

Industry 4.0 Readiness of Bangladeshi University Students: Insights from Technology Optimism, Access to Resources, and Perceived Technological Impact

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Abstract

This study examines Bangladeshi university students' readiness for Industry 4.0, focusing on three key factors: technology optimism, access to resources, and perceived technological impact. A quantitative approach was used, analyzing data from 467 students across different academic disciplines. The results highlight that access to practical training significantly enhances students' preparedness, while limited access to resources reduces their readiness. Gender disparities were also evident, with male students showing a higher likelihood of being ready for Industry 4.0. Interestingly, despite high levels of technology optimism, the correlation with practical preparedness was weak, indicating that attitudes alone do not ensure readiness. The study provides valuable insights into the psychological, educational, and structural factors influencing readiness in developing economies. It offers policy recommendations for curriculum enhancements, equitable resource distribution, and interventions to address gender gaps, contributing to Bangladesh's broader digital transformation and global competitiveness.

Keywords: industry 4.0 readiness, technology optimism, educational resources, practical training, Bangladesh university students

1. Introduction

The Fourth Industrial Revolution (Industry 4.0) represents a transformative shift in the global industry, characterized by the convergence of advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), robotics, and big data analytics (Schwab, 2016). Starting from the early part of the 2010s in Germany, Industry 4.0 has shifted the manufacturing systems, business strategies, and demand for employees around the world (Schwab, 2016). These have led to the emergence of the need for a flexible human capital with the right skill set to fit into technological world. In this context, universities have a critical responsibility to equip learners

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with these competencies to meet these demands by cultivating innovation, problem-solving, and digital competencies (Oke & Fernandes, 2020).

In Bangladesh, Industry 4.0 is on the right track from the government's side and enhanced interest from the private sector to improve productivity and to become more competitive globally (Rumi et al., 2020). However, certain barriers such as inequitable distribution of resources, digital literacy, and lack of synergy between the academia and industry slowdown the country's preparedness for these developments. Solving these issues presupposes knowledge of how prepared university students – future employees – are for Industry 4.0 technologies. This study evaluates their readiness by exploring three critical factors: In the study, four constructs derived from the literature were identified as antecedents to the innovation adoption, including technology optimism, access to resources, and perceived technological impact.

As technologies of Industry 4.0 are changing the global workplace, the preparedness of university students in developing countries such as Bangladesh is a crucial issue. The education sector needs to make sure that students are prepared to easily move into a world that is highly tipped with automation and integrated digital systems (Maria et al., 2020). However, there are still gaps to some extent in the provision of digital competency development opportunities, access to digital resources, and building a positive attitude toward technology use (Rumi et al., 2020).

This research is informed by these gaps as postulated in Schwab (2016) and Oke and Fernandes (2020). Understanding university students' perception and preparedness generates practical information that is useful in refining the academic approach to prepare graduates to augment Bangladesh's transformation into Industry 4.0.

Even though the world has been discussing a lot on Industry 4.0 readiness, few studies have addressed the readiness of university students in developing countries including Bangladesh. This lack of focus is worrying especially bearing in mind the critical role which these students have to play in future economic and technological development (Schwab, 2016). Rumi et al. (2020) have also found that students face challenges in terms of resources, digital environment, and technology best in order to meet Industry 4.0 changes.

Also there is lack of understanding about how the level of technology optimism, extent of resources available, and the perceived effects of technology on society are interconnected in the context of Bangladesh. This study aims to fill these gaps, it responds to the need for more research in this domain as Oke and Fernandes noted (2020). Through exploring these dimensions, the research offers a theoretical background to assess the possibilities for improving student readiness within the context of academic institutions and the role of policymakers in the transition to Industry 4.0.

The purpose of this study is to assess the readiness of Bangladeshi university students for Industry 4.0 by analyzing three key factors: technological optimism, availability of technological resources and perceived technological effects. The study will seek to fill existing gaps in literature to offer direction in reformation in educational and policies to match the students' competencies to that of Industry 4.0.

This study seeks to answer the following research questions:

RQ1. What level of optimism do Bangladeshi university students exhibit toward Industry 4.0 technologies?

