emphasize factors like performance expectancy, effort expectancy, and social influence as important determinants of technology adoption [18][19]. These models re-emphasize the importance of individual perception and external support for usage behavior.

Despite the use of several theoretical models, current research typically does not link adoption factors to educational outcomes. Most research looks at organizational readiness or user acceptance but does not relate these factors to actual academic efficacy.

2.2. Global trends in cloud computing in higher education

Cloud computing adoption differs from region to region. Countries such as India, Brazil, and South Africa widely use cloud computing to improve access to educational resources [20]. Cloud technologies support cross-border education through initiatives like the African Virtual University [21]. In developed countries, institutions are relying on cloud computing for advanced analytics, individualized learning, and administrative efficiency [22].

In contrast, developing countries face challenges related to limited infrastructure, small budgets, and a shortage of technical expertise [23]. Barriers impact adoption rates, as described by DOI, but they also reduce perceived ease of use from the TAM perspective.

2.3. The role of cloud computing in enhancing educational outcomes

Cloud computing enhances the quality of education by making learning more accessible and facilitating collaboration. Anytime access to academic materials improves students' flexibility in learning [24]. This section examines how Cloud computing makes academic work easier for students, supports staff members, and fits well with updated theories such as connectivism and constructivism. According to S. McMahon, various forms of learning materials are available on cloud platforms, including lectures, homework, supplementary materials, and digital books.

Tools like Google Drive and Microsoft OneDrive have allowed for real-time collaboration, fostering better teamwork and productivity [25]. By using such tools in platforms such as Google Classroom or Microsoft Teams, students can organize their work. This organized approach to school tasks frees the mind, as it no longer has to cope with a series of duties simultaneously [23].

Administrative tasks may be less burdensome for faculty using cloud computing, and it can also improve the way lessons are taught. An LMS brings lectures, information, quizzes, and the grading system together in one place, simplifying course management. Cloud platforms make it easier to manage courses and administer assessments, allowing educators to manage the learning process and provide efficient feedback [26].

2.4. Benefits, challenges, and limitations in implementing cloud computing

Cloud computing provides a range of advantages, including scalability, cost efficiency, and greater access to resources [2]. However, there are several challenges to adopting cloud computing. Moving computing resources to the Cloud is not without its challenges.

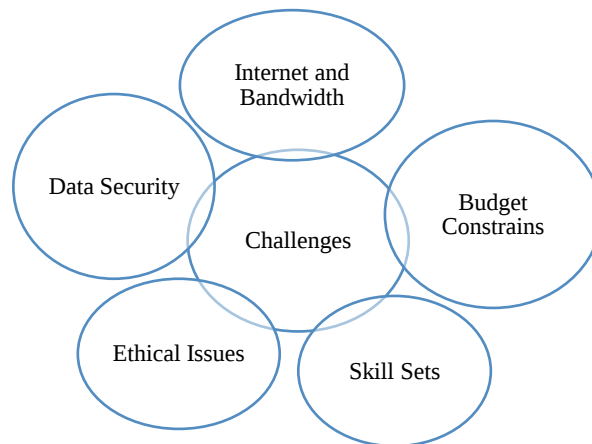


Figure 1. Challenges faced by the students in using cloud computing

Data security and privacy are always major concerns because sensitive data stored on external servers is at increased risk of cyber threats [27]. Hosting sensitive student and institutional data online carries inherent risks, including vulnerability to cyberattacks if systems are improperly secured and devices with saved credentials are stolen. Regulatory and compliance issues also constrain adoption [28].

Additionally, IT professionals' incorrect understandings of cloud security can further complicate implementation. Studies indicate that some professionals in Bangladesh are unclear about cloud security practices, resulting in ineffective cloud security strategies [29]. Another important limitation is the dependence on good internet connectivity. In areas with unstable networks, such as rural areas in Bangladesh, connectivity issues might hinder both teaching and learning [30]. High data costs and a lack of access to digital devices are also factors in a digital divide.

Furthermore, while cloud solutions save in the long term, the upfront cost for training, data migration, and system integration can be high. These financial and technical barriers often impede uptake in resource-constrained environments.

2.5. Cloud computing in Bangladeshi higher education

In Bangladesh, cloud computing in higher education is still in its early stages. Organizational readiness, technological infrastructure, and user acceptance are features that research suggests are important in adoption decisions [10]. As the leader, the University of Dhaka has the potential to play a pivotal role in the development of cloud-based education. However, challenges such as the lack of infrastructure, strategic planning, and training for faculty and staff make effective implementation difficult [10]. Recent research suggests a systematic framework customized to the local context to tackle these challenges [30].

