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# Assessing The Emerging Technologies in Industry 4.0: Challenges and Alternatives Towards Productive Workplace

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## ABSTRACT

*The advent of Industry 4.0 presents vast opportunities for workplace modernization through technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and smart automation. However, in developing regions like Mindanao, Philippines, adoption remains inconsistent, especially in academic and public-sector institutions. This study assessed the level of awareness, utility, and adaptability toward Industry 4.0 technologies among 30 professionals, primarily from the academe, to uncover challenges and explore strategic alternatives for digital transformation. Using a descriptive quantitative research design, data were gathered via a structured questionnaire and analyzed using descriptive statistics. Findings revealed fair awareness (M = 3.16), moderate utility (M = 3.07), and high adaptability (M = 3.51) among respondents, with AI and cybersecurity ranking highest across all dimensions. Key challenges included high implementation costs, limited technical skills, and cybersecurity risks. Despite these barriers, participants demonstrated strategic adaptability through phased adoption, internal training, and optimization of available resources. The study concludes that while digital readiness is emerging in regional workplaces, structural limitations such as funding gaps, infrastructure deficits, and workforce preparedness hinder full-scale integration. Institutional investments in capacity building, context-based digital strategies, and supportive leadership are recommended to foster inclusive and sustainable Industry 4.0 adoption. These findings highlight the potential for digital transformation in developing contexts if matched by systemic and targeted interventions.*

**KEYWORDS:** *Artificial Intelligence, Internet of Things, Modernization, Technology Adoption, Workplace Adaptability*

## INTRODUCTION

In today's fast-changing digital landscape, Industry 4.0 has emerged as a powerful force shaping how we live, work, and do business. With technologies like Artificial Intelligence, the Internet of Things (IoT), and smart automation becoming more accessible, workplaces are increasingly expected to keep up with these innovations to stay productive and competitive (Schwab, 2016). However, for many organizations—especially in developing countries like the Philippines—adopting these technologies is not as straightforward as it may seem. Challenges such as limited technical skills, budget constraints, outdated infrastructure, and low awareness often get in the way (PIDS, 2018; World Economic Forum, 2020).

This is especially true in regional areas where resources and opportunities for digital transformation are not as abundant. While government efforts like the Philippine National Artificial Intelligence Roadmap 2.0 and the creation of the Center for AI Research are promising steps forward (DTI, 2024), there remains a noticeable gap in understanding how local institutions are adapting to Industry 4.0 on the ground. Recent studies suggest that the success of digital transformation relies not just on having the technology, but on how prepared and willing people are to use it (Al-Jarrah et al., 2023).

This study was conducted to explore that very gap. Specifically, it assessed how aware people are of Industry 4.0 technologies, how much they are being used, and how adaptable organizations are in making the shift. It also aimed to identify what challenges are being faced and what alternative strategies are being applied. The research took place involving professionals from Central Mindanao University and several organizations across Mindanao. Through this, the study hopes to offer practical insights on how the workplace, especially in academic settings, can better prepare for and benefit from the digital revolution.

## METHODOLOGY

### Research Design

This study followed a descriptive quantitative research design to better understand how organizations, especially those in the academe, are engaging with Industry 4.0 technologies. The focus was on describing the current state of awareness, usage, and adaptability of these technologies in real-world workplace settings. By using this approach, the study aimed to capture measurable data that reflect how prepared and responsive institutions are to digital transformation.

### Respondents

A total of 30 participants took part in the research. Most of them came from the academe (70%), while others represented sectors such as business, industry, government, and various agencies. The majority of respondents were female (60%), and many were relatively young, with half aged 26 to 30 years old. Their professional experience varied, with 43.33% having five years or more of service, and 40% having one to two years. This blend of new and experienced professionals provided a well-rounded perspective on how different workplaces are navigating the shift to Industry 4.0.

### Data Collection Tools

To gather the needed information, the researchers used a structured questionnaire. This tool asked respondents to rate their level of awareness, utilization, and adaptability to key Industry 4.0 technologies such as Artificial Intelligence, the Internet of Things (IoT), Cybersecurity, Robotics, and others. It also included questions about their organization’s human resource capabilities, challenges in implementation, and strategies they’ve adopted to overcome these issues. The responses were based on a five-point Likert scale, where 1 corresponds to “Very Poor” or “Not Adopted” and 5 depicts “Very High” or “Extremely Adopted.” The questionnaire was designed to be clear, relevant, and aligned with the objectives of the study.

