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An Exploratory Study of Online Job Portal Data of the ICT Sector in Bangladesh: Analysis, Recommendations and Preliminary Implications for ICT Curriculum Reform

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Abstract: Many countries wish to achieve digital transformation, especially during the COVID-19 pandemic. The digital skills demand is changing fast. The time-series online job portal data for the ICT industry in Bangladesh provides an opportunity to analyze high demand job titles and skills over time. These time-series data address the question of the speed of changes in job titles and skills and responsiveness of computer science and engineering (CSE) curricula. This study gathers online job portal data of the ICT industry in Bangladesh from 2016 to 2021. Natural language processing is used to group similar skills and job titles following the O*NET Online taxonomy. In addition to the descriptive statistics, the statistical significance test and correlation analysis are conducted. The analysis could identify high demand ICT job titles (Software Developers, Computer System Engineers/Architects, Web Developers, Project Management Specialists) and skills (API, Database, JavaScript) but Computer System Engineer/Architect job titles and API skills are increasing fast. The shift from networking to JavaScript and UI Design is also noteworthy after COVID-19. The preliminary curricula analysis suggests the responsiveness of the CSE program, but online job portal data analysis might provide opportunities for developing unique CSE specialization, courses and curricula.

Keywords: skills demand; skills gap; labor market analysis; IT; ICT; online job; curriculum; higher education; Bangladesh

1. Introduction

Bangladesh, which has a population of 164 million, upholds the vision of Digital Bangladesh and puts a high priority on the information and communication technology (ICT) sector development [1–3]. The ICT sector in Bangladesh consists of around 4500 software firms with more than 300,000 local ICT professionals [4]. More than 10,000 university students graduate with ICT-related majors each year [5]. The average growth of the ICT sector has been more than 40% between 2015 and 2020 [4]. Bangladesh needs to develop digital-competent human capital to continue this growth trend, and higher education plays a key role to produce skilled ICT graduates for the labor market. Thus, higher educational institutes (HEIs) offering ICT degrees, particularly at the baccalaureate level, act as an important stakeholder in this context. However, it is generally understood that public HEIs do not necessarily update the curriculum periodically to meet the local industry demands [6]. Although website information of some HEIs suggests that there are systematic internal mechanisms in place for (frequent) computing and ICT curricula update,

it remains largely unknown, or even unexplored, whether such updates are performed regularly or driven by ICT skills demand of Bangladesh. In addition, to the best of our knowledge, there is a lack of any systematic or regular approach to assessing the said demand. Hence, there is a dire need to (a) develop ways to assess nation-wide ICT skills demand, for example, using time-series online job-posting data (N1) and (b) incorporate and leverage that assessment in the curricula update mechanism of the HEIs (N2) with an overarching goal of catering to the ICT industry in Bangladesh.

With the above brief backdrop, we conduct an exploratory analysis of an online job portal dataset that focuses on ICT jobs, thereby directly attending to the first need (N1) mentioned above. The broad research questions we asked are as follows:

- Can we analyze and infer the job demands and perhaps confidently answer questions such as what job titles are in the highest demand (from both industrial and job seekers' viewpoints)?
- Can we identify the changing trends in terms of demand and supply of a particular job position and whether the identified changes are statistically significant?
- Can the primary skills sought in the ICT sector be identified through appropriate analysis? Can we identify whether there are any changes in the required skills over time, especially after the coronavirus disease (COVID-19) pandemic?

We develop different methodologies to explore the dataset and answer the above questions. Our methods range from simple statistical summaries to more complex statistical tests and measures and further include state-of-the-art techniques from machine learning, particularly from natural language processing.

Very briefly, our analysis finds that Software Developer remains the most popular job title, but industry demands for Computer Systems Engineers/Architects are increasing. The skills related to API (i.e., application programmer interface) became the highest demanded skill, and COVID-19 might have induced a skills shift from networking to JavaScript and UI Design, whereas database skills remain top tier skills. The preliminary CSE curricula analysis suggests the alignment with online job posting requirements, but online job portal data might enable each university to develop their CSE specialization, courses and curricula considering their unique propositions.

The assessment methods and results presented in this article by attending to N1 directly pave the way to systematically approach N2, albeit without handling it in its entirety. Thus, we only briefly conduct a limited preliminary analysis to find the answer of the following peripheral question: how do the current computer science and engineering (CSE) curricula in Bangladesh relate to the required skills in the ICT job market? This article also proposes potential actions for universities and government to utilize these results and presents a pathway for future work.

The rest of the article is organized as follows. In Section 2, we present a brief literature review. Section 3 presents our methodology in detail, ranging from simple statistical summary to sophisticated statistical and computational analysis, including natural language processing. Section 4 presents the main results of the analyses performed in this work, followed by some relevant insightful discussions in Section 5. Finally, we briefly conclude in Section 6 with future research directions.

2. Literature Review

We focus our review on the market demand for technical and non-technical skills for ICT professionals. Next, we review articles on how tertiary education on ICT in Bangladesh has been established to meet the need of the ICT industry and research community. Then, we explore how the online job market in Bangladesh has changed in recent years and how it has been affected by the COVID-19 pandemic.

2.1. Required Skills for ICT Professionals

The skills demand of the global ICT sector has become more diverse in both technical and non-technical aspects [7,8]. On the one hand, the ICT industry needs skilled workforces

which can take advantage of the growing demand for the mastery of programming languages, such as SQL and Java [5,7,8]. Dice [7] reports that SQL ranks first as a technical skill in terms of job posting volume in the United States, followed by Java, Python, JavaScript, and Linux. DevSkiller [8] also shows a similar trend, listing Java, JavaScript, and SQL as the top three programming languages. On the other hand, these trends were mostly researched before the COVID-19 pandemic. There is less research on how the required skills have changed during the pandemic in a single country, which our study analyzes. In addition, the skills required in the United States and other countries with mature ICT industries must be different from those in Bangladesh—an emerging market. For Bangladesh, the only literature that addresses the specific required ICT skills indicates that Java, Net, HTML5, PHP, and SQL were listed as the most required skills [5].

Although the technical aspects of ICT engineers tend to attract attention, seeking those who have specific technical skills is not always the highest priority in the hiring process [7,9,10]. For example, one in five hiring managers in the United States is language agnostic when hiring ICT professionals [9]. Some other studies also claim the importance of non-technical skills, such as soft skills for ICT professionals [11,12]. In the United States, project management is ranked first as the required non-technical skill in the ICT sector, followed by business process and quality assurance and control [7]. A qualitative study for experienced engineers in Microsoft suggests that productivity, decision making, and the ability to learn new technical skills as the required factors to be a great software engineer [10]. BRAC [13] also lists complex problem solving, coordination, and critical thinking as the most relevant and important skills for ICT professionals in Bangladesh.

As a domestic geographical challenge in Bangladesh, they face the challenge of expanding the ICT industry outside of Dhaka (the capital city of Bangladesh) because more than 90% of global ICT-related delivery operations are concentrated in Dhaka [14]. The Bangladeshi government is attempting to change the current concentration of the ICT industry in Dhaka by actively attracting incubation centers and other facilities to regional areas [15].

Thus, both technical and non-technical aspects are required by the market. Higher education, especially the majors of CSE and Information Technology (IT), is expected to be a source of such human resource development to expand the ICT sector all over Bangladesh.