2.6. Gaps in existing literature

Although there is extensive research on cloud computing in education worldwide, several significant gaps remain regarding Bangladesh and Dhaka University.

First, much of the existing literature is descriptive rather than analytical and often focused on general trends without examining the real-world challenges of implementation. There is a lack of institution-specific studies that provide in-depth insight into how cloud computing is used in practice at Bangladeshi universities [32].

Second, student perspectives are not represented. While numerous studies have examined the benefits of technology, few have looked at how students subjectively experience cloud platforms, including issues related to usability, accessibility, and effectiveness in completing academic tasks [25].

Third, there is a scarcity of empirical evidence of the link between cloud computing and actual educational outcomes. Claims of improved performance, collaboration, and efficiency are often theoretical and unsupported by concrete data [33]. This lack of evidence does not make it easy for policymakers and institutions to justify further investment.

Finally, there is still little research on cloud-based Learning Management Systems (LMS) in Bangladesh. Most studies are conducted in developed contexts and do not account for the unique infrastructural and socio-economic challenges that developing countries face.

3. Research questions

The main focus of the research is to determine the benefits of cloud computing to enhance the academic experiences of students at Dhaka University. The research questions are:

RQ1: How are students at Dhaka University currently using cloud computing in their studies?

RQ2: What do students identify as benefits from using cloud-based tools to support their learning activities?

RQ3: What are the challenges and barriers for students to use cloud services for education?

RQ4: To what extent is cloud computing contributing to better learning outcomes, collaboration, and organizational efficiency among Dhaka University students?

RQ5: Is there any relationship between a student's familiarity with cloud services and their perceived educational impact?

4. Methodology

4.1. Research design

The research method was quantitative, using systematic numerical and statistical analyses to analyze the data. In this study, a quantitative framework was chosen to examine the number of students using cloud computing, the factors influencing its use, and students' perceptions of usefulness and the problems encountered, all in quantitative terms. The target population of this research consisted of undergraduate and graduate students from Dhaka University, specifically the four of the 13 faculties: the Faculty of Arts, the Faculty of Business Studies, the Faculty of Science, and the Faculty of Social Sciences. This study employed a combination of convenience and purposive sampling techniques. Convenience sampling was used to select the faculty, and students were selected randomly for this study to ensure that every student had an equal chance of being selected as a respondent. More than 16,000 students were currently studying at Dhaka University at the undergraduate and postgraduate levels. Of the four faculties, 310 students were randomly selected to participate in the survey. This enabled the use of statistical tools, such as SPSS, to identify significant relationships and trends in the data. The research design was descriptive. A descriptive design was employed to gather information on problems that influenced the use of cloud computing in schools. The research was conducted using a structured survey questionnaire consisting of both closed- and open-ended questions; these provided clear numerical answers while also allowing respondents to share their views. The survey began in early July 2025 and ended in September 2025. Printed questionnaires were circulated to the students during class time by a class representative. In addition, a Google Forms link (<https://forms.gle/SXvttKv1RfCSseYF9>) was sent to the graduate and undergraduate students via email, WhatsApp, Messenger, and Telegram.

4.2. Data collection methods

The survey questionnaire was the primary data collection method in this quantitative study. This questionnaire was developed through consultations with experts and a comprehensive analysis of the literature to ensure that the relevant dimensions of respondents' perceptions and expectations are captured. In the survey, a 5-point Likert scale (where 1 = Strongly Disagree and 5 = Strongly Agree) was used to measure perceptions of purpose and satisfaction. A random sampling technique was applied to ensure that every student had an

equal chance of being selected as a respondent. From the study population, 310 students were randomly selected to participate in the survey.

4.3. Data analysis techniques

The survey data were analyzed using descriptive and inferential statistics. The analysis was performed using the Statistical Package for the Social Sciences (SPSS) and Microsoft Excel. The data were summarized using descriptive statistics. Measures such as frequencies, percentages, means, and standard deviations were calculated to provide an overview of the student population's perceptions and expectations. As the questionnaire was based on an ordinal scale, the nonparametric tests used in this study were the Mann-Whitney U test, the Kruskal-Wallis H test, and Spearman's Rho Correlation test. The Mann-Whitney U test was used to assess whether there were differences in the effects of cloud services between male and female students. The Kruskal-Wallis H test was used to determine whether the effect of cloud services varied significantly among students of different ages. The Spearman's Rho Correlation test was used to evaluate the relationship between familiarity with cloud services and their perceived impact. It demonstrated whether more practiced students with cloud technologies considered them more influential in their education. A reliability test was conducted to assess the survey instrument's reliability. The reliability of the survey instrument was assessed using Cronbach's alpha to determine internal consistency, as shown in Table 1.

