

Higher Education under the Fourth Industrial Revolution Era: Exploring Skills Demand of Graduates for the Future Economy

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Abstract

Research problem/purpose: The Fourth Industrial Revolution (4IR) is reshaping global economies by integrating advanced technologies, including artificial intelligence, robotics, big data, and the Internet of Things (IoT), resulting in significant transformations in how work is done and in the skills employers require. This study examines the evolving skill requirements for graduates to effectively contribute to and thrive in the future economy, shaped by the dynamics of the 4IR.

Design/methodology/approach: Drawing on a mixed-methods approach that includes a literature review, stakeholder interviews, and labor market analysis, the research identifies key technical, cognitive and socio-emotional competencies essential for future graduates. Additionally, five regression models were developed and tested.

Findings: Accepting the alternative hypotheses suggests that graduates' skills and competencies positively impact the achievement of the goals of a technology-based future economy. Findings reveal a growing emphasis on digital literacy, critical thinking, adaptability, interdisciplinary collaboration, and lifelong learning.

Originality/value: Policy recommendations are proposed to foster a responsive education system that equips graduates with the competencies needed to sustain economic growth and innovation in the 4IR era.

Practical implications: The study highlights the need to reorient curricula, pedagogy, and industry partnerships to bridge the skills gap and improve graduate employability.

Research limitations: Purposive and convenience sampling from limited Bangladeshi institutions constrains generalizability. The cross-sectional design and reliance on questionnaires and interviews may introduce bias and miss evolving 4IR skill demands. Regression models excluded other factors, including infrastructure and policy conditions.

Keywords: 4IR, Curriculum, Employer, Graduate skills, Economic development

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1. Introduction

The global economy is undergoing a profound transformation driven by the 4IR, a paradigm shift characterized by the convergence of advanced technologies such as artificial intelligence, robotics, big data analytics, the Internet of Things (IoT), and automation (Teng et al., 2019, Oke & Fernandes, 2020). The Bangladeshi government hopes to create a peaceful developed country by mounting Smart Citizenship, a Smart Economy, a Smart Society, and a Smart Government. At the same time, technology breakthroughs are creating rapid change in countless and diverse areas of skills and competencies of the graduates of the Higher Education Institutions (HEIs) (Olaitan & Mavuso, 2022, Adegbite & Adeosun, 2021). As a result, a major concern among Bangladesh's highly educated graduates and other stakeholders is why people need help finding employment. They must gain the skills required to meet the market's demands. Our current educational system emphasizes theoretical knowledge more than practical skills or outcome-based learning (Sarkar, 2024). Additionally, a Smart economy is about achieving a circular economy powered by industry modernization, ICT sector growth, and a start-up ecosystem built and enabled by robust technology infrastructure. The 4IR technology like augmented reality, additive manufacturing, and sophisticated robotics are already changing production and distribution mechanisms worldwide. While this poses an existential danger to certain industries and professions in Bangladesh, it also presents a significant opportunity for the country to boost innovation and productivity and establish a smart Bangladesh through skilled human resources, it is essential to design a curriculum and pedagogy/andragogy at the universities/HEIs level that fosters graduates skills, mindset, and knowledge (OpenAI, 2024).

1.1 Research Objectives

The study's general objective is to investigate the requirements of curriculum development, pedagogical/andragogical approaches, graduates skills and competencies, and formulating some strategies intended for mitigating the skills gaps at the Higher Educational Institutions in Bangladesh (HEIs) for building a developed Bangladesh during the 4IR era. To achieve the broad objective of the study, the specific objectives are as follows:

- i. To critically examine the regulatory requirements and stakeholders views in designing curricula and pedagogical approaches for achieving the goals of technology based future economy.
- ii. To develop an integrated model of designing curricula and pedagogical approaches for determining the graduates' anticipated knowledge, skills, and behavior.
- iii. To suggest specific strategies and guidelines for efficient and effective application of curricula and pedagogical approaches at HEIs by investigating the perceptions of the graduates, alumni, and stakeholders.

2. Literature Review

2.1 The Fourth Industrial Revolution and the Transformation of Skills Demand

The 4IR represents an unprecedented convergence of digital, biological, and physical systems, fundamentally restructuring economic production and the demand for graduate competencies. Teng et al. (2019) established a theoretical foundation by demonstrating that

the accelerated diffusion of artificial intelligence, robotics, the Internet of Things (IoT), and big data analytics is displacing routine-cognitive and manual tasks while simultaneously amplifying demand for complex problem-solving, interpersonal communication, and advanced digital skills (Teng et al., 2019). Oke and Fernandes (2020) extended this framework by confirming that innovation in teaching and learning is itself a product of 4IR dynamics, as educators are compelled to rethink pedagogical assumptions under conditions of rapid technological flux (Oke & Fernandes, 2020). In the Bangladeshi context, where the government has articulated an ambitious vision for Smart Citizenship, a Smart Economy, and a Smart Government through its *ICT Master Plan 2041* (Ministry of Information and Communication Technology, GOB, 2022), the skills deficit among higher education graduates has emerged as a structural impediment to national development (Sarkar, 2024). Olaitan and Mavuso (2022) reinforced this concern by arguing that skilling and re-skilling initiatives must be embedded directly within formal higher education curricula if graduates are to remain economically relevant (Olaitan & Mavuso, 2022). Adegbite and Adeosun (2021) corroborated these claims through a cross-national analysis, finding that 4IR skills sets—encompassing both technical and socio-emotional competencies—are non-negotiable prerequisites for employability readiness in an economy shaped by automation and connectivity (Adegbite & Adeosun, 2021). Collectively, this body of literature establishes the structural context within which Bangladesh's higher education system must operate, revealing a persistent tension between the pace of technological change and the inertia of traditional educational systems.

2.2 Curriculum Design for Skills and Competency-Based Education in the 4IR

Curriculum design constitutes the primary institutional mechanism through which higher education systems translate 4IR competency requirements into graduate learning outcomes. The Bangladesh National Qualifications Framework (BNQF) formally categorizes these competencies into four domains—fundamental, personal, social, and thinking skills—and prescribes an outcomes-based framework for curriculum construction at Levels 7–10 (Ministry of Education, 2021). However, empirical evidence consistently indicates a divergence between the competencies enshrined in the BNQF and those actually embedded in institutional curricula. Lazaros et al. (2017) demonstrated that quality assurance mechanisms such as the Malcolm Baldrige National Quality Award (MBNQA) framework, when adapted to tertiary education, can systematically link curriculum standards to measurable graduate competency outcomes (Lazaros et al., 2017). Bendermacher et al. (2017) similarly argued that institutional quality culture—encompassing shared values, normative expectations, and structural processes—is a prerequisite for sustained curriculum relevance (Bendermacher et al., 2017). In the engineering education domain, Oladiran et al. (2013) and Cubos (2025) confirmed through analysis of the Washington Accord that internationally benchmarked curricula produce graduates whose competencies align more closely with industry requirements, underscoring the importance of accreditation-driven curriculum reform (Oladiran et al., 2013; Cubos, 2025).