2.2. Tertiary Education on ICT in Bangladesh

In Bangladesh, tertiary education in CSE and IT is a critical path to cultivating potential ICT leaders. A survey on career aspiration for CSE/IT university students shows that more than 90% of participants wished to work in the ICT sector [16]. The employment rate of CSE/IT graduates was 77.1% in 2018—higher than the overall university rate of 41% in Bangladesh [17]. A study on software engineering education claims that the skills that potential engineers need to learn are programming, verification/validation, and project management [10]. In contrast, the global investors point out that ICT education in Bangladesh is designed for traditional ICT demands, notwithstanding that market demand has shifted from traditional (e.g., business process outsourcing, hardware, and package software) to digital technologies (e.g., big data and cyber security) [18]. Therefore, the gap between industry and education needs to be bridged, but no study has analyzed the CSE curriculum based on industry needs. It is important to develop human resources from a short-term to a long-term perspective to strengthen the ICT export market [18].

The formal inception of CSE/IT education in Bangladesh dates back to 1986 when the first bachelor's degree program was introduced in the Department of CSE, Bangladesh University of Engineering and Technology (BUET). Since then, although the University Grants Commission of Bangladesh (UGC) is mandated to improve the overall quality and relevance of academic programs at universities, BUET has been playing a leading role in engineering research [6], including shaping the CSE curricula within the country following international curriculum standards (e.g., Curricula Recommendations of the ACM [19]). Most undergraduate programs in Bangladesh, if not all, offer the Bachelor of

Computer Science and Engineering degree and mostly follow a similar curriculum. The requirement of both computer science and computer engineering components within the curricula make it quite vast (around 160 credit hours). The CSE education in Bangladesh is slowly but surely reaching the global standard. As is evident by the 2021 QS Subject-wise Ranking of Universities, CSE, BUET was ranked in the range of 301–350, improving upon the previous rankings (351–400 in 2020 and 551–600 in 2019, respectively) [20,21]. Moreover, international tech giants, like Google, Microsoft, Facebook, Amazon, etc., regularly recruit CSE graduates directly from Bangladesh, indicating their standard and quality [22].

2.3. The Impact of COVID-19 and the Online Job Market in Bangladesh

The COVID-19 pandemic had a significant impact on the ICT-related job market. The demand for digital skills has drastically increased after the pandemic. Compared to January 2020 (before the pandemic), the demand for talent with digital skills has doubled or tripled in many countries [23]. When the pandemic was declared in March 2020, the number of online job postings reduced significantly, but the online job postings in the ICT industry came back relatively quickly [24]. In Bangladesh, whereas the number of online job postings in the ICT industry was negatively affected by the COVID-19 waves, the number of online job postings in the ICT sector in December 2021 became 19.3% higher than the figure in January 2019, as shown in Figure 1 [25]. This study discusses the changes in required skill sets associated with these transitions in depth.

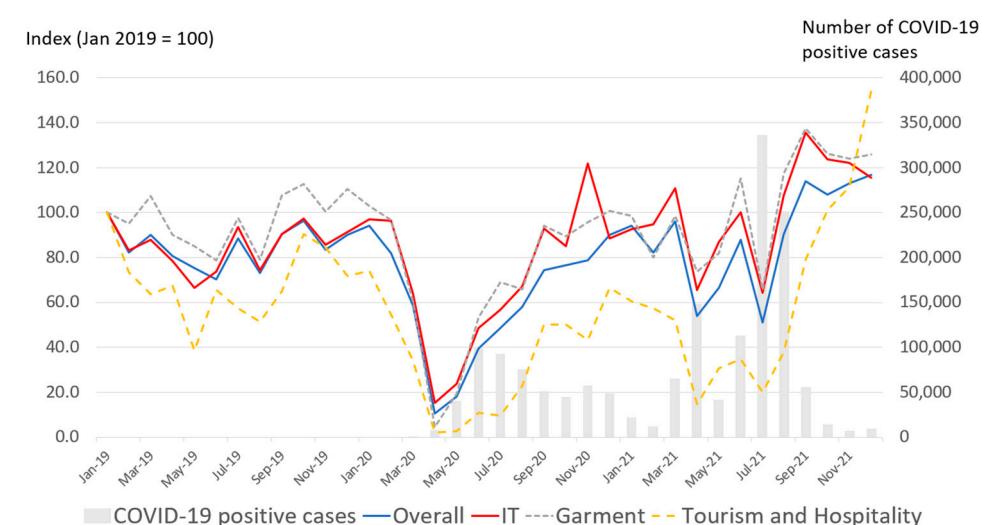


Figure 1. The online job posting index by selected industries from January 2019 to December 2021 (Source: Author's calculation using [Bdjobs.com](#) data [25] and Our World in Data [26]).

Sending job applications is the most common means for university students to apply to jobs. Approximately 36.7% of students used online job marketing sites, followed by traditional media advertisements (16.1%) [27]. [Bdjobs.com](#) is the largest job-matching site in Bangladesh [28]. The website has had more than 2.5 million registered jobseekers and 25,000 registered firms since its foundation in 2000, and there are currently 200,000 visitors per day and 40 million page views per month [28]. A study on online job portals in developing countries claims that big data on online job portals in India and Indonesia has contributed to predictive analysis of assessing demand for workforce skills [14,29]. Although several studies have discussed the relationship between skills demand and online job portals [14,30], they do not analyze sector specific data. Because there is limited analysis on online job portals for ICT workers in Bangladesh, this study analyzes the trend in the ICT sector using the data of [Bdjobs.com](#) and discusses the potential approach for improving the CSE curriculum.

3. Materials and Methods

This section explains the data we use in this study. Then, we describe the detailed analytical methods on statistics, natural language processing, skills and curricula.

3.1. Data

The data used in this study includes all ICT job postings at [Bdjobs.com](#) (a total of 31,526 job postings) during the period 2016–2021 (until 15 December 2021). Unless otherwise specified, this period is referred to as the “study period”. ICT jobs refer to the jobs requiring ICT skills and tasks as per their titles and descriptions; ICT job postings are not necessarily posted by firms in the ICT sector. The dataset of job postings includes job titles, locations, career levels, job descriptions and responsibilities, industries of employers and requirements on age, education, sex and years of professional experience. All information is anonymous and no personal information is included in our dataset.

3.2. Statistical Summary

We derived a straightforward statistical summary of the different requirements and properties of the online job posting. Building on the registered information from the employer, we firstly categorized different job postings into discrete subgroups. For example, the registered location information of the employers has city names, and we further organized it into three categories, namely, within Dhaka city, outside Dhaka city in Bangladesh and offshore. Another example is employment type categorized into full-time, part-time, contractor, intern and freelancer, to name a few. Then, we calculated the corresponding number of jobs and what percentage thereof falls into each category.

3.3. Natural Language Processing Based Analysis

The dataset contains diversified information that demands sophisticated analyses. The job titles and descriptions include a great amount of useful information, but they cannot be processed or analyzed directly because of their indistinguishable language. For example, there are 14,307 unique job titles in the dataset. Many of those overlap in their basic roles (e.g., software developer, senior software developer, etc., all usually refer to the same basic role, i.e., software developer). Therefore, we categorized job titles into 26 defined titles for ICT career following the O*NET OnLine taxonomy [31]. O*NET OnLine is an online application created for the general public to provide broad access to the O*NET database of occupation information [31]. We derived a high dimensional vector representation of these job titles and categories and calculated the cosine similarity to find the closest matched title in the O*NET database. We also tried to be explicit about the necessary skills mentioned in the job descriptions. We built unigram, bigram and trigram models to extract skills consisting of more than one word (for example, SQL Server, UI Design, etc.) and sorted words by frequencies. Notably, unigram is a one-word sequence whereas bigram and trigram are two- and three-word sequences, respectively. In general, an N-gram is a sequence of n words. We manually inspected ICT related skills and made a word cloud thereof (please see the Results section for further details). These sophisticated natural language processing techniques helped us to map 14,307 unique job titles with overlapping roles to only 26 standard O*NET job titles. This in turn allowed us to analyze trends, necessary skills, labor supply, significant switch and many other properties of different jobs available in Bangladesh thoroughly, which would have been less meaningful and possibly impractical for 14,307 unique job titles due to the lack of a sufficient sample.