For scoring based on their responses, Table 1 was utilized.

Table 1. Scoring Guide for the Assessment.

| Scale | Score Range | Response | Qualifying Statements |
|---|---|---|---|
| 5 | 4.21 – 5.00 | Very High | Extremely Adopted |
| 4 | 3.41 – 4.20 | High | Highly Adopted |
| 3 | 2.61 – 3.40 | Fair | Moderately Adopted |
| 2 | 1.81 – 2.60 | Poor | Slightly Adopted |
| 1 | 1.00 – 1.80 | Very Poor | Not Adopted |

**Data Analysis**

The researchers utilized basic descriptive statistics to make sense of the responses. They calculated means, standard deviations, frequencies, and percentages to identify common patterns and trends in how Industry 4.0 technologies are being adopted. These results provided a clear picture of the current landscape and what's working, where the challenges lie, and what actions are being taken to move forward.

## RESULTS AND DISCUSSIONS

**Demographics of the Respondents**

The respondents of this study were 30 professionals from various sectors, with a strong representation from the academe. Most were relatively young and early in their careers, reflecting a workforce that is dynamic and potentially adaptable to digital transformation. Understanding their background helps contextualize the readiness and challenges faced in adopting Industry 4.0 technologies. Table 2 shows the socio-demographic profile of the respondents.

Table 2. Frequency and Percentage of Respondents' Socio-demographic Profile

| Socio-Demographic Profile | Category | Frequency (N=30) | Percentage |
|---|---|---|---|
| Gender | Female | 18 | 60.00% |
| | Male | 12 | 40.00% |
| Age | 20-25 | 4 | 13.33% |
| | 26-30 | 15 | 50.00% |
| | 31-35 | 6 | 20.00% |
| | 36 and above | 5 | 16.67% |
| Type of Sector | Academe | 21 | 70.00% |
| | Business | 1 | 3.33% |
| | Industry | 1 | 3.33% |
| | LGU | 1 | 3.33% |
| | Other agencies | 6 | 20.00% |
| Years of service | 1-2 | 12 | 40.00% |
| | 3-4 | 5 | 16.67% |
| | 5 years and above | 13 | 43.33% |

The respondent profile reflects a predominantly young (50% aged 26–30), female (60%), and academe-based (70%) workforce, suggesting high potential for technology adoption due to digital familiarity. However, varying levels of work experience may influence adaptability. According to Yadav et al. (2023), younger professionals show higher digital readiness but may still require structured training. Similar findings by Putra et al. (2022) highlight that academic institutions are often early adopters but face gaps in infrastructure and skills support. This demographic distribution is aligned with the study's aim to evaluate institutional preparedness for Industry 4.0.

**Adoption of Industry 4.0 elements in terms of awareness in the workplace**

Table 3 presents the respondents' level of awareness of Industry 4.0 elements in the workplace. The overall mean score was 3.16 (SD = 1.10), indicating a fair level of awareness. Among the technologies assessed, Artificial Intelligence (M = 3.93, SD = 1.11) and Cybersecurity (M = 3.53, SD = 0.90) had the highest awareness levels, while Robotics Process Automation (M = 2.80, SD = 1.06) and Enterprise Resource Planning (M = 2.93, SD = 1.14) were among the lowest.

Table 3. Respondents' level of awareness of Industry 4.0

| Industry 4.0 Elements | Mean | SD | Description | Qualifying Statement |
|---|---|---|---|---|
| 1. IoT | 3.27 | 1.17 | Fair | Moderately Adopted |
| 2. Digital Twinning | 2.97 | 1.16 | Fair | Moderately Adopted |
| 3. Cyber Security | 3.53 | 0.90 | Fair | Moderately Adopted |
| 4. Factory digitalization | 3.10 | 1.06 | Fair | Moderately Adopted |
| 5. Cyber Physical Systems | 2.97 | 1.10 | Fair | Moderately Adopted |
| 6. Condition-based Monitoring | 3.10 | 1.03 | Fair | Moderately Adopted |
| 7. Artificial Intelligence | 3.93 | 1.11 | Fair | Moderately Adopted |
| 8. Machine Learning | 3.37 | 1.13 | Fair | Moderately Adopted |
| 9. Robotics Process Automation | 2.80 | 1.06 | Fair | Moderately Adopted |
| 10. Neural Networks | 2.90 | 0.88 | Fair | Moderately Adopted |
| 11. Virtual & Augmented Reality | 3.27 | 1.08 | Fair | Moderately Adopted |
| 12. Manufacturing Execution Systems (MES) | 2.97 | 1.03 | Fair | Moderately Adopted |
| 13. Enterprise Resource Planning | 2.93 | 1.14 | Fair | Moderately Adopted |
| **Overall** | **3.16** | **1.10** | **Fair** | **Moderately Adopted** |

Based on the table, a majority of respondents (33.33%) demonstrated fair awareness, with only 16.67% reaching high or very high levels. This suggests that awareness is still developing across many of the technologies assessed.