RQ2. How does access to technological resources affect students' readiness for Industry 4.0?

RQ3. What are students' perceptions of the societal and workforce impacts of Industry 4.0 technologies?

These questions are grounded in findings by Maria et al. (2020) and Rumi et al. (2020), which highlight the importance of understanding student attitudes and resource constraints in developing countries. Answering these questions will contribute to developing a comprehensive framework for improving Industry 4.0 preparedness.

The objectives of the study are following:

2. Objectives of the study

General objective

To assess the readiness of Bangladeshi university students for Industry 4.0 and the factors influencing their preparedness.

Specific Objectives

- i. To examine the impact of technology optimism on students' readiness for Industry 4.0, focusing on how positive perceptions of technological advancements shape their preparedness.
- ii. To evaluate the role of access to educational resources, including university-provided training and tools, in enhancing students' Industry 4.0 readiness, while also considering the influence of concerns about technology, such as privacy and security, on their willingness to prepare.

This study is significant for both academic and practical reasons. Academically, it expands the limited body of research on Industry 4.0 readiness in developing countries, with a specific focus on university students in Bangladesh. By examining factors such as technological optimism and resource access, the study provides insights into how these variables influence readiness.

Practically, the research has implications for universities, policymakers, and industry leaders. Educational institutions can use the findings to design targeted interventions, such as curriculum enhancements and digital resource investments. Policymakers can identify infrastructural gaps and prioritize equitable access to technology. Industry leaders can better understand the preparedness of the incoming workforce, fostering collaborations that bridge the gap between academia and industry. This study aims to support Bangladesh's broader development goals by ensuring that its youth are equipped to contribute effectively to Industry 4.0 advancements.

This study focuses on Bangladeshi university students enrolled in undergraduate and postgraduate programs, limiting its scope to this specific demographic. The geographic focus on Bangladesh provides context-specific insights, though findings may not be generalizable to other regions or countries.

The research is cross-sectional and relies on survey-based self-reported data, which may introduce biases such as over- or underestimation of competencies. Despite these limitations, the study

adopts robust sampling and analytical methods to ensure reliability. Similar constraints have been acknowledged in prior studies, such as those by Rumi et al. (2020) and Maria et al. (2020), underscoring the importance of focused, localized research in this area.

This paper is organized as follows: Section 2 reviews existing literature on Industry 4.0 readiness and its determinants. Section 3 presents theory and concepts of the study. Section 4 outlines the research methodology, including data collection and analysis methods. Section 5 presents the findings, followed by Section 6, which discusses the implications. The final section concludes the paper with recommendations.

3. Literature Review

Industry 4.0 was first introduced in Germany in the early part of the 2010s and refers to the integration of technologies like AI, IoT, and robotics into the industrial operations (Schwab, 2016). The earliest studies focused on Industry 4.0 with a technology lens, particularly on new technologies such as automation and big data. But as the revolution grew international, research emerged on the preparedness of the workforce and skill (Becker, 2009).

More recent research has been directed towards human aspects, especially organizational and individual response to change in technology. The focus on education and skill development can be supported by the Human Capital Theory that incorporates education as one of the essential factors of production contributing to productivity and innovation (Becker, 2009). For instance, Rumi et al. (2020) which focuses on developing economies has pointed to the problem of inadequate digital resources within the learning environment. This evolution shows that there is increased awareness of psychological, educational, and structural aspects in the Industry 4.0 preparedness.

Psychological Readiness – Technology Optimism and Insecurity: Psychological preparedness is a key component of how people make use of technology. Technology optimism, a construct from TRI, measures trust in technology's effectiveness. Parasuraman and Colby (2015) have noted that optimism leads to acceptance for use especially in education. For example, Maria et al (2020) have found that students with high level of optimism are more likely to perform activities that develop Industry 4.0 skills.

On the other hand, insecurity with regard to the technology works against achieving the state of readiness. These include issues to do with data protection, hacking and security of digital tools among others. Research by Castillo-Vergara et al. (2022) shows that insecurity is rife among learners especially those in a resource-deficit setting. These results indicate that there is ambivalent nature of the psychological readiness where optimism is conducive to participation and insecurity is conducive to stagnation.