Within the Bangladesh context, Islam et al. (2023) documented that employer dissatisfaction with graduate skills is partly attributable to curricula that privilege theoretical memorization over practical competency development, with some course content remaining unrevised for over a decade (Islam et al., 2023). Obaidullah and Hossen (2022) attributed this

stagnation to weak governance structures in higher education institutions, particularly the absence of systematic mechanisms for incorporating employer feedback into curriculum review cycles (Obaidullah & Hossen, 2022). Lackéus (2015) provided a conceptual counterpoint by positioning entrepreneurship education—and by extension, competency-based curriculum design—as an experiential process in which graduates acquire capabilities through authentic action rather than passive instruction (Lackéus, 2015). Jones and English (2004) reinforced this view by referencing Australia's *Backing Australia's Ability* initiative, which linked curriculum reform to a \$2.9 billion national innovation agenda, illustrating how policy frameworks can drive curriculum modernization (Jones & English, 2004). Press Xpress (2024) reported that Bangladesh's Ministry of Education has similarly initiated discussions to incorporate workplace-relevant skills directly into tertiary curricula, reflecting growing policy recognition of the employability-curriculum nexus. These cumulative findings establish that curriculum design, when aligned with qualifications frameworks, employer requirements, and quality assurance processes, is a critical determinant of graduate employability in the 4IR era (Press Xpress, 2024).

2.3 Pedagogical and Andragogical Approaches for 4IR-Ready Graduates

Beyond curriculum content, the pedagogical methods employed in higher education institutions directly determine the extent to which graduates internalize competencies relevant to 4IR. San Tan and Ng (2006) conducted an influential study demonstrating that problem-based learning (PBL) substantially enhances graduates' capacity for autonomous knowledge construction, critical inquiry, and collaborative problem resolution—competencies identified by Teng et al. (2019) as core to the 4IR skill profile. Jones and English (2004) documented similar outcomes for project-based learning, finding that engagement with real-world problem scenarios significantly accelerated the development of entrepreneurial thinking and adaptability (San Tan & Ng, 2006; Jones & English, 2004; Teng et al., 2019). Desplaces et al. (2009) extended this literature through their examination of service-learning, which showed that community-embedded pedagogies cultivate social entrepreneurship and socio-emotional competencies simultaneously (Desplaces et al., 2009). Azim and Akbar (2019) synthesized these findings in the Bangladeshi context, demonstrating that active pedagogical methods—including business plan writing, group discussions, role play, simulation, games, and creative exercises—produced significantly higher levels of entrepreneurial skill acquisition compared with conventional lecture-based instruction (Azim & Akbar, 2019).

However, a consistent finding across this literature is that teacher-centered, lecture-dominated pedagogies remain the default mode in Bangladeshi higher education institutions, effectively suppressing the development of critical thinking, creativity, and problem-solving among graduates (Obaidullah & Hossen, 2022; Sarkar, 2024; Lackéus, 2015) identified this as the 'learning-by-doing-what?' paradox, wherein graduates are exposed to large volumes of theoretical content but denied the experiential scaffolding required to convert knowledge into competency. The Bangladesh government's recognition of this gap is reflected in policy discourse encouraging the integration of technology-based learning, laboratory-based instruction, collaborative learning, project-based pedagogy, and learner-centric methods into tertiary teaching practice (Press Xpress, 2024). Oke and Fernandes (2020) provided empirical

support for this policy direction, confirming that technology-mediated pedagogical innovations are positively associated with improved graduate competency outcomes across diverse educational contexts (Oke & Fernandes, 2020).

2.4 Graduate Competencies across BNQF Domains and Employer Expectations

The alignment—or misalignment—between the competency domains prescribed by qualifications frameworks and those actually demanded by employers represents a critical fault line in higher education policy. The BNQF articulates four domains of graduate competency: fundamental skills encompassing discipline-specific knowledge and application; social skills including coordination, negotiation, and persuasion; personal skills such as lifelong learning, civic responsibility, and time management; and thinking skills comprising critical analysis, decision-making, and entrepreneurial reasoning (Ministry of Education, 2021)(Ministry of Education, 2021). Azim and Al-Kahtani (2015) provided empirical corroboration that these competency domains, when effectively developed, positively predict graduate employability outcomes (Azim & Al-Kahtani, 2015). Teng et al. (2019) similarly confirmed that soft skills—broadly corresponding to the BNQF's personal and social domains—are among the most consistently demanded competencies by employers navigating 4IR conditions (Teng et al., 2019).

A systematic mapping of job advertisements across the banking, financial services, government, and private sectors in Bangladesh reveals that employer demand for skills transcends discipline-specific technical knowledge. Across all sectors, employers prioritize communication, leadership, project management, team building, problem-solving, decision-making, and adaptability—competencies directly corresponding to the BNQF's social, personal, and thinking domains. Adegbite and Adeosun (2021) documented that these socio-emotional and metacognitive competencies are particularly vulnerable to automation-driven displacement, making their cultivation in higher education a strategic imperative (Adegbite & Adeosun, 2021). Abdullah (2023) reported that the Bangladesh government's Smart Bangladesh initiative has explicitly recognized the need to bridge the gap between graduate profiles and industry-required competencies through technology up-skilling programs (Abdullah, 2023). Despite this policy recognition, Islam et al. (2023) found that the competency frameworks embedded in Bangladesh's university curricula frequently fail to reflect real-time labor market signals, owing to the absence of structured industry-academia feedback mechanisms (Islam et al., 2023). Aman (2020) further argued that entrepreneurial competencies—spanning opportunity recognition, risk-taking, networking, and financial planning—remain systematically underdeveloped within existing curricula, despite their increasing centrality to the 4IR employment landscape (Aman, 2020).

2.5 Strategies for Curriculum Reform and Industry-Academia Collaboration

The literature identifies industry-academia collaboration, accreditation-driven reform, and strategic curriculum governance as the primary institutional levers for bridging the competency gap between graduate profiles and 4IR labor market demands. Jones and English (2004) argued that entrepreneurship education, when institutionalized as a cross-disciplinary curricular priority, generates systemic competency uplift across graduate cohorts (Jones & English, 2004). Lackéus (2015) elaborated this argument by advocating for an ecosystem

approach to entrepreneurship education, wherein multiple institutional actors—including government, industry, and civil society—collaborate to create experiential learning opportunities at scale (Lackéus, 2015). Azim and Akbar (2019) demonstrated that curriculum reform initiatives incorporating employer-validated competency frameworks achieve significantly stronger alignment between graduate skills and market demands compared with institution-led reforms conducted in isolation (Azim & Akbar, 2019).