The results imply that while some Industry 4.0 tools are becoming familiar, particularly AI and cybersecurity, overall workplace readiness may be hindered by uneven exposure to the broader spectrum of digital technologies. Singh et al. (2022) highlight that awareness significantly influences the success of digital transformation initiatives. Similarly, Akpan et al. (2022) argue that limited awareness is a common barrier in emerging economies, slowing technology uptake and institutional innovation.

Table 4 presents the frequency and percentage distribution of respondents' levels of awareness regarding Industry 4.0. The data reveal that a majority of the respondents demonstrated a moderate to high level of awareness.

Table 4. Frequency and Percentage of Respondents' level of awareness on Industry 4.0

| VALUE | RANGE | FREQUENCY | PERCENTAGE | DESCRIPTION |
|---|---|---|---|---|
| 1 | 1.0 – 1.80 | 1 | 3.33 | Very Poor |
| 2 | 1.81 – 2.60 | 9 | 30.00 | Poor |
| 3 | 2.61 – 3.40 | 10 | 33.33 | Fair |
| 4 | 3.41 – 4.20 | 5 | 16.67 | High |
| 5 | 4.21 – 5.0 | 5 | 16.67 | Very High |
| | **Total** | **30** | **100** | |

As presented, the table shows that 16.67% of respondents reported high awareness, 16.67% had a very high awareness, 33.33% had moderate awareness, and 33.33% exhibited low awareness of Industry 4.0 concepts. This indicates a generally positive familiarity with Industry 4.0 among the sample population, suggesting exposure through educational programs or professional experiences.

The predominance of moderate to high awareness levels implies that respondents are likely prepared to engage with Industry 4.0 technologies and practices. This readiness aligns with the growing emphasis on integrating smart technologies such as IoT, AI, and automation in current industry practices. It also reflects the increasing dissemination of Industry 4.0 knowledge across various sectors and educational curricula.

Recent studies corroborate these findings, emphasizing the critical role of awareness in successfully implementing Industry 4.0 initiatives. For instance, Almada-Lobo (2016) highlights that awareness and understanding of Industry 4.0 components are pivotal for organizational adaptation to the digital transformation. Similarly, Liao et al. (2017) note that awareness positively influences the acceptance and integration of Industry 4.0 technologies.

**Adoption of Industry 4.0 elements in terms of utility in the workplace**

Table 5 shows that respondents rated the overall utility of Industry 4.0 technologies in their workplaces as fair (M = 3.07, SD = 1.13), indicating moderate levels of actual use. Artificial Intelligence (M = 3.63) and Cybersecurity (M = 3.37) emerged as the most utilized, while Digital Twinning and Neural Networks both scored lowest (M = 2.87).

Table 5. Respondents' level of utility on Industry 4.0

| Industry 4.0 Elements | Mean | SD | Description | Qualifying Statement |
|---|---|---|---|---|
| 1. IoT | 3.20 | 1.21 | Fair | Moderately Adopted |
| 2. Digital Twinning | 2.87 | 1.01 | Fair | Moderately Adopted |
| 3. Cyber Security | 3.37 | 1.25 | Fair | Moderately Adopted |
| 4. Factory digitalization | 2.97 | 1.16 | Fair | Moderately Adopted |
| 5. Cyber Physical Systems | 2.97 | 0.96 | Fair | Moderately Adopted |
| 6. Condition-based Monitoring | 3.03 | 1.13 | Fair | Moderately Adopted |
| 7. Artificial Intelligence | 3.63 | 1.07 | Fair | Moderately Adopted |
| 8. Machine Learning | 2.97 | 1.13 | Fair | Moderately Adopted |
| 9. Robotics Process Automation | 3.03 | 1.13 | Fair | Moderately Adopted |
| 10. Neural Networks | 2.87 | 1.07 | Fair | Moderately Adopted |
| 11. Virtual & Augmented Reality | 3.07 | 1.08 | Fair | Moderately Adopted |
| 12. Manufacturing Execution Systems (MES) | 2.87 | 1.22 | Fair | Moderately Adopted |
| 13. Enterprise Resource Planning | 3.10 | 1.16 | Fair | Moderately Adopted |
| **Overall** | **3.07** | **1.13** | **Fair** | **Moderately Adopted** |

The moderate adoption across technologies reflects a cautious yet ongoing integration of Industry 4.0. Respondents may be selectively applying tools that offer immediate value or require minimal disruption, such as AI and cybersecurity, over more complex or resource-intensive systems like MES or neural networks. This aligns with Singh et al. (2022), who emphasized that perceived utility and ease of integration influence actual usage of digital technologies.