3.4. Statistical Significance

We conducted statistical analysis to understand the year-wise changes, considering job vacancies and applicant numbers. In particular, we conducted a one-tail *t*-test on the top 10 job titles (based on frequency) in our dataset. We tried to determine whether there is a statistically significant decline (or increase) in those criteria. A *t*-test is a type of inferential statistic used to determine if there is a significant difference between the means

of two groups [32]. A *t*-test allows us to compare the average values of the two datasets and determine if they came from the same population. We conducted these tests with 95% and 90% confidence intervals (CI).

3.5. Analysis of Skills

We also analyzed whether there was a change in demand for different skills in a company from within a specific time range. We construct a skill shift graph, $G_{A \rightarrow B}$ as follows, where “ $A \rightarrow B$ ” in the subscript signifies a shift from Year A to Year B. Formally speaking a (weight) graph $G = (V, E)$ comprises a set of nodes, $V = \{v_1, v_2, \dots, v_n\}$ and a set of edges (i.e., connections between two nodes), $E = \{e_1, e_2, \dots, e_n\}$, where each $e \in E$ has an associated positive integer as its weight. For $G_{A \rightarrow B}$, each skill in our dataset constitutes a node. For each company in our dataset, if the company required Skill X in Year A and Skill Y in Year B, we added a directed edge from X to Y and the weight of that edge is w if there are w such companies. For visualization purposes, we thicken an edge according to its associated weight. Considering the COVID-19 scenario, we constructed two skill shift graphs, namely, $G_{2016 \rightarrow 2019}$ and $G_{2019 \rightarrow 2021}$. In other words, we constructed skill shift graphs for two different time ranges, namely 2016–2019 (pre-COVID era) and 2019–2021 (COVID era).

Furthermore, we calculated Cohen’s Kappa coefficient among different skills. Cohen’s Kappa performs better for categorical variables than other correlation coefficients [33]. Cohen’s Kappa measures the degree of agreement between a pair of variables. The coefficient values lie in the range $[-1, 1]$, with 1 presenting complete agreement and 0 meaning no agreement at all, i.e., complete independence [34]. Our dataset for correlation analysis may be seen as a large matrix, M , where each row represents a job post, and each column represents a skill. A 1 in entry $M[i,j]$ implies that for job post i , skill j was present (i.e., sought for). So, our variable of interest here is clearly a categorical variable with a yes/no answer. Therefore, Cohen’s kappa statistics is a suitable metric for measuring the correlation among different skills in our dataset. Similarly, we analyzed the correlation among different job titles and skills using Cohen’s Kappa coefficient. We put an additional column in our previous matrix, namely job title. Then, using the method described above, we determined job titles’ correlations with different skills.

3.6. A Brief Curricula Analysis

As mentioned above, the CSE curricula in Bangladesh largely follow that of CSE, BUET. Therefore, we briefly analyze the existing CSE, BUET curricula. In particular, we want to investigate whether the skills required in the industry are covered by the CSE curricula in general. For the skills we extracted from our dataset, we mapped every skill to the courses in the CSE, BUET curricula that possibly cover it and provide weight to a particular course which we call “mean skill weight”. For a particular mapping (Skill A \rightarrow Course B) in a particular year, we assigned the percentage of the job post that included the skill as the weight of the course for that particular mapping. Then, for each course, we take the mean of all the weights from all possible mappings and assign that as the mean skill weight of that course.

4. Results

This section presents the main results of the analyses on online job posting and skill-demand shift between 2016 and 2021 using natural language processing and statistics.

4.1. Summary Statistics of Job Postings

Summary statistics of the online job postings at [Bdjobs.com](#) in the study period are presented in Table 1. The average number of vacancies for a job post is 2.27. Jobs are concentrated within Dhaka city (46% of all ICT jobs). Jobs within Bangladesh (including Dhaka city) account for 97.6% of all ICT jobs, whereas 2.4% corresponds to offshore jobs. Almost all jobs are full-time (92.7%) and mid- to entry-level (36.5% are mid-level; 43.2%

entry-level). Sixty-two percent of the job postings look for both male and female workers, 23% did not specify anything about gender (most likely, also indicating the previous category), 16% look for only men and only 1% specifically looked for women (Table 1). Thus, most jobs do not have any gender preference, but when they do, men are preferred in almost all cases. Because the data includes only ICT jobs, the industries in which employers run their businesses are mostly in the ICT sector (70%).

Table 1. Mean and frequency of key online job-posting information.

	No of Vacancies	Mean 2.27	N (Job Ads) 31,526
		Proportion	N (Job Ads)
Location	Dhaka city	46%	16,351
	Dhaka city or anywhere in Bangladesh	98%	31,174
	Outside Bangladesh	2%	352
Employment Type	Contract	4%	1003
	Freelance	1%	14
	Full-Time	93%	30,173
	Intern	1%	161
	Part-Time	1%	174
Position Levels	Entry	43%	11,185
	Entry, Mid	11%	2711
	Entry, Mid, Top	2%	230
	Entry, Top	0%	5
	Mid	37%	14,832
	Mid, Top	5%	1398
	Top	3%	1165
Gender Requirement	Both male and female	62%	18,116
	Female only	1%	240
	Male only	16%	4562
	Not specified	21%	8608
Industry	Bank/ Non-Bank Fin. Institution	1%	827
	Education	3%	1089
	Garments/ Textile	3%	1549
	Govt./ Semi-Govt./ Autonomous	0%	731
	Information Technology (IT)	71%	17,989
	Manufacturing (Heavy Industry)	1%	864
	NGO/Development	2%	1060
	Telecommunication	6%	1522
	Others	15%	5895

Figure 2 presents the chronological ranking of the latest high-demand job titles. Software Developers (3087 posts in 2021) had the largest number of vacancies during the study period, followed by Computer System Engineers/Architects (2354 posts), Web Developers (1786 posts), and Project Management Specialists (1390 posts) in 2021. Figure 2 also shows that Computer Systems Engineers/Architects and Computer Network Support Specialists have seen a steep increasing trend in recent years. The demand for Web and Digital Interface Designers and Business Intelligence Analysts registered a decreasing trend. The detailed information with the ranking and the number of posts is presented in Appendix A as Table A1.

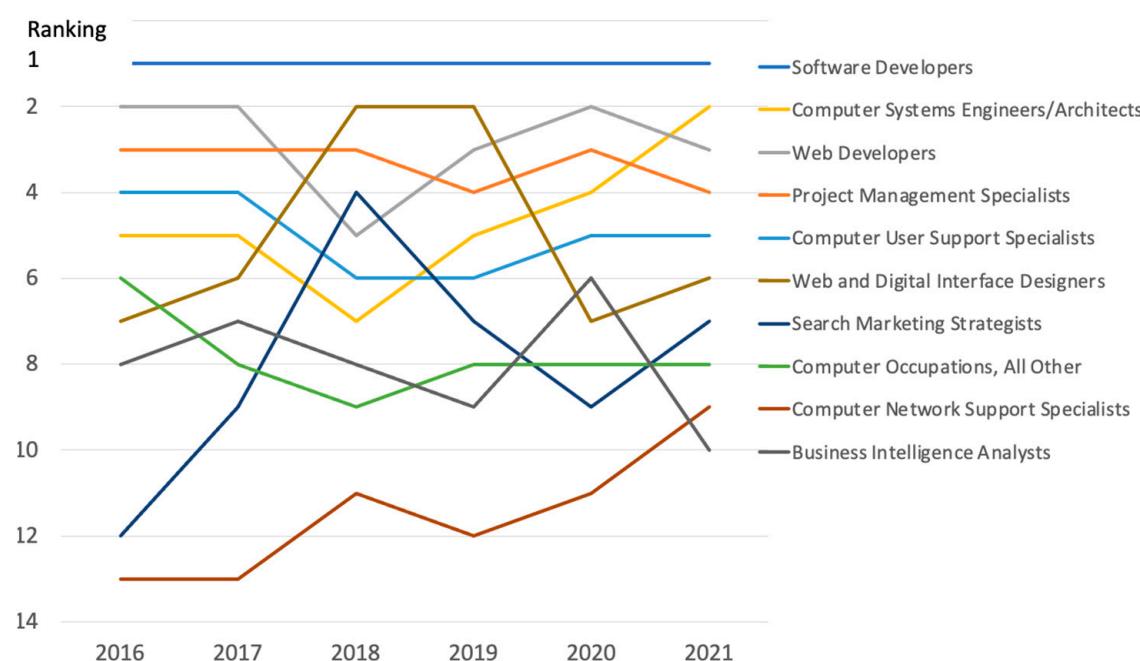


Figure 2. Ranking of high demand ICT job titles by year.