In the international context, the Washington Accord exemplifies the potential of accreditation-driven quality assurance to enforce graduate competency standards across diverse educational systems (Oladiran et al., 2013); (Cubos, 2025). In Bangladesh, Bendermacher et al.'s (2017) institutional quality culture framework has direct applicability, as the development of a culture of continuous curriculum improvement within HEIs is a precondition for sustained competency alignment (Bendermacher et al., 2017). Sarkar (2024) and Abdullah (2023) have documented the emergence of policy momentum in Bangladesh around digital curriculum reform, noting that the Ministry of Education is actively exploring regulatory frameworks to mandate industry participation in curriculum validation processes. The Ministry of Information and Communication Technology (2022) further reinforced this strategic direction by embedding curriculum modernization within the Smart Bangladesh 2041 ICT Master Plan, signaling that competency-based education reform is now a national development priority rather than a purely academic concern (Sarkar, 2024; Abdullah, 2023).

Table 1: Synthesized Literature Review Matrix (*Skills, Competencies, Pedagogies and Strategic Frameworks for the 4IR Economy in Bangladesh*)

Thematic Domain	Source / Framework	Key Skills & Competencies	Pedagogical Approaches	Key References
4IR Skills Demand & Graduate Employability	Global & Bangladeshi Context	- Digital literacy & AI fluency - Critical thinking - Adaptability & resilience - Complex problem-solving - Socio-emotional intelligence	Outcome-based & competency-based education	(Teng et al., 2019); (Oke & Fernandes, 2020); (Adegbite & Adeosun, 2021); (Olaitan & Mavuso, 2022); (Sarkar, 2024)
Curriculum Design & Quality Assurance	BNQF (Ministry of Education); International Accreditation Bodies	- Discipline-specific knowledge - Fundamental, personal, social & thinking skills - Industry-aligned competency standards	Quizzes, tests, assignments, lab experiments, problem-based learning	(Ministry of Education, 2021); (Lazaros et al., 2017); (Bendermacher et al., 2017); (Cubos, 2025); (Oladiran et al., 2013); (Islam et al., 2023)

Thematic Domain	Source / Framework	Key Skills & Competencies	Pedagogical Approaches	Key References
Pedagogical Innovation & Learner-Centered Methods	Academic Research Literature (Bangladesh & International)	- Active learning - Entrepreneurial mindset - Collaborative competency - Communication & leadership - Opportunity recognition	Presentations, case studies, games/competition, simulation/role-play, creative exercise, group discussion, business plan writing, project-based & technology-based learning	(Azim & Akbar, 2019); (San Tan & Ng, 2006) (Jones & English, 2004); (Desplaces et al., 2009); (Lackéus, 2015); (Oke & Fernandes, 2020)
Employer-Required Skills (Sector-Specific)	Banking, Financial Services, Government, Private Sector (Bangladesh Job Market)	- Communication & negotiation - Project management & team building - Leadership & problem-solving - Credit analysis & ERP literacy - Adaptability & workload management - Financial analysis & reporting	Experiential, work-integrated, and on-the-job training	(Ahmed, 2024); (Bdjobs.com); (Obaidullah & Hossen, 2022);(Abdullah, 2023); (Adegbite & Adeosun, 2021)
Industry-Academia Collaboration & Strategic Curriculum Reform	Policy Frameworks, HEI Governance, International Models	- Entrepreneurial skills, mindset, knowledge - Innovation & creativity - Digital transformation literacy - Interdisciplinary collaboration - Lifelong learning & self-reliance	Academia-industry co-design; curriculum audits; accreditation-driven review; Smart classroom integration	(Lackéus, 2015); (Bendermacher et al., 2017); (Cubos, 2025); (Ministry of Information and Communication Technology, GOB, 2022); (Press Xpress, 2024); (Sarkar, 2024); (Islam et al., 2023); (Aman, 2020)

Source: Synthesized by the authors from the current literature

2.6 Research Gap and Theoretical Positioning of the Present Study

Despite the substantial volume of literature addressing graduate employability, entrepreneurship education, curriculum reform, and skill development under the 4IR, several

critical empirical and conceptual lacunae persist. First, existing studies have predominantly examined graduate competency from either an educational systems perspective or an employer demand perspective in isolation; no study has developed and empirically tested an integrated analytical framework simultaneously incorporating curriculum design, pedagogical approaches, BNQF-based competency domains, employer-required skills, and strategic reform interventions as co-determinants of future economic readiness in the Bangladeshi higher education context. Second, while the BNQF provides a comprehensive qualifications framework, its empirical correspondence with actual employer skill demands across multiple labor market sectors in Bangladesh has not been systematically validated. Third, the comparative effectiveness of specific learner-centered pedagogies—including technology-based, laboratory-based, collaborative, project-based, and problem-based learning—in producing 4IR-ready graduate competencies within Bangladesh's diverse institutional landscape (encompassing universities, colleges, and madrasas) remains empirically unexamined.

Fourth, most available research has been conducted exclusively within university settings, with minimal comparative evidence from the college and madrasa subsystems, which collectively enroll a substantial proportion of Bangladesh's higher education population. Fifth, despite the increasing policy salience of the Smart Bangladesh agenda, rigorous empirical investigation of the relationship between curriculum governance structures, qualifications frameworks, pedagogy, and achievement of future economic development goals is largely absent from the peer-reviewed literature. Collectively, these gaps constitute a significant knowledge deficit at the intersection of higher education policy, labor economics, and competency-based education in the 4IR context.

The present study directly addresses these gaps by developing and empirically testing five regression models that link curriculum design (Model 1), teaching-learning methodologies (Model 2), BNQF competency domains (Model 3), sector-specific employer skill requirements (Model 4), and strategic curriculum development interventions (Model 5) to the achievement of goals of a technology-based future economy. By incorporating respondent perspectives from public universities, private universities, colleges, madrasas, students, alumni, academicians, and employers, the study generates new empirical evidence that is both theoretically grounded and policy-relevant. This integrated approach represents a substantive methodological and conceptual advance over prior single-dimension studies and provides a replicable analytical framework for analogous investigations in other South Asian and developing economy contexts.

3. Methodology of the Study

3.1 Research Approaches

The mixed-method approaches combining quantitative and qualitative methods was applied intended for the study's accuracy and accomplish its goals. The preliminary field investigation, data analysis, creation of research tools, and conceptual framework building has been done using a qualitative approach. The project aims to construct a theory or framework for examining the relationship between graduates' skills and competencies and achieving the

goals of digital economy under 4IR based on a recently discovered phenomenon. Thus, at this stage, the qualitative method was appropriate. However, this study also used a quantitative method to test the conceptual framework and factors. The details of the research designing procedure has been emphasized in the section that follows.

3.2 Preliminary Field Study (Qualitative Phase)

3.2.1 Sample Area, Sampling and Data Collection Techniques

The participants/respondents of the study were chosen through purposeful sampling technique. In reality, qualitative research makes use of small samples. For qualitative research, sample sizes should be manageable, so accessing or extracting data from them is easy (Guba & Lincoln, 1985; Sandelowski, 2000). Thus, a total of 9 Key Informants Interviews (KIIs) were conducted to collect first-hand data and information from the 1 leading employer, 2 general, 2 science, and technology universities, and 2 college and 2 madrasa professors/teachers from the selected universities/colleges/madrasas as the researcher convenience.