Structural Factors – Access to Educational Resources and Practical Training: Availability of resources is one of the fundamentals of Industry 4.0 preparedness. Human Capital Theory states that education and training are directly productive of improvements in workforce (Becker, 2009). Rumi et al. (2020) revealed that students who have access to technology and updated curriculum were better prepared for Industry 4.0 challenge.

Practical training also helps to overcome this gap because it brings the information received during training directly into practice. Internships, lab sessions and industry collaborations prepare the students to gain practical learning and apply the knowledge of Industry 4.0 solutions. Schwab (2016) suggest that the most effective approach to building adaptability and innovation is learning by doing. However, issues to do with equitable distribution of resources especially in the developing world somewhat hinders such campaigns (Rumi et al., 2020).

Technological Attributes and User Intention: Awareness of Industry 4.0's importance represents the most significant factor in readiness. Based on the UTAUT, perceived impact affects the relative importance of skill development among students (Venkatesh et al., 2003). Oke & Fernandes (2020) also discovered that students who had an understanding of the Industry 4.0 change process were more willing to pursue training in the Industry 4.0 fields.

However, there are differences in the perceptions. Chauhan et al (2024) also noted that some students tend to perceive Industry 4.0 as something that is either distant or irrelevant to them especially within non STEM fields. This gap emphasizes the importance of raising awareness and specific programs in order to modify perceptions to meet the requirements of the sector.

Survey based approaches are widely used as mentioned by Parasuraman and Colby (2015) because it is easier to measure psychological constructs such as optimism and insecurity. Despite this, the above mentioned methods are deficient in drawing self-report biases.

Observational data, on the other hand, do not provide information about the behavior of people under controlled conditions of experiments like Castillo-Vergara et al. (2022). While case studies such as Rumi et al. (2020) offer more fine-grained context-specific data, these data are far from easily up scalable. However, due to the cross-sectional nature of the studies, analyzing longitudinal trends of Industry 4.0 readiness is limited. However, these studies are deficient in some ways, and future studies should use mixed method approaches to improve the reliability of the findings.

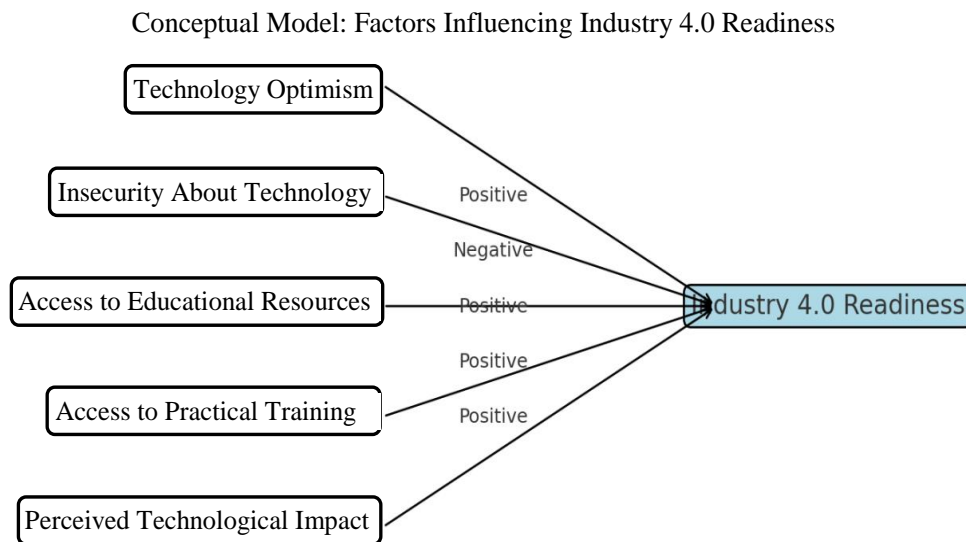
To the best of our knowledge, no prior studies have thoroughly examined how the interplay between resource scarcity and psychological factors influences Industry 4.0 readiness. While existing studies highlight the role of resources and psychological attitudes such as optimism and insecurity, there is limited empirical research examining how these factors interact in the context of developing countries like Bangladesh. Specifically, the literature lacks insight into how technology optimism, insecurity, and access to resources collectively influence students' preparedness for Industry 4.0.