These findings suggest that while awareness exists, full-scale implementation of Industry 4.0 technologies remains gradual and pragmatic. As Akpan et al. (2022) and Al-Jarrah et al. (2023) assert, organizations in developing contexts often face structural and financial constraints that limit how far they can implement sophisticated digital tools—even when their strategic value is recognized.

Support systems such as workforce upskilling and infrastructure investment are essential to move from awareness to meaningful application. As highlighted by Putra et al. (2022) and Yadav et al. (2023), the capacity to use advanced tools relies heavily on digital readiness, training access, and policy support. Therefore, while utility is progressing, comprehensive institutional backing is key to elevating usage levels from "moderately adopted" to "highly adopted."

Furthermore, Table 6 reveals that the majority of respondents reported fair (30%) to poor (26.67%) levels of utility in using Industry 4.0 technologies. Only a modest proportion indicated high (20%) or very high (13.33%) levels of utility, while 10% perceived their usage to be very poor.

Table 6. Frequency and Percentage of Respondents' level of utility on Industry 4.0

| VALUE | RANGE | FREQUENCY | PERCENTAGE | DESCRIPTION |
|---|---|---|---|---|
| 1 | 1.0 – 1.80 | 3 | 10.00 | Very Poor |
| 2 | 1.81 – 2.60 | 8 | 26.67 | Poor |
| 3 | 2.61 – 3.40 | 9 | 30.00 | Fair |
| 4 | 3.41 – 4.20 | 6 | 20.00 | High |
| 5 | 4.21 – 5.0 | 4 | 13.33 | Very High |
| | **Total** | **30** | **100** | |

These figures point to a slow but emerging engagement with Industry 4.0 tools in real workplace settings. The data suggests that while some early adopters exist, most respondents operate in environments where digital technologies are not yet fully leveraged. This trend corroborates Al-Jarrah et al. (2023), who noted that despite awareness, actual usage often lags due to barriers like cost, skills gaps, and lack of digital infrastructure.

The skew toward lower utility ratings suggests that institutional and operational constraints limit the real-world application of advanced technologies. As Yadav et al. (2023) emphasize, digital competence alone is insufficient without organizational readiness and leadership support. Similarly, Akpan et al. (2022) argue that without a strong enabling ecosystem, even digitally aware professionals may not experience high utility.

To elevate utility from fair to high, sustained interventions such as professional development, infrastructure investment, and policy-driven support are essential. Singh et al. (2022) propose that effective knowledge management systems and cross-sector partnerships can help translate digital awareness into actual productivity gains. Furthermore, Putra et al. (2022) recommend adaptive frameworks tailored to developing contexts to ensure gradual, yet sustainable, technological integration.

**Adoption of Industry 4.0 elements in terms of adaptability in the workplace**

Table 7 presents a generally optimistic view of adaptability to Industry 4.0 technologies among respondents, with an overall mean of 3.51 (SD = 1.14**)**, interpreted as *high* adaptability. The top-rated technologies in terms of adaptability include Artificial Intelligence (M = 3.80), Cybersecurity (M = 3.77), and IoT (M = 3.73), while Manufacturing Execution Systems (M = 3.30) and Digital Twinning (M = 3.40) still reflect *high* but relatively lower adoption.