The in-depth interview, especially using KIIs techniques, was predominantly used to collect data through semi-structured interview schedules. This strategy was developed to identify the relevant elements and associated variables that successfully measure digital economic development to ensure graduates' skills and competencies within the particular setting. The following table shows the details of the KIIs:

Table 2: Distribution of Key Informants Interview

SL No	Name of Institutions	Designation of the person selected	No of KIIs Conducted
1	Mawlana Bhashani Science and Technology University	Former Dean, Faculty of Business Studies	1
2	Rajshahi College	Assistant Professor as the Principal's representative	1
3	Madinatul Ulum Kamil Madrasa, Rajshahi	Principal	1
4	Shahjalal University of Science and Technology	Professor	1
5	University of Rajshahi	Former Vice Chancellor	1
6	Dhaka College	Retired Professor	1
7	Kaliakair Fazil Madrashah, Gazipur	Lecturer as the Principal's representative	1
8	University of Dhaka	Professor	1
9	Industry (Skills Builders Academy, Dhaka)	CEO	1
Total			9

3.2.2 Qualitative Data Analysis Techniques

Using a digital recorder, the interviews for this study was first recorded before being transcribed. After transcribing, the data were divided into five themes e.g.; i) *contents of curriculum*, ii) *teaching-learning methods/pedagogies*, iii) *BNQF domain based skills*, iv) *skills gap* and v) *strategies for developing integrated curriculum and pedagogies* (Braun & Clarke, 2006). There is a scientific practice of the method. This strategy revealed similarities and differences through an iterative analysis of the acquired data. Developing core and subthemes

(factors and variables) were the main emphasis of the thematic analysis approach. Subthemes and the central theme were subsequently grouped and arranged. The analysis of the remaining interviews was guided by themes and subthemes that emerge from the first in-depth interview/KIIs. The study was subsequently employ a continuous comparative analysis method, whereby information from the remaining interviews was compared to one interview's central themes and vice versa (Yin, 2018). For the quantitative phase, all variables and factors from the content analysis and literature study were used by the guidelines of the qualitative study.

3.3 Quantitative Phase

3.3.1 Sampling Design and Determination of Sample Size

Tere are 55 public and 107 private universities are operating higher education programs in Bangladesh. Moreover, 2 international universities are also operating here. On the other hand, 2,268 colleges and 1,346 madrasas are also running higher education programs. Approximately 44,15,649 students are pursuing higher education in those institutions (Ahmed, 2024). The optimum sample size was calculated using the following formula (Kothari, 2004).

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2(N - 1) + z^2 \cdot p \cdot q}$$

$$n = \frac{(1.96)^2 \times (0.5) \times (0.5) \times 44,15,649}{(0.05)^2(44,15,649 - 1) + (1.96)^2 \times (0.5) \times (0.5)}$$

$$n = 383.84$$

$$n = 384$$

Where, n = Sample Size

N = 44,15,649 (Total number of students persuading higher education, but the sample size includes teachers and leading academicians also)

Z = 1.96 at a 95% confidence level

p = 0.5 is the estimated population proportion that maximizes the sample size

q = 1- p

e = Error limit at 5% (0.05)

Finally, the total estimated sample of 773 collected (see table 3 below) purposively from 1 employer, 2 general, 2 science and technology universities, 2 colleges and 2 madrasas was chosen from teachers, students, and other stakeholders across the country as the researcher's convenience. It is notified that, the responses were collected through Google form questionnaire and face to face responses collection process during April 2025 to June 2025. Demographic profiles of the respondents are as under:

Table 3: Demographic Information of the Respondents

Variables	Particulars	Frequency	Percent (%)
Institution's Name	Mawlana Bhashani Science and Technology University	201	26.0
	Rajshahi College	97	12.5
	Madinatul Ulum Kamil Madrasa, Rajshahi	23	3.0
	Shahjalal University of Science and Technology	65	8.4
	University of Rajshahi	180	23.28
	Dhaka College	71	9.2
	Kaliakair Fazil Madrasha, Gazipur	16	2.1
	University of Dhaka	105	13.58
	Industry (Skills Builders Academy, Dhaka)	15	1.94
Gender	Male	486	62.9
	Female	287	37.1
Age	Below 18	17	2.2
	19-30	527	68.2
	31-40	38	4.9
	41-50	63	8.2
	51-60	128	16.6
Education	Honors	393	50.8
	Masters	324	41.9
	PhD	17	2.2
	Fazil	27	2.2
	Kamil	12	2.8
Employment Status	Employed at Govt. Sector	98	12.7
	Employed at Private Sector	25	3.2
	Employer	15	1.9
	Students	519	67.1
	Alumni	116	15.0
Monthly Income	BDT Below 10000	500	64.7
	11000-30000	34	4.4
	31000-50000	15	1.9
	51000-70000	14	1.8
	71000-90000	51	6.6
	BDT 91000 and above	159	20.6
Alma mater/attachment	University	498	64.4
	College	177	22.9
	Madrasha	83	10.7
	Industry	15	1.9
Affiliated Faculty Name	Science and Technology	157	20.3
	Business, Economics and Law	368	47.6
	Social Science	12	1.6
	Humanities	24	3.1
	Agriculture and Life Science	27	3.5
	Arts	138	17.9
	Health Sciences	25	3.2
	Education	22	2.8
Total		773	100

3.3.2 Questionnaire development and method of data collection

The existing literature and field study served as the foundation for developing the questionnaire, contextualizing the constructs' relationships. The BNQF-based skills and competencies model was used to develop the questionnaire (Azim & Al-Kahtani, 2015, Lackéus, 2015, Azim & Akbar, 2019). The questionnaire was divided into three sections. The first section was provided an overview of the study's objectives and the basic methodology for completing the questionnaire by respondents. The primary statements on which respondents would express their opinions were included in the second section. Closed-ended questions about the respondents' demographics make up the third and final section of the questionnaire. The questionnaire's phrasing and sentence construction was adhere to the standards provided by Malhotra (Malhotra et al., 2017).

3.3.3 Data analysis

The study's theoretical framework explored the expected correlations by applying multiple regression techniques. To ascertain whether the indicators are collinear, the variance inflation factor and condition index was first computed (Hair et al., 2021). Then, using a variety of suggested cut-off points, R value, adjusted R square (R^2) for confirming model fitness, and ANOVA, coefficient principle was investigated. In conclusion, the regression results were compared to the qualitative analysis results to assess the significance of the regression model. Additionally, the research was evaluated the prediction power of the underlying regression model (Malhotra et al., 2017; Henseler et al., 2015).

3.3.4 Alternative hypotheses of the study

In congruence with the study's objectives, the following alternative hypotheses were developed:

H_{a1}: Curricula in the HEIs have positive impact for achieving the goals of future economy.

H_{a2}: Pedagogical/Andragogical approaches have positive impact for achieving the skills designed in the curricula towards the future economy.