Figure 3 shows the number of applications per vacancy. Interestingly, the two high-demand jobs (i.e., Software Developers, Computer System Engineers/Architects) received only 35 and 45 applications per vacancy, respectively. These numbers are comparatively lower than other main ICT job titles. On the other hand, the two relatively low-demand jobs in Figure 2, namely Network/Systems Administrators and Business Intelligence Analysts, attracted a lot of interest from the job seekers. The detailed information with the specific number of applications is presented in Appendix A as supplementary Table A2.

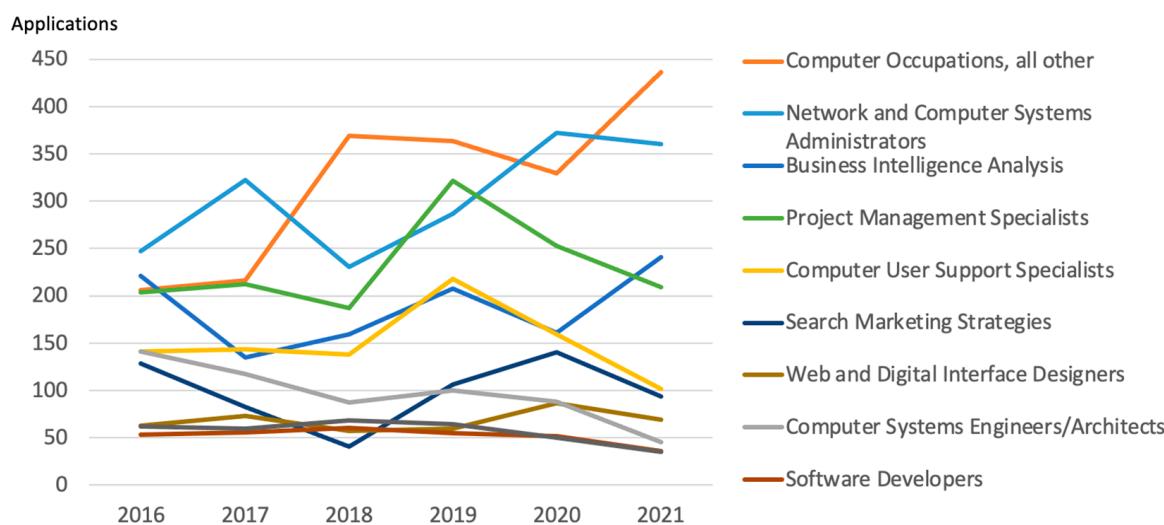


Figure 3. Labor supply (the mean number of applications per vacancy).

Figure 4 shows statistics of required job skills. JavaScript achieved the top position in 2016 and 2017, only to lose the place to Database, which remained at the top from 2018 to 2020. Database managed to climb the rank from 5 to 1 during the same period. Subsequently, in 2021, Database was overtaken by API. The sharp rise of API from position 14 in 2016 to the topmost position during the study period clearly indicates an increase in the usage of API based applications in the ICT industry of Bangladesh. PHP was second in 2016 but it gradually lost its rank in 10th in 2021 whereas HTML went from position 3 in

2016 to position 7 in 2021. Some other sharp climbs during the study period are achieved by Git (from 36 to 16), Laravel (from 33 to 20) and React (from 45 to 24) according to supplementary Table A3 in Appendix A.

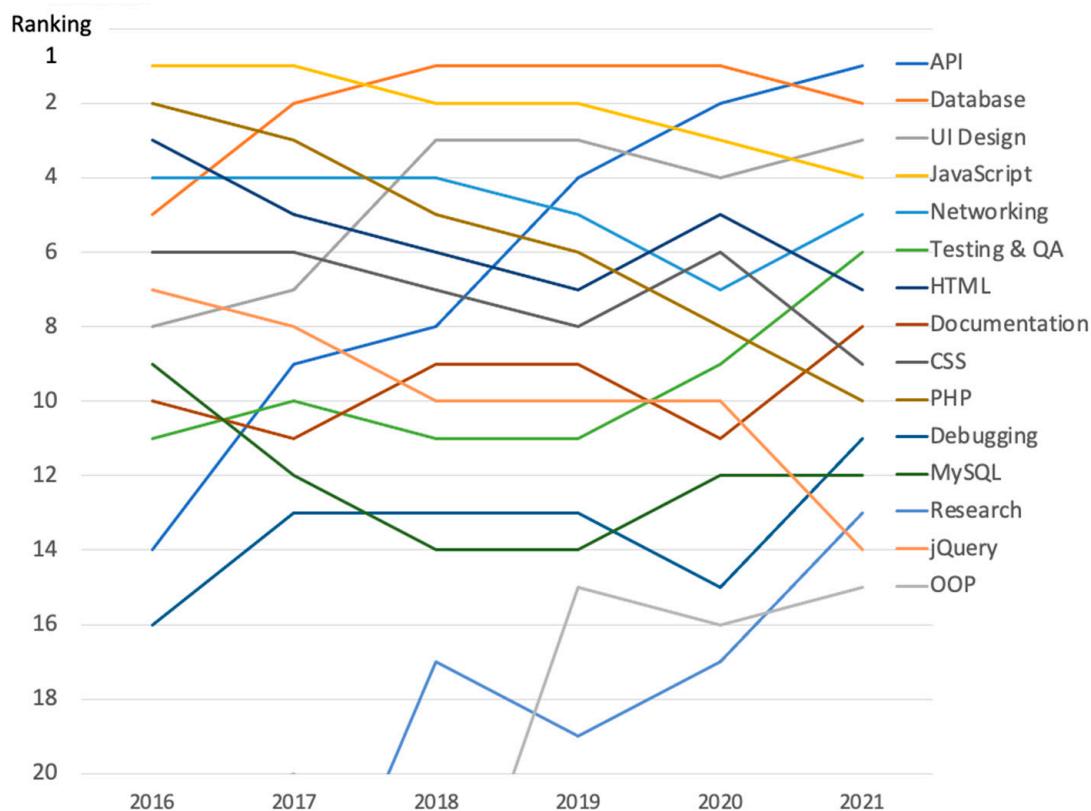


Figure 4. Ranking of required skills in the ICT sector (top 15 in 2021).

Overall, nearly all job posts are for jobs within Bangladesh except a few abroad ones, and around half of the job posts in Bangladesh are concentrated in Dhaka. The jobs are mostly for full-time employees with entry or mid-level positions. Most of the jobs do not have gender preferences and most of the jobs are from the ICT sector as expected.