Table 1. Reliability statistics

Reliability Statistics	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Overall Scale	.930	.933	22
Perceived Benefits	.942	.943	7
Faced Challenges	.879	.880	8
Perceived Impact	.939	.939	7

5. Data analysis of the study

Figure 2 presents the results of the total valid responses obtained by 310 students out of the four major faculties of Dhaka University. The Faculty of Arts received the highest number of responses (49%), indicating that students in the faculty were the most active in the survey. The largest response was from the Faculty of Science, with the Faculties of Business Studies and Social Science accounting for a relatively lower but significant proportion of the sample. The survey was distributed with greater weight given to humanities students, while ensuring an equal representation of viewpoints across the science, business, and social science areas. The representation of various student groups enhanced the credibility of the results, as cloud computing applications could be considered across a variety of disciplinary settings. All in all, the replies provided a broad perspective on cloud computing as a practice among university students.

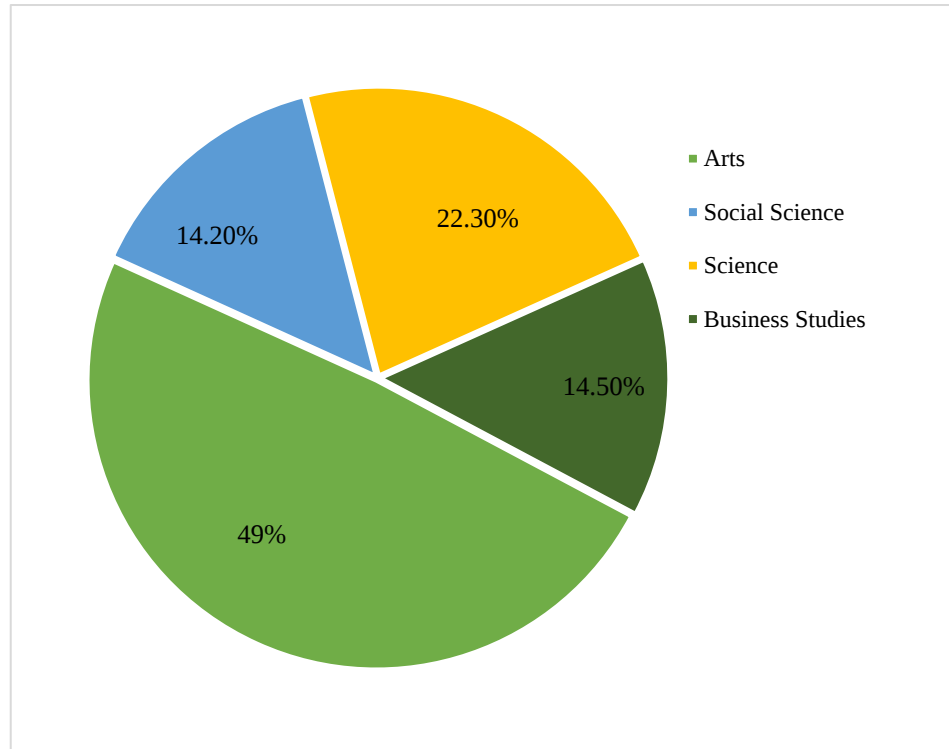


Figure 2. The response rate of the questionnaire

5.1. Demographic profile of the respondents

The survey had 310 respondents, whose demographic characteristics are summarized in Table 2. The percentage of female students in the sample was higher than that of male students, indicating greater involvement among female respondents. Many participants were in the age group 24–26, followed by 21–23, indicating that the sample consisted mainly of students in their early twenties. Academically, fourth-year students accounted for the largest share of participants, followed by a significant number of mastery students, indicating participation at both the undergraduate and postgraduate levels.

The respondents had varying levels of computer proficiency, with the majority describing themselves as having intermediate or moderate skills. Even though a smaller portion of them viewed themselves as knowledgeable, a significant part of the students also reported beginner-level technological competence, signifying discrepancies in technological expertise among students. In general, the demographic picture indicated that both sexes were represented, which represented a wide range of academic statuses and computer-user skills, and those more apt with computers, i.e., female students, senior undergraduates, and people in their early twenties.