This study aims to bridge this gap by investigating the interplay between psychological factors (optimism and insecurity) and structural barriers (such as resource access) in shaping Industry 4.0 readiness. Using a binary logit model, it will empirically analyze how these factors affect the preparedness of Bangladeshi university students. The research will provide valuable insights into how optimism may not always translate into actionable preparedness without sufficient resources, and how concerns about technology insecurity might hinder students' willingness to engage with Industry 4.0. By addressing these gaps, the study will contribute to a more holistic understanding of readiness and inform targeted interventions for educational institutions, policymakers, and industry leaders.

4. Theory and Concepts

This study draws upon three interconnected theoretical perspectives: From the literature, the following theories: Technology Readiness Index (TRI), Unified Theory of Acceptance and Use of Technology (UTAUT), and Human Capital Theory have been identified. Parasuraman & Colby (2015) have created a scale called Technology Readiness Index TRI which measures psychological preparedness of a person for the adoption of new technologies. The dimensions of optimism, innovativeness, discomfort, and insecurity are useful in examining students' readiness concerning Industry 4.0 especially in countries such as Bangladesh. Out of all the factors, perceived usefulness and perceived ease of use offer unique lens into students' views on technology use. UTAUT by Venkatesh et al. (2003) describes the behavioral intention to use the technology by the help of such factors as performance expectancy, effort expectancy, and social influence factors. These constructs are useful to determine students' perception as to the applicability of Industry 4.0 technologies in their learning and career paths.

Human capital theory as postulated by Becker (2009) expound on the importance of education and training as tool of increasing human productivity in the society. It is important to have access to resources, acquire skills and receive practical training to prepare students for Industry 4.0 according to this theory. Altogether, these theories constitute a theoretical framework; they provide complex information on students' psychological readiness and behavioral intentions as well as on their capacities to receive proper educational resources and training for facing technological challenges of Industry 4.0



Source: Author

This conceptual model visually represents the relationships hypothesized in this study. It illustrates how independent variables such as technology optimism, insecurity, and resource access influence the dependent variable, Industry 4.0 readiness. The model also highlights the mediating role of perceived technological impact, offering a clear roadmap for the study's analysis.

Key Constructs and Variables

The theoretical framework identifies key constructs derived from the chosen theories:

- **Industry 4.0 Readiness (Dependent Variable):** Defined as the extent to which students feel prepared to engage with Industry 4.0 technologies. Operationalized as a binary outcome (ready or not ready).
- **Technology Optimism:** Derived from TRI, this construct reflects students' positive expectations regarding the impact of technology on their careers (Parasuraman & Colby, 2015).
- **Insecurity About Technology:** Also from TRI, this construct measures students' concerns about privacy and security risks associated with new technologies.
- **Access to Educational Resources:** Anchored in Human Capital Theory, this variable assesses the availability of university-provided training and tools relevant to Industry 4.0.
- **Access to Practical Training:** Captures students' opportunities to engage in hands-on learning, such as internships or lab sessions.
- **Perceived Technological Impact:** Reflects students' beliefs about how Industry 4.0 will influence their future careers and industries.

These constructs are interlinked, providing a comprehensive basis for analyzing Industry 4.0 readiness.

Based on the theoretical relationships outlined, the study proposes the following hypotheses:

- **H1:** Technology optimism positively influences Industry 4.0 readiness among university students. (Parasuraman & Colby, 2015).
- **H2:** Insecurity about technology negatively affects Industry 4.0 readiness (Müller et al., 2018).
- **H3:** Access to educational resources is positively associated with Industry 4.0 readiness (Sony & Naik, 2019).
- **H4:** Access to practical training significantly enhances Industry 4.0 readiness.
- **H5:** Perceived technological impact positively correlates with Industry 4.0 readiness (Ghobakhloo, 2020).

These hypotheses will guide the data collection and analysis, providing a structured approach to testing the theoretical framework.