4.2. Jobs and Skill Sets

The frequency of O*NET job titles (according to the analysis of our dataset) is represented in the word cloud in Figure 5. Notably, in what follows, when we refer to job titles, we mean the job titles after aligning those with the O*NET ICT ones. In Figure 3, we calculated the labor supply in terms of the mean number of applications per vacancy for each job title. The skills in high demand in the ICT industry are ranked in Figure 4 (Figure 6 presents the word cloud). The most frequent job titles (aligned to the O*NET ICT career titles) are Software Developers, Project Management Specialists and Web Developers (Figure 2; also see Figure 3). As for applicants' skills, the most commonly listed ones are Database, UI Design, Networking, HTML, CSS, API, etc. (see Figure 4).



Figure 5. Word cloud of the frequency of O*NET job titles in data.

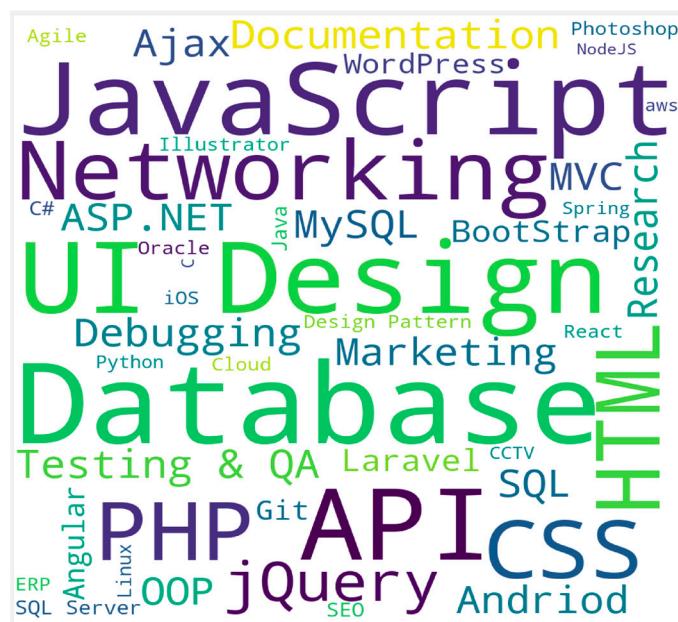


Figure 6. Word cloud of computer skills extracted from different job posts.

4.3. Statistical Significance Analyses for Changes in Demand

When the confidence interval (CI) was set to 95%, we do not observe any significant changes; therefore, we report and interpret the results with 90% CI. In particular, we report in Table 2 the results of the most frequent four job titles in 2021, namely Software Developers, Computer Systems Engineers/Architects, Web Developers and Project Management Specialists. We observe a statistically significant decline in the demand (i.e., number of vacancies) for both Software Developers and Web Developers from 2019 to 2020. Interestingly, for Web Developers, we notice a statistically significant increase in the next time period, i.e., from 2020 to 2021. In addition, both jobs had a constant decline in the number of applicants from Year Y to Year $Y + 1$ where $Y \in \{2018, 2019, 2020\}$ (Table 2). As for Computer Systems Engineers/Architects, from 2018 to 2019, in both counts, the decline is

statistically significant, with a statistically significant decline in the number of applicants in the earlier time period (i.e., 2017 to 2018) as well. Promisingly, like Web Developers, Computer Systems Engineers/Architects also experienced a statistically significant increase from 2020 to 2021.

Table 2. T-test results for the four most frequent job titles.

	(2016, 2017)	(2017, 2018)	(2018, 2019)	(2019, 2020)	(2020, 2021)
<i>T-test results for Statistically Significant Decline</i>					
Software Developers	FALSE (False)	FALSE (False)	FALSE (True)	TRUE (True)	FALSE (True)
Computer Systems Engineers/ Architects	FALSE (False)	FALSE (True)	TRUE (True)	FALSE (False)	FALSE (False)
Web Developers	FALSE (False)	TRUE (False)	FALSE (True)	TRUE (True)	FALSE (True)
Project Management Specialists	FALSE (False)	FALSE (False)	TRUE (False)	FALSE (True)	FALSE (True)
<i>T-test results for Statistically Significant Increase</i>					
Software Developers	FALSE (False)	FALSE (False)	FALSE (False)	FALSE (False)	FALSE (False)
Computer Systems Engineers/ Architects	TRUE (True)	FALSE (False)	FALSE (False)	FALSE (False)	TRUE (False)
Web Developers	FALSE (False)	FALSE (False)	FALSE (False)	FALSE (False)	TRUE (False)
Project Management Specialists	FALSE (True)	TRUE (False)	FALSE (False)	FALSE (False)	FALSE (False)

Note: True in column (Y, Y + 1) means that there was a statistically significant decline (upper table) or increase (lower table) in demand, i.e., job vacancy from Year Y to Year Y + 1 and False means otherwise. The values within the brackets correspond to the decline/increase in the number of applicants. The results reported here are at a 10% statistically significant level (i.e., 90% CI); at 5% statistically significant level (i.e., 95% CI), no significant changes were observed.

Overall, demand for Web Developers increased during the COVID-19 period but the number of job applications for this title decreased. Applicants for titles such as Software Developers and Project Management Specialists are decreasing whereas there is no significant change in demand. Computer System Engineers/Architects are interesting titles that have increased demand in the COVID-19 era but showed no significant change in the number of applicants.

4.4. Skill Requirement Shift

We present our constructed skills shift graph in Figure 7. Figure 7a corresponds to the skills shift from 2016 to 2019., i.e., in the pre-COVID-19 era within the study period. Figure 7b illustrates the skills shift during the COVID-19 pandemic, i.e., from 2019 to 2021. We observe that before the COVID-19 pandemic, the ICT industries were moving toward Networking, Database and Testing and QA related services. During the pandemic, however, industries have focused more on JavaScript and UI Design with Networking, Testing and Database.

4.5. Skills Correlation

Figure 8 presents the skills correlation heatmap; skills are assumed to be correlated in our context if they co-occurred in the same job post. This figure reveals some interesting insights. For example, HTML and CSS are found to be highly correlated. This suggests that if a job post requires the candidate to be an expert in HTML, it is highly likely to require expertise in CSS concurrently. Similarly, we see a very high correlation between Illustrator and Photoshop. JavaScript is highly correlated to Ajax, jQuery, HTML and

CSS—all tools for web development. SEO is highly correlated to marketing. C# is highly correlated to ASP.NET. Some other significant correlated pairs are (C#, SQL Server), (SQL Server, ASP.NET), (OOP, Design Pattern), (PHP, MySQL), etc.

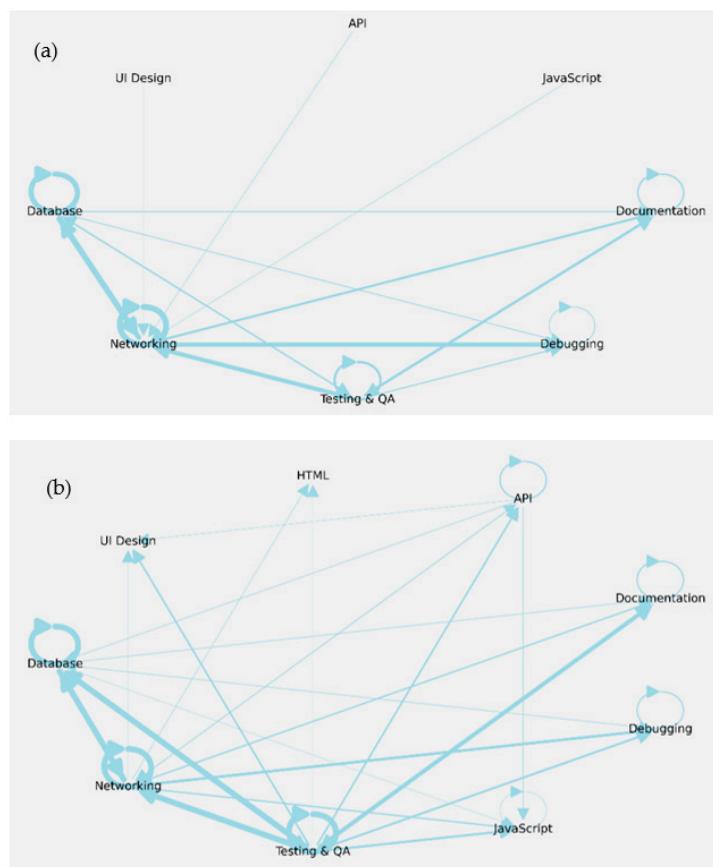


Figure 7. Skills shift graph illustrating skills requirement shift in Bangladesh ICT Sector. (a) Skills shift from 2016 to 2019 (pre-COVID-19) (b) Skills shift from 2019 to 2021 (COVID-19).