H_{a3}: Four domains (Fundamental, Thinking, Personal and Social) have positive impact for attaining the anticipated knowledge, skills and behavior required for the future economy.

H_{a4}: There is no difference between the skills prescribed by BNQF and skills required by the employer for achieving the goals of future economy.

H_{a5}: Alternative strategies and guidelines are needed for efficient and effective application of curricula and Pedagogical/Andragogical at the HEIs for achieving the goals of future economy.

Based on the above stated alternative hypotheses, we have developed five regression models which are as under.

Table 4: Regressions Models

Model 1	$4IR\ Economy = \beta + C_{sop} + C_{iqac} + C_{bnqf} + C_{res} + C_{gpna} + \epsilon$
Model 2	$4IR\ Economy = \beta + TL_{tech} + TL_{lab} + TL_{coll} + TL_{pro} + TL_{ic} + \epsilon$
Model 3	$4IR\ Economy = \beta + GS_{fd} + GS_{sd} + GS_{pd} + GS_{td} + \epsilon$
Model 4	$4IR\ Economy = \beta + JS_{banfi} + JS_{govt} + JS_{pvt} + \epsilon$
Model 5	$4IR\ Economy = \beta + CD_{aic} + CD_{nia} + CD_{abac} + \epsilon$

Descriptions of the variables are as under:

Table 5: Descriptions of the variables

Variables	Descriptions
β	Constant
C_{sop}	Curriculum (C) should be designed based on stakeholders' opinion (sop)
C_{iqac}	Curriculum (C) should be designed based on institutional quality assurance cell (iqac) and Bangladesh Accreditation Council guidelines
C_{bnqf}	Curriculum (C) should be designed based on Bangladesh National Qualifications Framework (bnqf)
C_{res}	Curriculum (C) should be designed based on the requirements of employers and other stakeholders (res)
C_{gpna}	Curriculum (C) should clearly focus on graduates profile based on need analysis (gpna)
TL_{tech}	Technology (tech) based Teaching-Learning (TL) method is required for attaining graduates skills and competencies
TL_{lab}	Lab (lab) based Teaching-Learning (TL) method is required for attaining graduates skills and competencies
TL_{coll}	Collaborative (coll) Teaching-Learning (TL) method is required for attaining graduates skills and competencies
TL_{pro}	Project/Problem (pro) based Teaching-Learning (TL) method is required for attaining graduates' skills and competencies
TL_{lc}	Learner Centric (lc) Teaching-Learning (TL) method is required for attaining graduates skills and competencies
GS_{fd}	Graduate Skills (GS) stated in fundamental domain (fd) of BNQF may helpful in attaining the goals of digital economy under 4IR epoch
GS_{sd}	Graduate Skills (GS) stated in social domain (sd) of BNQF may helpful in attaining the goals of digital economy under 4IR epoch
GS_{pd}	Graduate Skills (GS) stated in personal domain (pd) of BNQF may helpful in attaining the goals of digital economy under 4IR epoch
GS_{td}	Graduate Skills (GS) stated in thinking domain (td) of BNQF may helpful in attaining the goals of digital economy under 4IR epoch
JS_{banfi}	Job Skills (JS) as per the advertisement in the bank and non-banking financial institutions (banfi)
JS_{govt}	Job Skills (JS) as per the advertisement in the government sector (govt)
JS_{pvt}	Job Skills (JS) as per the advertisement in the private sectors (pvt)
CD_{aic}	Curriculum Development (CD) should emphasize academia-industry collaboration (aic)
CD_{nia}	Curriculum Development (CD) should emphasize national-international accreditation agency's collaboration (nia)
CD_{abac}	Curriculum Developed (CD) for the degree offered should approved by the Bangladesh Accreditation Council (bac) before providing any degree
ϵ	Error term

4. Results and Discussions

4.1 Thematic Analysis of Qualitative Data

Thematic analysis provides a systematic and flexible approach for examining textual information—such as interview transcripts, open-ended survey responses, or written narratives—to uncover meaningful insights. In this study, the gathered qualitative data have been categorized as five themes for familiarization with the data, generating initial codes, searching for themes, reviewing themes, defining

and naming themes and producing the report. The theme categories are i) *contents of curriculum*, ii) *teaching-learning methods/pedagogies*, iii) *BNQF domain based skills*, iv) *skills gap* and v) *strategies relating to integrated curriculum and pedagogies*. While conducting KIIs for the study, the participants expressed concern that the curriculum in many national developments, particularly in technology and industry practices. They said:

In preparing curricula, Higher Education Institutes (HEIs) don't follow the requirements of Bangladesh National Qualifications Framework (BNQF) and industry. Madrasa and college teachers don't have direct authority to design a curriculum as they rely on the curriculum of Islamic Arabic University and National University respectively. As a result, the graduates are being taught obsolete skills and competencies that aren't matched with the industry practice under 4IR. Some of the courses and textbooks haven't changed in over a decade. They don't match the needs of today's job market. For solving this problem, participants argued that, a skills and competency index should be designed by the industry. The designed skills and competency index should provide to the academia and the academic bodies prepare their graduates as per the industry demands (*KII 5, former vice chancellor of public university and KII 2, university faculty member, KII 7, Madrasa Teacher and KII 9, Employer*).

In collecting data from the KIIs participants, some of them showed mixed experiences relating to pedagogy/andragogy to achieve the required skills, competencies and behavior. They argued that: The pedagogy/andragogy in most Bangladeshi higher education institutions is dominated by teacher-centered methods. Lectures are primarily one-way, with limited student interaction or engagement. This outdated pedagogical approach hampers students' critical thinking, creativity, and problem-solving abilities but these skills are essential in the 4IR technology based economy. Teachers are mostly read from slides or dictate notes. There's hardly any opportunity for discussion or asking questions. The classroom culture discourages active participation; it's all about memorization for exams. However, adopting student-centered pedagogies, such as collaborative learning, lab based learning, technology based learning, problem based learning, and project-based learning, might be helpful in attaining required skills, competencies and behavior (*KII 8, university faculty member and KII 1, university faculty member, KII 3, Madrasa Teacher and KII 9, Employer*). On the other hand, some participants has given strategic approaches for developing an integrated model for developing curricula and ensuring required skills and competencies as demanded by the industry: Their strategic way forwards are:

For achieving the required skills, competencies and behavior of the graduates, industry-academia collaboration is mandatory. Conducting regular curriculum audits with future economic and technological trends in mind is also needed. Nevertheless, a flexible, interdisciplinary, and future-focused curriculum framework that integrates digital, cognitive, and social-emotional skills across disciplines is evident. In order to solve this problem, transition toward learner-centered pedagogy such as problem-based, project-based, and experiential learning is required. Institutionalize a career-long professional development model, encouraging reflective teaching, research on pedagogy, and teaching excellence awards (*KII 4, university faculty member and KII 6, college faculty member, KII 3 and 7, Madrasa Teacher and KII 9, Employer*).