5. Data and Methods

The study employed a quantitative research approach to explore the relationships between multiple independent variables (e.g., technological optimism, insecurity, access to resources) and the dependent variable (Industry 4.0 readiness). A quantitative design is ideal for identifying the strength and direction of these relationships and for generalizing findings to a broader population.

5.1 Sampling strategy

The target population comprised Bangladeshi university students, with a focus on those enrolled in undergraduate and postgraduate programs. A convenience sampling technique was employed in this study. Participants were selected based on their accessibility and willingness to participate, without any specific stratification based on demographics such as gender, academic discipline, or geographic location.

The sample size determined using the following general formula:

$$SS = \frac{p \times (1 - p) \times z^2}{e^2}$$

$$= \frac{(.5) \times (.5) \times (1.96)^2}{(0.05)^2}$$

Here, $SS = 384$

SS = Sample size

p= 0.50 (proportion of the unknown population)

z=1.96 (Sample variant considering 95% confidence level)

e= 5% (margin of error)

By applying Fisher's (1993) general formula to calculate the sample size for an unknown population, the determined sample size is 384. However, for this study, a sample size of 467 will be employed for quantitative study, exceeding the initially anticipated sample size significantly.

Sample Inclusion criteria include active enrollment in university programs and an age range of 18–30 years, as these groups represent the future workforce most impacted by Industry 4.0.

Sample Exclusion criteria include non-students or individuals outside the specified age range.

5.2 Data collection methods

This study utilized a structured online questionnaire as the primary data collection method. The questionnaire was designed to gather information from university students across Bangladesh on their readiness for Industry 4.0. The online format, through platforms such as Google Forms, was selected to ensure wide accessibility, convenience, and efficiency in reaching a large, geographically dispersed sample of participants.

5.3 Data collection procedure

The following steps were involved in the data collection process:

Design of the questionnaire: The questionnaire was divided into two main sections: the first section gathered demographic information (e.g., age, gender, academic background), while the second section focused on constructs related to Industry 4.0 readiness. The items were adapted from validated scales, such as the Technology Readiness Index (TRI) 2.0 (Parasuraman & Colby, 2015) for Technology Optimism and Insecurity About Technology, and Human Capital Theory (Becker, 2009) for Access to Resources and Practical Training. The dependent variable, Industry 4.0 Readiness, was assessed with a binary Yes/No response, as per Castillo-Vergara et al. (2022).

Development and validation of the questionnaire: The questionnaire items were based on validated scales to ensure reliability and accuracy. Experts in the fields of technology readiness and education reviewed the survey to ensure its relevance and clarity.

Pilot Testing: A pilot test with 20 participants was conducted to assess the clarity, coherence, and reliability of the questionnaire. Adjustments were made based on the feedback, ensuring the items were clear and captured the intended data effectively as emphasized by Creswell (2014).

Online distribution: The survey was distributed online via Google Forms. The survey link was shared through university mailing lists and social media groups targeting students across various universities in Bangladesh. Participants were given an informed consent form and instructions on how to complete the survey.

Data collection period: The survey remained open for two weeks to allow sufficient time for participants to respond. Reminders were sent periodically to encourage completion and ensure a robust response rate.

Data cleaning and preparation: After the survey closed, the responses were exported from Google Forms to Excel, where the data was cleaned by removing incomplete or duplicate responses. Inconsistencies were also checked to ensure the data's integrity.

Final data set: The final dataset consisted of 467 valid responses, exceeding the initially calculated sample size of 384. This ensured the study had a sufficiently large sample for analysis.

5.4 Data analysis techniques

The collected data analyzed using logistic regression analysis, which is suitable for modeling binary outcomes such as Industry 4.0 readiness (Ready vs. Not Ready). Logistic regression allows for the examination of multiple independent variables simultaneously, providing insights into their predictive strength and direction (Field, 2017).

The logistic regression equation can be expressed as:

$$\log \frac{p}{1-p} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + u_t$$

Where, p is the probability of being ready ($Y = 1$). $1-p$ is the probability of being not ready.