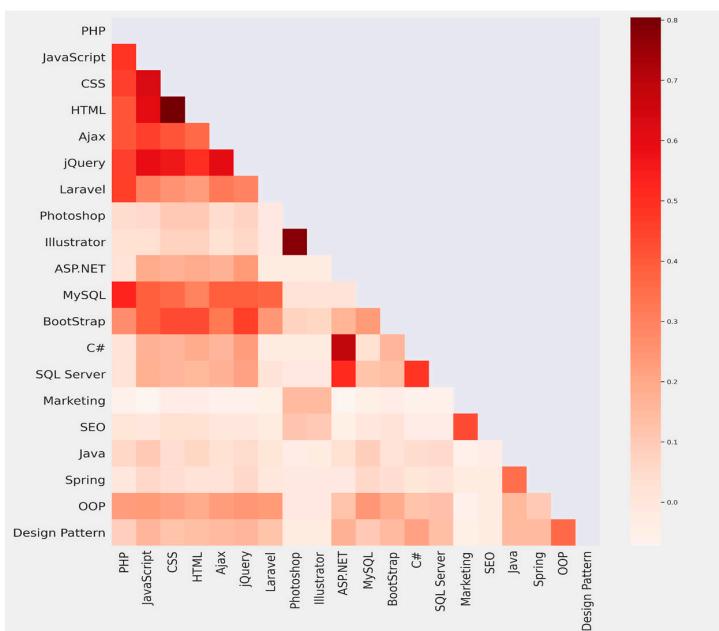


Figure 8. Correlation heatmap between ICT skills.

4.6. Skill–Job Correlation

We have also investigated the correlations between skills and job titles (aligned with the O*NET titles) to help job seekers identify skills to achieve a particular job (Figure 9). We can see that a Web Developer requires many skills, such as PHP, CSS, HTML, MySQL, WordPress, Laravel, jQuery, Bootstrap and API. Web and Digital Interface Designers require Photoshop, Illustrator and Marketing skills. Skills requirement for Software Developers is somewhat blended in many skills as different companies require different skills; some prominent ones are: Android, C, Java, iOS, ASP.NET, MVC, API and so on. Finally, Search Marketing Strategists require SEO and marketing and research skills.

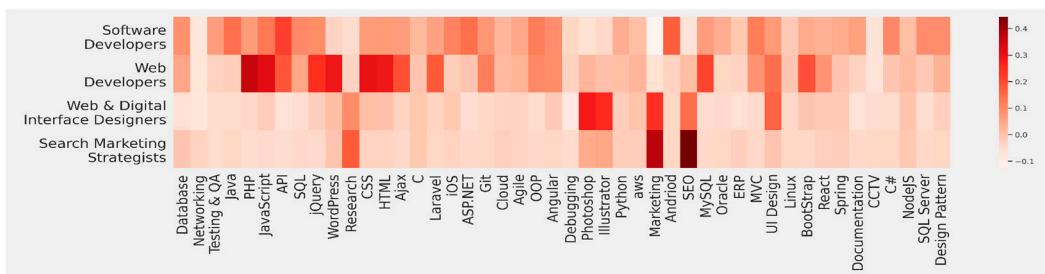


Figure 9. Correlation heatmap between skills and job titles.

4.7. Skills vs. Curricula

Figure 10 illustrates the number of skills covered by a particular course with an important related measure: the mean skill weight. As can be noticed, the Software Development Project turns out to be a crucial course that covers many skills, achieving a mean skill weight of 11.3. In terms of skills covered, the Database course comes second with a similar mean skill weight of 11.1. Object-Oriented Programming and Software Engineering courses also strongly contribute to the ICT sector's skill demands.

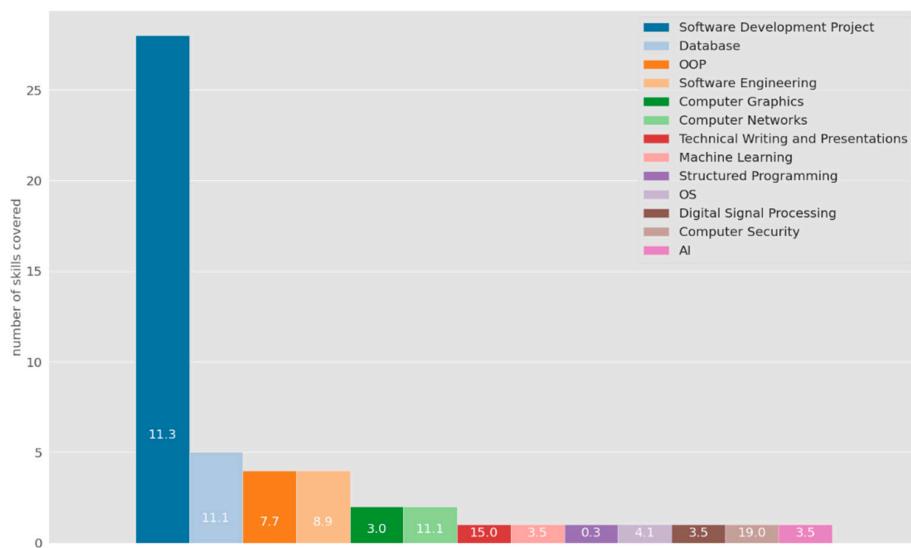


Figure 10. The number of skills covered by some of the courses. The value mentioned within the bar chart represents the mean skill weight of the respective course.

5. Discussions and Implications

First, this section discusses the interpretation of the results (statistical analysis on online job postings and the shift of skills demand). Second, we discuss the implications of the results of this study for future curricula development in Bangladesh, followed by several policy recommendations and the study's limitations.

5.1. Interpretation of Job-Demand Analysis

From the straightforward descriptive data analysis, the ICT job requirement in Dhaka, the capital city of Bangladesh, is evident because almost half of the job posts are within the Dhaka area (see Table 1). It is consistent with the strong concentration of ICT global delivery operations in Dhaka [14]. ICT jobs could be performed digitally from anywhere with good devices and internet access, but this might indicate that the ICT industry requires analogue interactions with clients. Despite several policy-level initiatives to expand the ICT sector outside of Dhaka (e.g., through multiple incubation centers and/or high-tech parks outside the capital) [15], ICT job agglomeration in the urban center has not changed much. Many universities are also concentrated in Dhaka. Students in urban areas have many opportunities to interact with industries whereas HEIs outside Dhaka face challenges in understanding the ICT industry skills needed on the ground.