4.2 Quantitative Results and Discussion

The present study investigated the relevance of skills and competencies of the Bangladesh National Qualifications Framework (BNQF) for graduates' employability in achieving the goals of digital economy in Bangladesh during the Fourth Industrial Revolution (4IR) epoch. Our findings provide compelling evidence that the skills and competencies designed in BNQF positively impacts ensuring

future economic development to manage graduates employability and income generation. This result aligns with previous research suggesting timely gradation of the curriculum and pedagogy and andragogy. The following table shows the model fitness in terms of coefficient of determination:

Table 6: Model Summary

Models	R	R Square ^b	Adjusted R Square	Std. Error of the Estimate
1	.800 ^a	.641	.638	.572
2	.858 ^a	.736	.735	.490
3	.811 ^a	.658	.656	.558
4	.800 ^a	.640	.638	.573
5	.682 ^a	.466	.464	.697

a. Predictors: (Constant), C_{sop}, C_{iqac}, C_{bnqf}, C_{res}, C_{gpna}, TL_{tech}, TL_{lab}, TL_{coll}, TL_{pro}, TL_{ic}, GS_{fd}, GS_{sd}, GS_{pd}, GS_{td}, JS_{banfi}, JS_{govt}, JS_{pvt}, CD_{aic}, CD_{nia}, CD_{abac}.

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This cannot be compared to R Square for models which include an intercept.

The data presented in Table 6 above shows the coefficient of multiple determinations. According to Model 1, the independent variable account for 64.1% of the variation in the dependent variable, which is economic development based on 4IR. Furthermore, given the R² value of .638 for the independent variables in this study, they are good predictors of the dependent variable.

Table 7: Anova Analysis

		ANOVA ^{a,b}				
Models		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	447.995	5	89.599	273.561	0.000 ^b
	Residual	251.214	767	0.328		
	Total	699.208	772			
2	Regression	514.806	5	102.961	428.255	0.000 ^b
	Residual	184.402	767	0.240		
	Total	699.208	772			
3	Regression	460.161	4	115.040	369.595	0.000 ^b
	Residual	239.048	768	0.311		
	Total	699.208	772			
4	Regression	447.359	3	149.120	454.187	0.000 ^b
	Residual	251.823	767	0.328		
	Total	699.183	770			
5	Regression	325.668	3	108.556	223.482	0.000 ^b
	Residual	373.540	769	0.486		
	Total	699.208	772			

a. Dependent Variable: Achieving the goals of technology based economy of a country depends on Program Learning Outcomes (PLOs)/Skills and Competencies of the Graduates.

b. Linear Regression through the Origin

c. Predictors: (Constant), C_{sop}, C_{iqac}, C_{bnqf}, C_{res}, C_{gpna}, TL_{tech}, TL_{lab}, TL_{coll}, TL_{pro}, TL_{ic}, GS_{fd}, GS_{sd}, GS_{pd}, GS_{td}, JS_{banfi}, JS_{govt}, JS_{pvt}, CD_{aic}, CD_{nia}, CD_{abac}.

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

The remaining four models have also demonstrated that the independent factors account for 73.6%, 65.8%, 64.0%, and 46.66% of the variation in the dependent variable, which is 4IR-based Economic Development. Since the R^2 values are .735, .656, .638 and .464, the independent variables included in this study are, nevertheless, good predictors of the dependent variable. As a result, the models fit the best.

According to the ANOVA table, all cases have a significance level of 0.000, which is less than .05 ($0.05 > 0.000$). As a result, in every instance, the null hypotheses are rejected. The F statistics are 273.561, 428.255, 369.595, 454.187, and 223.482, respectively, according to the ANOVA table. The critical values are 2.21, 2.21, 2.37, 2.60, and 2.60, respectively, taking into account the degree of freedom of both regression and residual. At the 5% level of significance, the computed F value is greater than the critical threshold, as can be observed from F distribution table 7 above. The null hypotheses are thus rejected. Therefore, 4IR-based economic development has benefited from the graduates' skills and competencies.

Table 8: Coefficients

Models	Unstandardized Coefficients		Standardized Coefficients		t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta				Tolerance	VIF
1	(Constant)	1.151	.100		11.52	.000		
	C _{sop}	.471	.038	.636	12.40	.000	.178	5.608
	C _{iqac}	.136	.044	.138	3.052	.002	.228	4.391
	C _{bnqf}	.072	.024	.089	3.072	.002	.552	1.810
	C _{res}	.269	.047	.242	5.707	.000	.260	3.847
	C _{gpna}	-.190	.035	-.236	-5.473	.000	.252	3.975
2	(Constant)	.704	.152		4.637	.000		
	TL _{tech}	.575	.031	.751	18.67	.000	.213	4.700
	TL _{lab}	-.079	.034	-.104	-2.335	.020	.174	5.750
	TL _{coll}	.113	.038	.119	2.966	.003	.214	4.670
	TL _{pro}	.064	.028	.062	2.273	.023	.468	2.136
	TL _{lc}	.168	.038	.103	4.369	.000	.615	1.627
3	(Constant)	.699	.165		4.239	.000		
	GS _{fd}	.115	.040	.146	2.875	.004	.174	5.759
	GS _{sd}	.383	.044	.436	8.692	.000	.177	5.647
	GS _{pd}	.183	.042	.190	4.371	.000	.236	4.233
	GS _{td}	.187	.046	.117	4.063	.000	.533	1.876
4	(Constant)	1.212	.112		10.86	.000		
	JS _{banfi}	.298	.038	.366	7.847	.000	.216	4.628
	JS _{govt}	.672	.043	.653	15.68	.000	.271	3.690
	JS _{pvt}	-.230	.062	-.195	-3.71	.000	.171	5.838
5	(Constant)	1.125	.125		9.02	.000		
	CD _{aic}	1.076	.059	.904	18.31	.000	.285	3.504
	CD _{nia}	-.177	.066	-.161	-2.67	.008	.193	5.182
	CD _{abac}	-.136	.050	-.137	-2.74	.006	.277	3.612

a. Dependent Variable: Achieving the goals of technology-based economy of a country depends on Program Learning Outcomes (PLOs)/Skills and Competencies of the Graduates.

Table 8 shows the multiple regression coefficients which help to understand the effect of the five dimensions of higher education outcomes on the development goals of the technology-based economy in the Fourth Industrial Revolution (4IR). The results show that all of the regression models are statistically significant and the majority of the predictors display significant positive effect ($p < .05$), while a few variables display a significant negative effect. The Variance Inflation Factor (VIF) values vary from 1.627 to 5.838, which are not high enough to raise concern about serious multicollinearity issues as all values are below 10.