Table 2. Demographic profile

Demographic		Frequency (N=310)	Percentage (%)
Gender	Male	138	44.5%
	Female	172	55.5%
Age Group	18-20 years	48	15.5%
	21-23 years	95	30.6%
	24-26 years	141	45.5%
	Above 26 years	26	8.4%
Current Study Level	1 st Year	62	20%
	2 nd Year	46	14.8%
	3 rd Year	53	17.1%
	4 th Year	115	37.1%
	Master's	34	11%
Computer Proficiency Level	Beginner	68	21.9%
	Intermediate	103	33.2%
	Moderate	85	27.4%
	Expert	54	17.4%
Total		310	100

5.2. Familiar with the term “cloud computing”

Table 3. Familiar with the term “cloud computing”

Are you familiar with the term "cloud computing"?	Frequency (N=310)	Percentage (%)
I have never heard of clouds until now	24	7.7%
I have heard of Cloud but am not exactly sure of the concept	80	25.8%
I have heard of the Cloud, but it has been a challenge for me to understand	39	12.6%
I am familiar with Cloud	116	37.4%
I have good knowledge of Cloud	51	16.5%
Total	310	100

The findings in Table 3 showed that most LIS students were somewhat aware of cloud technology. The largest percentage reported having general knowledge of the concept, while a significant group had heard of cloud technology but were not well informed or certain about what it entailed. A smaller sample showed a good understanding of the concept, and only a few respondents had never heard of cloud technology before the survey. These findings indicated that, despite a general awareness of cloud technology, respondents' knowledge levels varied significantly.

5.3. Usage of cloud computing services in studies

The survey results indicated that nearly all respondents had used cloud computing services such as Google Drive, Microsoft OneDrive, Dropbox, and Apple iCloud in academia, with a very small percentage reporting no experience with these services. This result indicated that cloud-based platforms were adopted by many students and implied that the technologies were a significant aspect of their learning.

Table 4. Usage of cloud computing services in studies

Have you ever used any cloud computing services (e.g., Google Drive, Microsoft OneDrive, Dropbox, iCloud) in your studies?	Frequency (N=310)	Percentage (%)
Yes	283	91.3%
No	27	8.7%
Total	310	100

5.4. Frequency of using Cloud for academic purposes

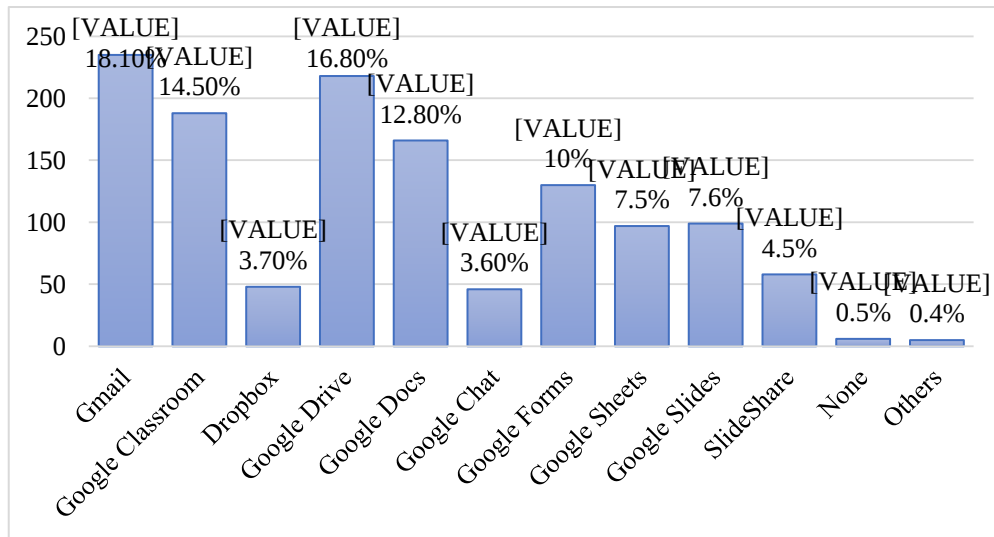
Table 5. Frequency of using the Cloud for academic purposes

How often do you use cloud services for academic purposes?	Frequency (N=310)	Percentage (%)
Daily	129	41.7%
Weekly	72	23.3%
Monthly	43	13.9%
Rarely	52	16.8%
Never	13	4.2%
Total	310	100

The results indicated that cloud services were regularly used by numerous students in their educational endeavors, with daily use being the most commonly reported mode. They were also used weekly, with smaller percentages being used monthly or very infrequently. Most respondents said they used cloud services. These results indicated that cloud services were a common part of students' academic lives and made a major contribution to the maintenance of their educational process.

5.5. Cloud services that students usually use

The results showed that Gmail was the most used cloud service among the students, with Google Drive and Google Classroom ranking second and third, respectively, in terms of their importance in academic research/activity. Other Google tools showed significant usage, though to a lesser extent: Google Docs, Google Forms, Google Slides, and Google Sheets. On the contrary, platforms like SlideShare, Dropbox, and Google Chat were less common originally, and only a small proportion of respondents did not use any cloud services or turned to other platforms. In general, the findings indicated that the Google ecosystem was very popular among students, and the set of tools it provides was the most commonly used cloud-based environment in their studies.