The summary statistics also reveal that 36.5% of ICT jobs are in the mid-level category as opposed to 43.2% belonging to the entry-level category. Considering a pyramid organizational structure, this arguably suggests that the ICT industry is itching toward maturity. The high demand for Software Developers (at various levels) and higher-level posts such as Project Management Specialists and Computer Systems Architects together perhaps also support this proposition. This increased need for project managers and other non-technical workers has been noted in previous studies in developed regions, such as the United States [7,9], which seems different than Bangladesh, where the market emphasis is on technical requirements [5]. Consistent with the indication by BRAC [13], the results of this study may suggest that there is a growing need for developing both field-level engineers and management-level personnel simultaneously where HEIs have a role to play. Of course, strong contenders are Web Developers and Computer User Support Specialists, inferring that still there is a high demand for entry-level tasks, as expected.

Although the high demand for Software Developers remained constant throughout the study period, an interesting trend is observed through the steady (and perhaps somewhat surprisingly) increasing demand for Computer Systems Engineers/Architects. This may be attributed, at least partially, to Bangladesh's ongoing overall digital transformation that has increased the need for the operation and maintenance of sophisticated ICT systems. Informatively, there is also non-standard use of the term "System Engineers" across the ICT industry in Bangladesh where the terms of reference for these jobs sometimes includes hardware/system maintenance or preliminary assembly tasks (e.g., building a PC system with different components of choice by the customer). This also provides evidence for a hardware footprint, however small, in the ICT industry in Bangladesh.

A closer look at Figures 2 and 3 suggests that there are jobs with an apparent low demand that are receiving a lot of interest from the job seekers. One such striking example is the Network and Computer Systems Administrator post. In terms of demand, it remains toward the lower end throughout the study period. However, the mean number of applications per vacancy thereof is relatively high, quite consistently throughout the study period. A similar trend is noticeable for Business Intelligence Analysts. Both Network and Computer Systems Administrator and Business Intelligence Analysts posts are rather mid- or higher-level posts, and hence the lower demand thereof compared to other entry-level posts (e.g., Web Developer) is somewhat justified. This apparent high interest in these higher-level posts somewhat raises the question of whether the ICT labor force is willing and, perhaps more crucially, equipped, to take up more challenging jobs. Furthermore, with respect to being equipped for such challenges, another pertinent question would be how the HEIs are contributing in this context, or perhaps more fundamentally, whether they are contributing at all. Both of these questions demand a further systematic study.

What job skills are in high demand in the industry is an important question, the answer whereof could be immensely beneficial for the job seekers. Insight on this could also be beneficial for the policymakers and HEIs, particularly to fine tune the curricula for the latter. Some interesting insight is available from Figure 4, which shows the ranking of the skills required through the job postings during the study period. Further insight is

captured in the skills shift graph illustrated in Figure 7. The analysis therefrom can add a novel and specific skill-shifting trend, on top of the increasing trend in the number of ICT-related jobs [23] and reveal essential insights into job shifts resulting from the pandemic. For example, there is a shift toward JavaScript and UI Design (from 2019 to 2021), which can be attributed to the pandemic's most prominent feature: the increase in remote work and digitization. During this pandemic period, efficient and effective electronic presence for every organization became crucial, thereby increasing the need for web programming (e.g., JavaScript) and UI/UX design skills. The trend seems to be consistent with the short-term change in market needs, where the promotion of digital transformation of various services has progressed. However, the fact that Networking, Testing, and Database as skills remained agnostic toward COVID-19 indicates the ICT industry's maturity in Bangladesh. The lack of change in the need for Networking and Databases is also presumably consistent with the long-term trends in the ICT sector, such as the constant need for Internet of Things and Big Data specialists [7,8]. Understanding and analyzing this skills shift graph could be instrumental for both HEIs and industry people to train and produce the needed skills. The policymakers can also gain insight on the required policy shifts to build an ecosystem that supports (or perhaps amend or even reverse the shift) if that is healthy for the industry.

5.2. Implications on Curricula Development

The preliminary CSE, BUET curricula analysis carried out in this study, although far from being complete and comprehensive, still reveals some interesting insight, as follows. Evidently, many skills are covered by the course titled Software Development Project. This lab-based course aims to complete a "Term project of making software on some practical problems with sound software engineering practices" [35]. These term projects are supervised by individual faculty members. As opposed to the traditional classroom teaching, it is rather expected that the students would self-learn the skills required under their supervision and apply those as if they were in a real-life scenario. A relevant discussion point would be whether one such course is enough or more open-ended courses like this, similar in spirit, should be introduced (e.g., internship courses).

The above discussion raises another important question: whether these skills should be "formally taught" under the university curricula. It is worth noting the following two crucial points in this context:

- The Curricula Recommendations of the ACM [14] acknowledge that the CS/CSE/IT students need to "develop skills" on their own.
- The Washington Accord document on Graduate Attributes and Professional Competencies [36] clearly stipulates "Independent and Lifelong Learning" and "adaptability to new and emerging technologies" as indispensable attributes of a (CS) engineering graduate. This is adopted and endorsed by the national engineering accreditation board as well [37].

Therefore, on an ending note of this preliminary analysis, the spirit of the current CSE, BUET curricula seems broadly in line with international standards and practices. So, although we have somewhat answered the peripheral question posed with respect to the second (i.e., N2) mentioned in our introductory discussion, this limited preliminary analysis must be followed up with an in-depth and systematic analysis, including other HEIs, to adequately address this crucial need.

5.3. Outlook

This research work primarily focuses on developing ways to assess nation-wide ICT skills demand (N1). However, as mentioned earlier, it is crucial to incorporate the outcome of the above assessments into the curricula update mechanism of the HEIs to close the loop. Furthermore, attending to our main focus (i.e., N1), we did a limited preliminary analysis that puts us in a position to formulate some strategy recommendations for the relevant stakeholders, which we present in this section as follows:

- (a) By collaborating with [Bdjobs.com](#), it is recommended that BUET and other leading HEIs in Bangladesh regularly monitor the fast-changing ICT industry skills demand through data analysis of online job postings to fine tune, revise and perhaps create new courses/programs, curricula and syllabi. This is crucial as tertiary education in CSE and IT is a critical path to cultivating potential ICT leaders. Furthermore, although the higher employment rate of CSE/IT graduates (77.1% in 2018—higher than the overall university rate of 41% in Bangladesh [17]) is definitely promising, there is room for improvement and no time for complacency, particularly because the demand for ICT professionals is expected to increase everywhere (e.g., “in finance, health, retail, and trade industries” as mentioned in [13]).
- (b) The industry skills demand through this analysis could also be disseminated to all HEIs through UGC, which is a custodian of quality and relevant academic programs in higher education. The analytical results will help HEIs in Bangladesh develop unique CSE study programs that meet the industry demands and value proposition of the respective university.
- (c) In parallel to HEIs, another important stakeholder in this context is the IT training institutes. The surveys and analysis in [5] suggest weakness in the ICT curriculum in these training institutes. Thus, an important recommendation is to improve these training institutes, which could bridge the skill gaps, for example, through short-term trainings focusing on the immediate industry needs.
- (d) The analysis pipeline presented in this article is the first of its kind in this context and should be considered as the first milestone of many more to come. More comprehensive and sophisticated analyses could be performed in the future to better identify the skills and competencies. Data from other sources should also be collected and analyzed as many companies have their own job searching websites. In addition, it is important to conduct a post-validation process for the outcome of this analysis through qualitative interviews with employers and other stakeholders.
- (e) Finally, as has been alluded to above, with respect to N2, our analysis is only preliminary and inadequate. Our goal was to only pave the way for a comprehensive analysis. Therefore, a comprehensive analysis of CSE curricula involving all HEIs in Bangladesh should be conducted; this is expected to help us assess alignment with industry demands. In addition, considering the wide range of market demand for ICT workers, curricula analysis on (i) other majors, such as IT and management (e.g., MBA) and (ii) other education levels, such as college and vocational training, will also be important.