Descriptive statistics used to summarize demographic characteristics and distributions of key variables. The primary analysis involved calculating odds ratios to quantify the likelihood of readiness based on predictors like optimism, insecurity, and access to resources.

The analysis performed using SPSS software, which offers robust capabilities for logistic regression and inferential statistics. This approach aligns with methodologies employed in prior research on technological readiness (Parasuraman & Colby, 2015; Maria et al., 2020), ensuring that the findings are statistically sound and interpretable. Creswell (2014) supports the use of robust statistical software to enhance the accuracy of quantitative data analysis.

5.5 Ethical considerations and limitations

The study adheres to ethical guidelines outlined by the Declaration of Helsinki. Participants provided **informed consent**, ensuring that they understand the study's purpose, procedures, and their rights to withdraw at any time. Confidentiality maintained by anonymizing responses and securely storing data on password-protected systems.

No sensitive personal information was collected, and participants' privacy was respected throughout the study. Creswell (2014) underscores the importance of adhering to ethical standards to ensure the integrity and credibility of research.

5.6 Limitations of the study

This study acknowledges several limitations, including its reliance on self-reported data, which may introduce biases. The cross-sectional design also limits the ability to infer causality between variables. Additionally, the focus on Bangladeshi university students restricts the generalizability of findings to other contexts.

6. Findings and Discussion

This section delves into the findings of the survey and the subsequent analysis, offering insights into Bangladeshi university students' readiness for Industry 4.0. The results are presented in two parts: the survey responses summarized in Table 1, and the logistic regression analysis detailed in Table 2.

Table 1: Survey Responses on Perceptions and Preparedness for Industry 4.0 Technologies

Questionnaire Items	Code	Frequency	Percentage
Do you have opportunities (e.g., internships, lab sessions) to gain practical experience with Industry 4.0-related technologies?	No	175	37.47
	Yes	292	62.53
Do you believe that advancements in technology will positively impact your career	No	8	1.71
	Yes	459	98.29
Do you actively seek out and use new technologies as they become available?	No	55	11.78
	Yes	412	88.22
Are you concerned about privacy and security risks when using new technologies?	No	36	7.71
	Yes	431	92.29
Does your university provide sufficient resources and training to help you stay updated with technological developments?	No	227	48.61
	Yes	240	51.39
Do you believe that Industry 4.0 will significantly impact your job or industry?	No	19	4.07
	Yes	448	95.93
Does your university actively provide technological support and guidance to prepare students for Industry 4.0?	No	196	41.97
	Yes	271	58.03
Are you interested in learning new skills (e.g., data analysis, AI) relevant to Industry 4.0?	No	26	5.57
	Yes	441	94.43
Gender	Female	141	30.19
	Male	326	69.81

Table 1 presents the survey responses on Bangladeshi university students' perceptions and preparedness for Industry 4.0 technologies, covering aspects like access to practical experiences, career optimism, and resource availability. The data reveals that 62.53% of respondents had opportunities for practical training, such as internships or lab sessions, while 98.29% believe technological advancements will positively impact their careers. A significant majority (88.22%) actively engage with emerging technologies, although 92.29% express concerns about privacy and security risks. Regarding institutional support, only 51.39% felt their universities provided sufficient resources for technological development, and 58.03% agreed that their universities offer adequate technological guidance. Gender distribution shows a disparity, with 69.81% of respondents being male.

These findings indicate a mixed readiness for Industry 4.0. While optimism about career impacts and interest in acquiring new skills (94.43%) are high, gaps in resource availability and practical training remain a challenge. Notably, concerns about privacy and security are pervasive, signaling a need for addressing digital literacy and safety. The gender imbalance and uneven resource distribution further highlight systemic issues. These insights emphasize the necessity for universities to bolster experiential learning opportunities and equitable resource allocation to enhance Industry 4.0 preparedness.