*Notes: Multiple responses were permitted

Figure 3. Cloud services that students usually use

5.6. Practical experience using Cloud

The respondents also had to give their reasons for using cloud facilities. According to most of the students, cloud services were used to store assignments and other academic files. Another typical use was sharing documents with classmates and accessing lecturers' materials, indicating that they collaborated academically and shared resources. Other forms, such as supporting notes and group tasks, were also used, both to support group work and, to a lesser extent, for research-based tasks. Very few respondents reported having no practical experience or other uses. In general, it showed that cloud services were primarily used for academic storage and collaboration, but not for more sophisticated or specialized research applications.

Table 6. Practical experience using Cloud

What do you mostly use cloud services for?	Frequency	Percentage (%)
Storing assignments/files	217	23.13
Sharing documents with classmates	191	20.36
Group projects and collaboration	124	13.22
Accessing materials from teachers	158	16.84
Backing up notes	143	15.24
Research proposal	79	8.42
I have no practical experience	24	2.56
Others	2	0.21
Total	938	100

*Notes: Multiple responses were permitted

5.7. Opinions about the benefits of cloud computing

The students responded to the perceived value of cloud services in their studies. The results indicated that the opportunity to study materials at any time and place was the most appreciated one. This was then closely accompanied by increased teamwork in group activities, perfectly organized study materials, and time saved in performing academic tasks.

Other benefits of cloud platforms identified by respondents included sufficient storage capacity and the ability to share files across devices. The role of cloud services in enhancing communication with supervisors and faculty members, however, was rated comparatively low. All in all, the findings showed that the students mostly appreciated cloud services for the accessibility, collaboration, and efficiency they provided in managing their academic lives.

Table 7. Opinions about the benefits of cloud computing

Statements	1	2	3	4	5	Mean	SD
Cloud computing makes it easier for me to access my study materials anytime, from anywhere.	9	14	83	87	117	3.93	1.04
It improves collaboration with classmates on group assignments.	6	10	78	128	88	3.91	0.91
Cloud tools help me stay organized with my academic tasks.	4	11	95	107	93	3.88	0.92
Using cloud platforms saves me time and effort in my studies.	7	13	83	109	94	3.88	0.97
They provide ample storage capacity for important documents.	9	13	89	102	97	3.85	1.01
They ease the interaction with the research supervisor/ faculty members	4	18	117	99	70	3.70	0.92
Cloud computing allows for real-time updates and file syncing across devices.	4	18	107	97	82	3.75	0.94

5.8. Opinions about the challenges faced in using cloud computing

The respondents were questioned about the challenges they encountered when using cloud services. According to the results, the cost of cloud services was the most significant problem, especially paid subscriptions. Issues associated with data security and privacy was also top of the list, as were system portability issues. Other reported issues included a lack of training or guidance on using cloud computing tools, the complexity of using cloud computing, and unreliable internet connections when using cloud computing platforms. Delays and system downtime were observed a few times as well. Conversely, device compatibility and performance constraints proved to be comparatively minor issues. In general, the findings indicated that although students found the use of cloud services beneficial, financial, security, and usability limitations prevented continued use.

Table 8. Opinions about the challenges faced with using cloud computing

Statements	1	2	3	4	5	Mean	SD
I face internet issues while using cloud services.	19	58	107	86	40	3.23	1.09
I worry about data privacy and security when using cloud tools.	17	46	108	103	36	3.31	1.04
I don't get enough guidance or training on how to use cloud computing properly.	15	54	114	94	33	3.25	1.02
Sometimes the tools are too complex or confusing to use.	22	44	114	98	32	3.24	1.05
My devices (mobile/laptop) are not compatible or fast enough for cloud apps.	36	69	123	54	28	2.90	1.10
Cloud services are often too expensive or require paid subscriptions.	14	40	110	96	48	3.39	1.03
I experience delays or downtime when accessing cloud services.	14	43	128	97	26	3.23	0.93
I find it difficult to migrate data between different cloud platforms.	15	41	130	90	32	3.26	0.97

5.9. Opinions about the educational impact of cloud computing

Table 9. Opinions about the educational impact of cloud computing

Statements	1	2	3	4	5	Mean	SD
Cloud computing helps me learn more effectively.	5	19	101	85	100	3.83	1.01
It supports better communication with teachers and classmates.	3	11	94	132	70	3.82	0.85
It provides 24/7 global access to my files.	4	14	94	95	103	3.90	0.96
Cloud tools help me manage deadlines and schedules more efficiently.	1	25	109	109	66	3.69	0.91
Cloud tools reduce my reliance on physical materials like notebooks or USB drives.	4	14	111	92	87	3.79	0.95
Cloud platforms make group projects and collaboration easier to manage.	1	16	104	113	74	3.82	0.85
Using cloud tools has improved my digital literacy and tech skills.	4	18	103	102	81	3.82	0.94