5.4. Caveats and Limitations

A caveat in using online job portal data, in general, is that the data may not represent an entire population of interest [38]. In our case, the data of [Bdjobs.com](#) may not represent the entire ICT job market in Bangladesh. For example, the offshore job opportunities may not be posted on [Bdjobs.com](#) because they may be posted through other international job portals instead. It is important to be aware that the population that an online job portal dataset represents may differ from an entire population in the job and labor market. This will remain a limitation of this study. Another limitation is that the study period (i.e., 2016–2021), although it seems acceptably large for such an analysis, contains an unusual global pandemic event (i.e., COVID-19) that disrupts the natural trend. Although this study attempted to do additional analyses considering the pre-COVID (2016–2019) and within-COVID era (2020–2021), these two segments may not be long enough to make confident conclusions. Finally, as mentioned earlier, the statistical significance test with 95% CI did not reveal anything significant and subsequently, the exercise was repeated with 90% CI. Thus, although quite acceptable in the social science analysis context, the said analysis has a slightly larger margin of error [39] and should be interpreted cautiously.

6. Conclusions

Online job portal data offer new and exciting opportunities for analyzing and updating higher education courses and curriculum in line with industry demands, which was not possible with traditional survey data. This article uses time-series data during 2016–2021 from the largest online job portal in Bangladesh, [Bdjobs.com](#), to analyze high-demand job occupations, titles and skills in the ICT industry. The online job postings include not only job occupation and title but also skills requirements in the job descriptions that can be extracted through natural language processing. The limitation of the data, however, is the representativeness of the sample and the availability of a sufficient amount of data by sector. Yet, this relatively large dataset can be available for analysis on a time-series basis, providing the opportunity to assess the fast-changing skills demand trend in the ICT industry.

This study finds Software Developer to be a high-demand job, with the demand remaining relatively stable throughout the study period. The Web Developers and Project Management Specialists also exhibit high demand, but intriguingly, demand for the Computer Systems Engineers/Architects has been rising in recent years. The ICT skills related to API, Database, and UI Design are in high demand, and web scripting languages, such as JavaScript, are also frequently included in the ICT related job descriptions. This is all key information to guide curriculum revision and design for effective CSE/IT education and training. These and further insights through future investigation—either in a deeper manner or in a broader spectrum—can be leveraged in both tertiary education sector as well as for diploma/certificate level education and training that are prevalent in Bangladesh in the ICT context.

Many developing countries place high priorities on developing digital skills and industry. For example, under the vision of Digital Bangladesh, the government expands skills training programs. In many countries, the COVID-19 pandemic disrupted socio-economic activities, but the ICT industry is recovering fast compared with other industries, and time-series online job portal data analysis could identify the most relevant skills. This will help existing higher education and training institutions to prepare for or revise relevant curricula tailored toward industry demand, particularly considering any applicable focus shift in the post-pandemic period. High-quality ICT courses are also readily available through massive open online courses. Higher education and training institutions may wish to consider addressing skills mismatch by taking appropriate online education courses.

A cautionary note in this regard is that there were some limitations, as is the case in any research work. These limitations have been discussed above already and hence all the results presented here should be cautiously interpreted in the right context. Although the conclusions reached in our discussion have taken these limitations under due consideration, any extrapolation or usage thereof in a different context may not be valid. We cannot emphasize this point enough because often it is the case that the conclusions reached in a research work are cited or used out of context. In addition, along this line, future research works may be designed to mitigate any such limitations.

Finally, results and interpretations aside, the analysis pipeline developed in this study, comprising simple as well as sophisticated statistical and computational techniques, could be of independent interest. It is expected that this analysis pipeline will be repeated periodically as and when more data are available. In addition, future research work may be directed toward making this pipeline more sophisticated to serve the task even better, overcoming the limitations of this study.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. High demand ICT job titles by year with the number of postings (detailed information of Figure 2).

	2016		2017		2018		2019		2020		2021	
	Rank	Count										
Software Developers	1	2775	1	2692	1	2507	1	2964	1	2135	1	3087
Computer Systems Engineers/Architects	5	936	5	1157	7	1175	5	1000	4	807	2	2354
Web Developers	2	1442	2	1572	5	1327	3	1265	2	1100	3	1786
Project Management Specialists	3	1357	3	1448	3	1648	4	1006	3	838	4	1390
Computer User Support Specialists	4	1108	4	1274	6	1221	6	737	5	671	5	1295
Web and Digital Interface Designers	7	583	6	954	2	1876	2	1547	7	425	6	686
Search Marketing Strategists	12	218	9	654	4	1476	7	551	9	318	7	420
Computer Occupations, All Other	6	697	8	799	9	528	8	528	8	404	8	399
Computer Network Support Specialists	13	209	13	209	11	349	12	200	11	117	9	361

Table A2. Labor supply (the mean number of applications per vacancy) for top 10 O^{*}-NET job titles (detailed information of Figure 3).

ONET Title	2016	2017	2018	2019	2020	2021
Business Intelligence Analysts	221.19	135.21	159.72	207.95	161.17	240.61
Computer Occupations, All Other	257.66	216.42	369.35	363.15	329.30	436.45
Computer Systems Engineers/Architects	141.30	117.49	84.10	99.75	88.23	45.51
Computer User Support Specialists	141.16	143.19	138.14	217.84	159.48	101.26
Network and Computer Systems Administrators	247.43	322.49	230.76	286.62	372.59	360.51
Project Management Specialists	203.81	212.19	186.95	321.72	252.50	208.85
Search Marketing Strategists	128.37	82.93	40.70	106.05	140.07	93.45
Software Developers	52.95	55.43	60.64	54.91	51.46	35.91
Web Developers	61.97	59.57	68.63	64.69	50.47	35.24
Web and Digital Interface Designers	63.01	72.79	57.13	59.42	86.76	69.31

Table A3. Skills ranked by high demand (frequency of their appearance) by years (detailed information of Figure 4).

	2016	2017	2018	2019	2020	2021
API	14	9	8	4	2	1
Database	5	2	1	1	1	2
UI Design	8	7	3	3	4	3

Table A3. *Cont.*

	2016	2017	2018	2019	2020	2021
JavaScript	1	1	2	2	3	4
Networking	4	4	4	5	7	5
Testing & QA	11	10	11	11	9	6
HTML	3	5	6	7	5	7
Documentation	10	11	9	9	11	8
CSS	6	6	7	8	6	9
PHP	2	3	5	6	8	10
Debugging	16	13	13	13	15	11
MySQL	9	12	14	14	12	12
Research	32	26	17	19	17	13
jQuery	7	8	10	10	10	14
OOP	22	20	26	15	16	15
Git	36	28	30	23	18	16
Marketing	27	19	12	12	14	17
SQL	19	17	16	16	25	18
Andriod	21	21	19	22	20	19
Laravel	33	30	20	17	13	20
SEO	37	35	27	26	23	21
Angular	26	24	22	25	24	22
Design Pattern	30	33	36	27	29	23
React	45	43	40	38	28	24
MVC	15	15	18	18	26	25
BootStrap	17	18	25	24	19	26
ASP.NET	12	16	24	21	30	27
Ajax	13	14	15	20	22	28
WordPress	18	22	21	30	21	29
Java	23	27	23	28	27	30
SQL Server	20	23	28	31	31	31
iOS	28	32	32	36	34	32
Agile	35	38	37	33	32	33
C#	24	25	31	32	36	34
Cloud	39	39	39	39	33	35
Oracle	25	34	35	35	40	36
Linux	31	31	34	37	35	37
Python	41	41	42	41	42	38
ERP	38	36	38	40	38	39
aws	44	45	43	44	41	40
Photoshop	29	29	29	29	37	41
Illustrator	34	37	33	34	39	42
Spring	40	42	44	42	43	43
CCTV	42	40	41	43	44	44
NodeJS	46	46	46	45	45	45
C	43	44	45	46	46	46

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