Table 2: Logit Model Output

Variables Dependent Variable: Industry 4.0 Readiness	B	S.E.	Wald	Sig.	Exp (B)	95% C.I. for EXP(B)	
						Lower	Upper
Gen 1=Female; 2=Male	.679	.339	4.013	.045	1.972	1.015	3.831
Tech_Opt No=1; Yes=2	-3.120	.945	10.908	.001	.044	.007	.281
Proact_Tech No=1; Yes=2	-.390	.358	1.184	.276	.677	.335	1.367
Insecurity No=1; Yes=2	.082	.552	.022	.883	1.085	.367	3.204
Resources No=1; Yes=2	-1.003	.370	7.324	.007	.367	.178	.758
Impact_of_4.0 No=1; Yes=2	-.987	.650	2.308	.129	.373	.104	1.332
New_Skills No=1; Yes=2	-1.028	.531	3.747	.053	.358	.126	1.013
Tech_Support No=1; Yes=2	.073	.338	.046	.830	1.075	.555	2.085
Training No=1; Yes=2	-2.177	.334	42.467	.000	.113	.059	.218
Constant	3.217	.342	88.548	.000	24.958		

Significant Predictors of Table 2

Gender: Gender significantly affects Industry 4.0 readiness. Male students are 1.972 times more likely to be ready for Industry 4.0 than female students, holding all other variables constant.

Technology Optimism (Tech_Opt): A counterintuitive result: students with higher technological optimism are significantly less likely to be ready for Industry 4.0. The odds of readiness decrease by a factor of 0.044 for each unit increase in optimism. This may suggest a gap between positive perceptions and practical readiness.

Access to Educational Resources (Resources): Limited access to resources negatively impacts readiness. Students with better access to educational resources are 0.367 times as likely to be unprepared compared to those with poorer access, highlighting the importance of improving resource distribution.

Access to Practical Training (Training): Practical training has the strongest influence. Students with access to hands-on training opportunities are 0.113 times less likely to be unprepared. This underscores the critical role of experiential learning in enhancing readiness.

Interest in Future Skills (New_Skills): Students interested in developing new skills are 0.358 times less likely to be unprepared, though this variable is marginally significant ($p=0.053$)

Insignificant Predictors of Table 2

Several predictors in the logistic regression model were found to be non-significant in explaining students' readiness levels. Proactivity with Technology (Proact_Tech), representing students who actively explore and use new technologies, showed no significant relationship with readiness. Similarly, Insecurity About Technology, characterized by privacy and security concerns, was not a significant predictor, with a coefficient $B=0.082$, $p=0.883$ and an odds ratio $\text{Exp}(B)=1.085$, suggesting a negligible effect on readiness. University Technological Support (Tech_Support), indicating assistance provided by universities, also had no significant impact $p=0.830$. Lastly, the Perceived Impact of Industry 4.0 (Impact_of_4.0), which reflects students' views on how technological advancements might shape their future, was not significant. Despite the varied odds ratios, ranging from marginal increases to decreases in odds, none of these predictors reached statistical significance, indicating their limited contribution to explaining readiness in this context.

These findings suggest that gender disparities play a notable role in Industry 4.0 readiness. The higher readiness among males may reflect cultural or structural biases in access to technological resources. This aligns with studies by Rumi et al. (2020), who highlighted gender-based differences in access to digital tools in Bangladesh.

The counterintuitive relationship between Tech_Opt and readiness may stem from students' limited exposure to practical applications of technology despite their optimism. This complements findings by Maria et al. (2020), who reported a gap between positive attitudes and actual technological preparedness. The strong predictive value of Training emphasizes the need for universities to prioritize internships, lab sessions, and industry collaborations, reinforcing Schwab's (2016) argument that experiential learning is critical for adapting to Industry 4.0.

Negative associations with Resources and New_Skills likely reflect systemic issues in resource allocation and curriculum alignment with modern industry demands. This supports the notion by Castillo-Vergara et al. (2022) that inadequate resource distribution hampers technological advancement in developing economies.

These findings advance the theoretical understanding of Industry 4.0 readiness by highlighting the interplay between optimism, training, and structural barriers. The negative relationship of Tech_Opt challenges assumptions in the Technology Readiness Index (Parasuraman & Colby, 2015), suggesting that optimism must be paired with actionable opportunities for skill development.