Students were self-reporting on the perceived benefits of cloud services in their learning. The results showed that the highest-rated point was 24/7 access to files worldwide, indicating flexibility in educational tasks. Other firmly rated benefits were a smoother learning experience, better teacher engagement and peer connections, and simpler cooperation during group activities. The interviewees were also aware that cloud technology was used to enhance digital literacy and reduce reliance on print-on-paper storage media, such as notebooks and USB drives. Students further admitted that cloud systems helped them keep track of academic timetables and deadlines, but this was also the least highlighted advantage. All in all, the findings indicated that the students perceived cloud services very positively, particularly regarding access, collaboration, and academic performance.

5.10. Mann-Whitney U test for gender differences in perceptions of cloud services

The findings of the Mann-Whitney U test (Table 10) showed that male and female students differed significantly in their attitudes towards cloud services. There were statistically significant differences in several areas, including perceived effectiveness in learning, communication with teachers and fellow students, 24/7 access to files, decreased dependence on physical materials, ease of cooperation in group work, and improvements in digital literacy and technological competencies. Male students, in all instances, showed more positive attitudes than female students. The general results suggested that gender was a modifying factor in students' perceptions of cloud computing, with males reporting a relatively higher perceived benefit.

Table 10. Mann-Whitney U test for gender differences in perceptions of cloud services

Opinions about using cloud services	Gender	Mean Rank	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Cloud computing helps me learn more effectively.	Male (N=138) Female (N=172)	Male=175.60 Female=139.37	9094.0	23972.0	-3.706	0.000
It supports better communication with teachers and classmates.	Male (N=138) Female (N=172)	Male=177.19 Female=138.10	8875.0	23753.0	-4.060	0.000
It provides 24/7 global access to my files.	Male (N=138)	Male=182.83	8097.0	22975.0	-5.050	0.000

	Female (N=172)	Female=133.58				
Cloud tools help me manage deadlines and schedules more efficiently.	Male (N=138) Female (N=172)	Male=176.52 Female=138.64	8967.5	23845.5	-3.892	0.000
Cloud tools reduce my reliance on physical materials like notebooks or USB drives.	Male (N=138) Female (N=172)	Male=177.68 Female=137.70	8806.5	23684.5	-4.107	0.000
Cloud platforms make group projects and collaboration easier to manage.	Male (N=138) Female (N=172)	Male=182.93 Female=133.49	8082.0	22960.0	-5.095	0.000
Using cloud tools has improved my digital literacy and tech skills.	Male (N=138) Female (N=172)	Male=180.83 Female=135.17	8372.0	23250.0	-4.677	0.000

5.11. Kruskal-Wallis H test on cloud computing perceptions by age

The results of the Kruskal-Wallis test showed that no statistically significant differences existed among the 4 age groups (18–20, 21–23, 24–26, and above 26) for most statements regarding the use of cloud technology. Perceptions of the effectiveness of learning, managing deadlines, having fewer requirements for printed materials, working in groups, and being digitally literate showed broad similarities across all ages. Nevertheless, a significant disparity was observed in the statement about 24/7 worldwide access to files ($p = 0.006$), indicating that different age groups had varying preferences regarding the importance of this advantage. This example indicated that older learners were more likely to be concerned about compromised access to files than their younger colleagues.

Table 11. Kruskal-Wallis H test on cloud computing perceptions by age

Statements	Age	N	Mean Rank	Kruskal-Wallis H	Df	Asymp. Sig.
Cloud computing helps me learn more effectively.	18-20	48	156.76			
	21-23	95	141.92	3.819	3	0.282
	24-26	141	161.66			
	Above 26	26	169.38			
It supports better communication with teachers and classmates.	18-20	48	146.35			
	21-23	95	139.09	7.535	3	0.057
	24-26	141	167.44			
	Above 26	26	167.6			
It provides 24/7 global access to my files.	18-20	48	140.03			
	21-23	95	136.32	12.632	3	0.006
	24-26	141	173.47			
	Above 26	26	156.71			
Cloud tools help me manage deadlines and schedules more efficiently.	18-20	48	144.95			
	21-23	95	142.62	5.41	3	0.144
	24-26	141	165.37			
	Above 26	26	168.52			
Cloud tools reduce my reliance on physical materials like notebooks or USB drives.	18-20	48	146.33			
	21-23	95	146.73	2.98	3	0.395
	24-26	141	162.33			
	Above 26	26	167.42			

Cloud platforms make group projects and collaboration easier to manage.	18-20	48	144.34			
	21-23	95	139.89	7.425	3	0.06
	24-26	141	167.7			
	Above 26	26	166.96			
Using cloud tools has improved my digital literacy and tech skills.	18-20	48	152.72			
	21-23	95	142.73	3.877	3	0.275
	24-26	141	162.24			
	Above 26	26	170.71			

5.12. Spearman's Rho correlation test for educational impact

A Spearman's Rho correlation test was conducted to examine the relationship between a student's level of familiarity with cloud services and their perceived educational impact.