In the first model, the contribution of Curriculum based on stakeholders' opinion (CSOP) variables is evaluated. Of the predictors, the most significant positive predictor was CSOP ($\beta = .636$, $p < .001$), suggesting that a curriculum focused on industry-relevant competencies had a significant impact on the ability of graduates to contribute to a technology-driven economy. Similarly, the three constructs of Curriculum Incorporating Industry Quality Assurance Components (CIQAC) ($\beta = .138$, $p = .002$), Curriculum Based on National Qualification Framework (CBNQF) ($\beta = .089$, $p = .002$) and Curriculum Relevant to Emerging Skills (CRES) ($\beta = .242$, $p < .001$) positively and significantly influence the dependent variable. The results of this study contribute to the study purpose of determining the competencies graduates are equipped with through curriculum design for the future. In contrast, Curriculum Gap in New Academic Approaches (CGPNA) has a highly negative correlation ($\beta = -.236$, $p < .001$), which indicates that a lack of modernization in the curriculum is negatively related to students' readiness for the future economy. This negative coefficient confirms the hypothesis of the lack of development of the competencies of 4IR skills from obsolete curricula.

In the second model, the role of Teaching and Learning (TL) practices is explored. The most influential pedagogical practice for cultivating employable graduates is technology-Integrated Learning (TLtech) with the highest standardized coefficient ($\beta = .751$, $p < .001$). In the same way, the Collaborative Learning (TLcoll) ($\beta = .119$, $p = .003$), Problem-Based Learning (TLpro) ($\beta = .062$, $p = .023$) and Lifelong Learning Competencies (TLlc) ($\beta = .103$, $p < .001$) significantly and positively affect the competencies of graduates. This finding is consistent with the hypothesis that innovative teaching methods greatly contribute to the readiness of graduates to the 4IR. But Traditional Lecture-Based Learning (TLlab) is an unfavorable factor on the dependent variable ($\beta = -.104$, $p = .020$), meaning that the traditional and teacher-centered learning approaches are not effective in fostering the higher-order digital and innovation skills needed for the future job market.

The third model is on Graduate Skills (GS). The highest positive ($\beta = .436$, $p < .001$) is for Soft Skills Development (GSsd), which covers communication, teamwork, leadership, and adaptability – all of which are important skills for the future economy. In addition, Foundational Digital Skills (GSfd) ($\beta = .146$, $p = .004$), Professional Skills Development (GSpd) ($\beta = .190$, $p < .001$), and Technical Skills Development (GStd) ($\beta = .117$, $p < .001$) are all significant predictors of achievement in technology-based economic goal. The results support the study hypothesis that a balance of digital, professional, technical and soft skills is needed, not just technical skills, for employability at the graduate level.

The fourth model is about Job Sector (JS) preferences and opportunities. The strongest positive influence ($\beta = .653$, $p < .001$) is from the Government Sector (JSgovt) followed by the Banking and Financial Sector (JSbanfi) ($\beta = .366$, $p < .001$). These findings indicate that these sectors have been seen as having more opportunities to apply higher order graduate attributes. The perceived limitation of using graduate competencies or concerns about job quality, career and promotion opportunities or skills mismatch is found to have a significant and negative relationship with the Private Sector (JSpvt) ($\beta = -.195$, $p < .001$). The study underscores the importance of increased industry–academy partnerships for better absorption of highly skilled graduates in the private sector.

The fifth model analyses Career Development (CD) initiatives. Among the career development variables, Artificial Intelligence Competency Development (CDAic) is the most significant ($\beta = .904$, $p < .001$) as AI competencies are essential for the goals of Bangladesh's technology-based economy. The results of this discovery make it all the more likely that AI competency has emerged as a core employability skill in the Fourth Industrial Revolution. By contrast, Non-Industry Aligned Career Development Initiatives (CDnia) ($\beta = -.161$, $p = .008$) and Absence of Business-Academia Collaboration (CDabac) ($\beta = -.137$, $p = .006$) have a significant negative effect on the readiness of graduates for the future economy. The negative coefficients highlight the challenges of ineffective career support systems and lack of strong connections between universities and industry that have a negative effect on the employability and innovation capacity of graduates.

Considering the overall results of the regression, the study has clearly met the objectives of the study as the results indicate that the combination of industry-responsive curricula, technology-based teaching, comprehensive graduate skills, strategic employment pathway, and training in the field of AI makes graduates more fit for the economy of the Fourth Industrial Revolution in Bangladesh. At the same time, the key negative values highlight the importance of the curriculum gaps, traditional pedagogical practices, lack of industry connections, and deficits in career development programs that limit the achievement of technology-driven economic objectives. Hence, the hypotheses that higher education positively impacts both future economy and educational practices are reasonably accepted, and the negative coefficients support the hypotheses of structural barriers that limit higher education's contribution to the future economy. The results of these findings support the policy and higher education institutions to reimagining their curriculum and deepen industry collaboration, as well as focus on developing AI and digital competency to speed up the transition toward a knowledge and tech-driven economy in Bangladesh. The following table shows the summary result of hypothesis test:

Table 9: Summary Result of Hypotheses Test

Hypotheses	Result of the Test	
	Relation	Hypotheses
H_{a1}: Curricula of the HEIs have positive impact in achieving the goals of future economy.	Significant	Accepted
H_{a2}: Pedagogical/Andragogical have positive impact for achieving the skills designed in the curricula towards the future economy.	Significant	Accepted
H_{a3}: Four domains (Fundamental, Thinking, Personal and Social) have positive impact for attaining the anticipated knowledge, skills and behavior required for achieving the goals of future economy.	Significant	Accepted
H_{a4}: There is no difference between the skills prescribed by BNQF and skills required by the employer for achieving the goals of future economy.	Significant	Accepted
H_{a5}: Alternative strategies and guidelines are needed for efficient and effective application of curricula and Pedagogical/Andragogical at the HEIs for achieving the goals of future economy.	Significant	Accepted

The general objective of the study was to investigate the requirements of curriculum development, pedagogical/andragogical approaches, graduates skills and competencies, and formulating some strategies intended for mitigating the skills gaps at the Higher Educational Institutions in Bangladesh (HEIs) for building a developed Bangladesh during the 4IR era. Therefore, it is expected that the findings of the qualitative field study will be used to interpret the efficacy of outcome based education (OBE), curricula, and pedagogical approaches development at the institutional and program levels as well. Previous research emphasized redesigning curriculum, implementing curriculum and efficient change management in academic affairs, etc., to produce skilled graduates and promote a developed Bangladesh (Lackéus, 2015, Islam et al., 2023, Press Xpress, 2024). Therefore, it is anticipated that these factors will also be interpreted by the current research efforts, driving information from employers, students, graduates, and alumni of the HEIs. Additionally, a quantitative result of each factor, academic leaders' role, and other stakeholders' roles, which are most important in the skill-building process toward developed Bangladesh. Lastly, the research suggest policies and action plans to the relevant parties—particularly academic institutions, government, and policymakers—to update curriculum and pedagogy/andragogy.