While access to practical training and educational resources emerged as significant predictors of Industry 4.0 readiness, the study highlights the ongoing systemic challenges within the educational infrastructure. Gender disparities in readiness suggest that cultural and structural biases continue to influence educational outcomes, particularly in STEM fields. These disparities point to the need for a fundamental shift in how resources and opportunities are allocated to ensure equal access, especially for female students in technical disciplines.

Furthermore, the weak correlation between technology optimism and practical preparedness calls attention to the disconnect between students' positive attitudes towards technology and their actual ability to engage with it in a professional setting. This highlights a critical gap in the educational system—while students may embrace the idea of technological progress, they are not always equipped with the necessary tools, training, and hands-on experience to meet the demands of Industry 4.0. This gap between perception and preparation underscores the importance of not only fostering a positive attitude toward technology but also ensuring that these attitudes translate into tangible skills through experiential learning.

In terms of resource access, the study demonstrates how uneven distribution of resources can limit students' preparedness. It suggests that institutions must prioritize the equitable distribution of technological tools, such as access to updated software, devices, and industry-standard tools, across all student demographics. Furthermore, the study's finding that privacy and security concerns did not significantly impact readiness is noteworthy, suggesting that security concerns, while important, might not be the central barrier to readiness that they are often perceived to be in other contexts. Instead, addressing accessibility to resources and practical engagement may be far more critical in preparing students for the demands of Industry 4.0.

These findings point to the broader implications of policy change, educational reforms, and industry collaborations. There is a clear need for a more integrated approach that brings together academia, industry, and policymakers to design curriculum improvements, hands-on training programs, and resource allocation strategies that align more closely with the evolving needs of the labor market. By addressing these gaps, Bangladesh can better prepare its workforce for the opportunities and challenges of Industry 4.0.

7. Conclusions and Policy Recommendations

The present research offers an assessment of Bangladeshi university students' preparedness for Industry 4.0 from aspects of technology enthusiasm, availability of resources, and perceived technology influence. The results reveal that there are substantial differences in readiness and these depend on the availability of realistic training and educational materials. There were also differences by gender: the readiness levels of male students were markedly higher; there might be

cultural and systemic prejudice here. However, it was notable that optimism about technology was high, but readiness was not always as high, which highlighted an attitude behaviour gap. The ability to gain access to hands-on training was identified as the most significant factor affecting readiness supporting the fact that internships and lab sessions should be incorporated into teaching. These findings respond to the research questions and add knowledge to the nature of the relationship between resource access and psychological factors in determining Industry 4.0 readiness among students.

The implications of the findings are therefore generalizable to academia, industry, and policy. Theoretically, this study contributes to the academic literature by advancing an argument that while technology optimism and readiness are desirable, they cannot be realized separately from the action plans that make these possible. In practical terms, the findings point to the fact that universities should incorporate Industry 4.0 requirements into their programs so that learners develop relevant technical and interpersonal competencies needed in a digital society. In policy implications, the study recommends policy strategies aimed at ensuring that resources are distributed fairly, and that specific efforts are made to redress gender disparities in readiness. Such information can help design more extensive approaches to facilitate a diverse and skilled human capital, in line with the country's digital transformation agenda.

To address the identified gaps and enhance Industry 4.0 readiness among university students, the following policy recommendations are proposed:

Short-Term Strategies:

- **Curriculum Enhancement:** Universities should incorporate Industry 4.0 topics, such as AI, IoT, and big data, into existing programs, ensuring that students acquire relevant knowledge and skills.
- **Experiential Learning Opportunities:** Institutions should prioritize internships, project-based learning, and partnerships with industry leaders to provide students with hands-on training.
- **Resource Allocation:** Immediate efforts should focus on improving access to digital tools and infrastructure, particularly for underrepresented groups such as female students.

Long-Term Strategies:

- **Gender-Inclusive Policies:** Government and educational institutions should implement targeted initiatives, such as scholarships and mentorship programs, to encourage female participation in STEM fields.
- **National Skills Development Framework:** Policymakers should establish a cohesive framework to align academic programs with industry demands, ensuring consistency across institutions.
- **Public-Private Partnerships:** Collaborative efforts between academia, government, and industry stakeholders can create sustainable models for skill development and resource sharing.

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