The .353 correlation indicated that the educational impact increased as a person's familiarity with a subject grew. This suggests that higher levels of familiarity were associated with a greater perceived educational impact.

The 0.01 level of significance was met in the correlation (two-tailed), as evidenced by a p-value of .000, which is below the required 0.01. The study included 310 participants, providing a robust sample size to support this conclusion.

Table 12. Spearman's Rho correlation test between familiarity and educational impact

Variable		Familiarity	Educational Impact
Familiarity	Correlation Coefficient	1	.353**
	Sig. (2-tailed)	.	0
	N	310	310
Educational Impact	Correlation Coefficient	.353**	1
	Sig. (2-tailed)	0	.
	N	310	310

6. Findings and discussions

This section provides a clear, factual look at the main data points that we pulled out from the survey analysis. It provides the basis for the subsequent discussion. The results are arranged to interpret the RQs' findings.

RQ1: How are students at Dhaka University currently using cloud computing in their studies?

When students were asked about their knowledge of cloud computing, about one-third of respondents said they know the term and have a good grasp of it. However, many still did not understand well. This demonstrates that although cloud services are popular, many students are not fully aware of the concept. The findings reveal a very high rate of adoption. An overwhelming majority of respondents used cloud services such as Google Drive, Microsoft OneDrive, Dropbox, and iCloud for their studies. Most students use these services regularly. The data on service usage mostly point to a strong preference for Google products. Gmail was the most popular, followed by Google Drive and Google Classroom. Other Google tools were also used, such as Google Docs, Google Forms, Google Slides, and Google Sheets. Together, these results suggest a high degree of dependence on a single integrated suite of tools for a range of academic tasks. Students generally use cloud services for basic academic work. The two most common uses were for storing assignments and files and sharing documents with peers in class. Other significant uses included accessing teacher materials and backing up notes. A smaller but still notable group used the services for group projects and collaboration.

RQ2: What do students identify as benefits from using cloud-based tools to support their learning activities? Students rated various aspects of their experience with the Cloud using a Likert scale. For benefits, the top ratings were for accessibility and collaboration. Students strongly agreed that cloud computing makes it easier to access study materials anytime, anywhere, and to collaborate on group assignments. Other benefits that were highly rated included better organization, time savings, and more storage. The lowest-rated benefit was that the Cloud helps with interactions with research supervisors/faculty.

RQ3: What are the challenges and barriers for students to use cloud services for education? When considering challenges, cost and data security were the most common concerns among students. The biggest concern was that cloud services could be too expensive or require paid subscriptions. This was closely followed by concerns about data privacy and security, and by problems with moving data across cloud platforms. Of least concern was their devices not being compatible or fast enough for their use with cloud apps.

RQ4: To what extent is cloud computing contributing to better learning outcomes, collaboration, and organizational efficiency among Dhaka University students? The total impact on education was equivalent to the perceived benefits. The best-rated impact was 24/7 access to files globally. Other significant impacts were that the Cloud helps students learn more effectively, communicate better with teachers and classmates, and manage group projects. The lowest-rated impact, though still high, was better management of deadlines and schedules.

RQ5: Is there any relationship between a student's familiarity with cloud services and their perceived educational impact? Inferential statistics indicated several associations between students' views and their backgrounds. A chi-square test indicated a significant relationship between the students' faculty and their understanding of cloud computing. This means that the level to which students understand the concept of clouds varies by faculty. Of particular interest was that students in the Faculty of Arts showed the highest level of understanding, a finding that warrants follow-up research. The Mann-Whitney U test also supported this, showing significant differences by sex across all educational impact statements, namely, getting things learned, communicating, working in groups, and computer literacy. In all instances, male students held a significantly more positive understanding of the educational value of cloud services than female students.

Nevertheless, a Kruskal-Wallis H test of perceptions by age band revealed a significant difference. Whilst, in most perceptions, there was no statistically significant difference by age, for the statement "It provides 24/7 global access to my files," a statistically significant difference was found. Older students, namely those aged 24-26 and over 26, indicated a significantly greater mean rank in regard to the benefit compared with younger students. Lastly, a Spearman's Rho correlation test was conducted in an attempt to establish the relationship between a student having knowledge of cloud services and the educational value they believe it provides. The test created a significant positive relationship. This shows that as a student understands and learns more about cloud computing, their perception of its positive educational value increases as well.