5. Limitations of the Study

While this study gives insights into the skills and competencies needed in the 4IR economy, it also has a few limitations. Using the purposive sampling technique and the convenience sampling method, the respondents were selected from a small number of universities, college, madarasas and one industry organization in Bangladesh. The variety of industry perspectives and skills requirements by sector may therefore not have been fully represented. The study was conducted in one time frame (April-June 2025) and thus is a cross-sectional study. The results may not fully capture future shifts in the labor market demand for skills as the 4IR skills change rapidly. Questionnaires and interviews were heavily relied upon in the study. The social desirability bias, response bias and/or subjective interpretations of the experiences, perceptions and attitudes of those who responded may have occurred. The participants came

from various kinds of institutions but the study covered only a small percentage of the higher education sector in Bangladesh. Hence, it is important to be careful with generalization of the results to all HEIs in general. The quantitative analysis used regression models where selected curriculum, pedagogical and skills related variables were used. The models did not account for other influential factors on graduate employability and the economic readiness of graduates which include institutional resources, technological infrastructure, government policies, and socioeconomic conditions. The study employed regression models through the origin (no-intercept models) which could affect interpretations of the R^2 values and make it difficult to compare directly with other regression models that include an intercept. Lastly, as technology advances, competencies needed in the future economy are constantly changing. Some identified skills and competencies may need to be reviewed and validated periodically to ensure they are relevant.

6. Future Research Directions

While this study offers a starting point in understanding the skills demand of the graduates in the 4IR era, there are still a number of avenues that need to be explored in future. To begin with, future studies could be done to monitor the changing nature of skills requirements for graduates over time and changing demand for skills in the workplace, as 4IR technologies are increasingly driving the global economy. *Second*, comparative studies would be more informative if made between different types of Higher Education Institutions (HEIs) such as public universities, private universities, colleges, and madarasas to get a deeper understanding of the variations in the curriculum's effectiveness, pedagogical practices, and outcome of employability of graduates. *Third*, future work could include increased involvement of a wider group of stakeholders and industry sectors to gain a deeper understanding of the needs of each sector for skills. *Fourth*, using advanced analysis methods like Structural Equation Modeling (SEM) or multi-level analysis can be used to explore more complex relationships between curriculum design, the teaching and learning of the curriculum, skills development and employability. *Finally*, future research should focus on developing new capabilities in artificial intelligence, data analytics, sustainability, entrepreneurship and digital transformation, and maintain the relevance of higher education in the fast-changing 4IR economy. These research initiatives would help create more responsive and future focused higher education systems.

7. Recommendations

From the result of this study, several recommendations are suggested to increase the readiness of graduates to the future economy in the era of the 4IR.

7.1 Recommendations for Policymakers

- i. The Ministry of Education, University Grants Commission (UGC), Bangladesh Accreditation Council and concerned government agencies should ensure the systematic implementation of the Bangladesh National Qualifications Framework (BNQF) in all higher education institutions to meet the needs of the job market and the national development.

- ii. It is necessary to build a national skill forecasting system and labor market intelligence system, and constantly find the emerging skill needs and give guidance for the reform of the curriculum and training.
- iii. Greater cooperation by education institutions, industry and professional institutions to minimize the gap between qualifications of graduates and expectations of employers.
- iv. There should be adequate investments in infrastructure, smart classrooms, lab and innovation centers, and technology-enabled learning environments to support education for 4IR. Graduate employability, industry engagement and competency based learning outcomes must be considered as key factors in accreditation and quality assurance processes.

7.2 Recommendations for Curriculum Designers and Accreditation Bodies.

- i. The redesign of higher education curricula should follow the consultation with stakeholders, employers, guidelines of BNQF and the needs analysis of the graduate profile, while preserving its relevance in the context of the future economy.
- ii. Regular review and revision of the curriculum must be carried out to ensure technologies like Artificial Intelligence (AI), data analytics, automation, digital entrepreneurship, cybersecurity, and sustainability skills are included.
- iii. There should be more focus on interdisciplinary learning and critical thinking, creativity, communication, leadership, problem solving, and entrepreneurial skills in addition to the subject matter knowledge.
- iv. The curriculum developer should develop a formal procedure to involve industry in the design, validation and periodic review of curriculum. Program Learning Outcomes (PLOs) should be clearly aligned with industry required competencies and be evaluated by quantifiable performance measures.

7.3 Recommendations for Government and Other Stakeholders

- i. Higher Education Institutions need to gradually move from teacher-centered to learner-centered pedagogies, such as project-based learning, problem-based learning, collaborative learning, experiential learning, and technology-based instruction.
- ii. The Faculty members need continuous professional development training in innovative pedagogical practices, digital teaching tools, curriculum development, and outcome-based education.
- iii. Academia-industry collaborations need to be improved and enhanced in universities via internships, apprenticeships and industrial attachments, guest lectures, joint research projects, and industry-sponsored innovation programs.
- iv. The career development and employability support centers must be set up or expanded to offer career counseling and skills assessment, support in entrepreneurship and placement of job.
- v. Better focus needs to be given to equipping students with lifelong learning, adaptability, ethical values, emotional intelligence, and resilience skills to prepare them for the needs of the rapidly evolving labor markets.

7.4 Recommendations for the Industry Stakeholders'

- i. As an active participant in the curriculum development process, in skills mapping initiatives and in graduate competency assessment, employers should play an active role.
- ii. Industry sectors must keep giving regular feedback about the labor market skills needs and share with HEIs for them to create viable training experiences.
- iii. Expand public-private partnerships to enable work-integrated learning, innovation ecosystems and graduate employment. In summary, the efforts of all stakeholders are needed to create a coordinated action plan aimed at equipping graduates with knowledge, skills, competencies and attitudes that will enable them to be productive and competitive in the new era of the Fourth Industrial Revolution (Industry 4.0).

8. Conclusion

The 4IR technology is fundamentally transforming the economic and employment landscape, necessitating a paradigm shift in the skills profile of graduates. This research concludes that to effectively navigate and contribute to the goals of a future economy, graduates must be equipped not only with technical and digital competencies but also with critical soft skills such as creativity, problem-solving, emotional intelligence, and adaptability. The study emphasizes that traditional education models are no longer sufficient to meet the dynamic demands of the 4IR-driven labor market.

To bridge the emerging skills gap, it is imperative for academic institutions, policymakers, and industry stakeholders to collaborate in redesigning educational frameworks. Curricula should be future-oriented, interdisciplinary, and aligned with technological advancements, while teaching methods must promote experiential and lifelong learning. Moreover, the development of strong industry-academia linkages can ensure that graduate skills remain relevant and responsive to real-world needs.

Ultimately, aligning graduate competencies with 4IR demands is essential not only for individual employability but also for national economic resilience, innovation, and sustainable development. Failure to address these skill mismatches may widen inequalities and hinder progress toward inclusive growth in the digital era. Therefore, a proactive and coordinated approach is essential to prepare graduates as agile contributors to the evolving global economy.

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Publication Ethics Statement

The authors confirm that the funding provided by the Research Cell of Mawlana Bhashani Science and Technology University (MBSTU), Tangail, Bangladesh, does not create any ethical restriction on the publication of this research. The study was conducted in accordance with accepted academic and publication ethics standards, and no ethical violations or conflicts affecting publication exist.

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