6.1. Contributions and implications

This research is one of the initial attempts to gauge preparedness and mindset regarding cloud computing at the University of Dhaka. In Bangladesh, there is limited research in this field; earlier studies have tended to be very general, either on e-learning adoption [10] or on security misperceptions among the tech workforce [29], with university students as a second

interest group. However, this study focuses on the student community at the University of Dhaka. In addition to gauging overall awareness, the study examines usage behavior within the Google ecosystem, the relationship between technical familiarity and educational efficacy, and specific socio-economic obstacles such as subscription costs. These factors help define the uniqueness of this piece of research, filling an essential knowledge gap regarding how student populations at the highest ranks of a national university mass-accessing transition to cloud-based education cope. This study has serious implications in terms of academic theory and its practical application:

6.1.1. Theoretical implications

This research contributes to the body of literature by providing empirical evidence of students' perceptions in a developing country regarding the usefulness of cloud services. It confirms the theoretical connection between user familiarity and perceived influence on learning outcomes and provides future researchers with a framework for investigating digital transformation in resource-constrained learning environments. This will provide a more academic insight into the digital divide in higher education [30].

6.1.2. Practical implications

The results show that although most students are connected, many cannot fully use the capabilities of cloud collaboration. The awareness of such trends in this study will empower students to go beyond simple storage mechanisms and adopt real-time collaborative tools to enhance their performance effectiveness and career preparedness. This study provides a roadmap for administrators to overcome specific challenges, primarily expenses and the lack of appropriate infrastructure. It implies that the main disappointments of the student body can be addressed through institutional involvement in campus-wide licensing and enhanced technical assistance. Revealing gender disparities in such perceptions enables the development of more targeted digital literacy programs so that the advantages of cloud computing can be equally accessible across the campus. Overall, this study offers a thorough view of the cloud computing environment at the University of Dhaka, and the feedback obtained can be used to implement changes to transition to an even more effective and digitally integrative future.

7. Conclusion

This is one of the first attempts to assess students' attitudes toward cloud computing at a large public university in Bangladesh. The study fills a significant knowledge gap and provides general insight into cloud computing usage and students' perceptions at Dhaka University. The study focuses, for the most part, on students' utilization patterns, their perceptions of shaping factors, and the challenges they perceive. This originality and narrowness give unique insights into the peculiar case of a large educational organization in a developing economy. The results of the research have implications for Dhaka University and for the broader world of academia. The research sheds light on how students themselves understand cloud computing, which is directly related to working effectively with it. By understanding students' perceptions and misconceptions, the university can correct them and develop a greater understanding of the value. This research also reveals which applications and approaches are most widely used and can be used in determining policy at the university. Additionally, by exposing the perceived advantages and drawbacks, the work will help

university officials determine which aspects shape their students' experiences and formulate policy as a result. Overall, the work presents a general picture of cloud computing in the educational scenario of Dhaka University.

7.1. Recommendations

Here are some recommendations from the researcher to the authority based on the research findings of Dhaka University regarding the implementation of cloud computing:

- i. **Develop a Formal Cloud Strategy:** The university cannot afford to sit on the sidelines; it must aggressively lead in cloud technology adoption. This means providing a safe, institution-blessed cloud platform that puts students' minds at ease regarding cost and data privacy.
- ii. **Invest in Targeted Digital Literacy:** The positive relationship between knowledge and perceived educational impact provides a clear call to action. The university should develop mandatory and voluntary training programs that not only teach students how to use a particular tool but also cover the fundamentals of cloud computing, making them savvy users.
- iii. **Address the Gender Disparity:** The pronouncement and persistence of the horrific perception gap along gender lines calls for closer attention. The university should conduct qualitative research to identify the reasons for the divide and subsequently plan specific programs or support systems to ensure equal access and opportunity for all students.
- iv. **Strengthening IT Infrastructure:** Although most students have internet access, some still experience connectivity issues. The college should invest more in on-campus internet infrastructure to ensure all students have seamless access to cloud services.

7.2. Scope of further research

To mitigate the limitations of self-report data, future research should combine self-report questionnaires with other data-collection procedures, e.g., focus groups or in-depth interviews. This would enable researchers to test hypotheses and gain a deeper understanding, thereby mitigating potential biases, e.g., social desirability bias. Tracking a student cohort over time to add more knowledge on the long-term impact of cloud adoption—a comparative study among various universities to recognize the best practices in integrating Cloud in education.

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