Table 7. Mean and Standard Deviation on Respondents' level of adaptability to Industry 4.0

| Industry 4.0 Elements | Mean | SD | Description | Qualifying Statement |
|---|---|---|---|---|
| 1. IoT | 3.73 | 1.26 | High | Highly Adopted |
| 2. Digital Twinning | 3.40 | 1.19 | High | Highly Adopted |
| 3. Cyber Security | 3.77 | 1.14 | High | Highly Adopted |
| 4. Factory digitalization | 3.50 | 1.14 | High | Highly Adopted |
| 5. Cyber Physical Systems | 3.43 | 1.07 | High | Highly Adopted |
| 6. Condition-based Monitoring | 3.50 | 1.11 | High | Highly Adopted |
| 7. Artificial Intelligence | 3.80 | 1.16 | High | Highly Adopted |
| 8. Machine Learning | 3.50 | 1.17 | High | Highly Adopted |

| | | | | |
|---|---|---|---|---|
| 9. Robotics Process Automation | 3.37 | 1.30 | High | Highly Adopted |
| 10. Neural Networks | 3.37 | 1.07 | High | Highly Adopted |
| 11. Virtual & Augmented Reality | 3.43 | 1.10 | High | Highly Adopted |
| 12. Manufacturing Execution Systems (MES) | 3.30 | 1.09 | High | Highly Adopted |
| 13. Enterprise Resource Planning | 3.50 | 1.07 | High | Highly Adopted |
| **Overall** | **3.51** | **1.14** | **High** | **Highly Adopted** |

These results suggest that respondents are not just aware of Industry 4.0 concepts—they are actively adjusting to them. This is particularly evident in AI and cybersecurity, which are often prioritized due to their relevance in both operational efficiency and data protection. According to Al-Jarrah et al. (2023), such adaptability is a key predictor of digital transformation success, especially in settings where rapid technological evolution is reshaping job roles and organizational processes.

The consistently high adaptability scores suggest a workforce that is not only exposed to digital tools but also willing to evolve with them. This may be attributed to the younger professional demographic in the study (50% aged 26–30), who, as Yadav et al. (2023) observed, tend to be more digitally agile. However, the high standard deviations (e.g., AI SD = 1.16; RPA SD = 1.30) indicate variability in adaptability across respondents—some may be excelling, while others still lag behind.

To sustain and elevate this level of adaptability, institutions must provide continuous training, peer learning models, and flexible digital infrastructures. Singh et al. (2022) stress the role of knowledge management in facilitating adaptability, while Putra et al. (2022) advocate for phased technology rollouts tailored to local capacities. Building this kind of adaptive environment ensures not just technology adoption, but meaningful digital transformation.

Moreover, Table 8 indicates that 43.33% of respondents reported *high to very high* levels of adaptability to Industry 4.0 technologies (10% high; 33.33% very high). Meanwhile, 26.67% reported fair adaptability, and the remaining 30% experienced *poor to very poor* adaptability levels.

Table 8. Frequency and Percentage of Respondents' level of adaptability on Industry 4.0

| VALUE | RANGE | FREQUENCY | PERCENTAGE | DESCRIPTION |
|---|---|---|---|---|
| 1 | 1.0 – 1.80 | 2 | 6.67 | Very Poor |
| 2 | 1.81 – 2.60 | 7 | 23.33 | Poor |
| 3 | 2.61 – 3.40 | 8 | 26.67 | Fair |
| 4 | 3.41 – 4.20 | 3 | 10.00 | High |
| 5 | 4.21 – 5.0 | 10 | 33.33 | Very High |
| | **Total** | **30** | **100** | |

The distribution highlights a positively inclined but fragmented adaptability profile. A strong proportion of respondents have embraced digital transitions effectively, yet nearly a third continue to struggle—suggesting gaps in exposure, training, or organizational support. As Al-Jarrah et al. (2023) noted, adaptability is highly dependent on both individual readiness and institutional environments that nurture innovation.

These findings echo the digital divide within emerging economies: while early adopters are thriving, others are hindered by infrastructure limitations, resistance to change, or lack of formal support systems. Yadav et al. (2023) emphasized that such divides can lead to unequal outcomes in digital transformation, even within the same organization or sector. The fair scores (26.67%) also suggest many professionals are in transition—aware and engaged, but not yet fully comfortable.

Bridging this adaptability gap requires more than just awareness—it calls for deliberate, ongoing institutional efforts. This includes capacity-building programs, digital literacy integration, and creating a culture of innovation. Singh et al. (2022) point out that knowledge management systems can accelerate adaptability by fostering shared learning. Additionally, Putra et al. (2022) recommend context-specific strategies in resource-limited settings, such as phased technology deployment and collaborative training ecosystems.

**Human Resource Requirements**

Table 9 shows that the most commonly identified Industry 4.0 technologies requiring human resource investment were Artificial Intelligence (n = 19), IoT (n = 22), and Machine Learning (n = 17). Meanwhile, technologies such as Neural Networks (n = 3) and Cyber Physical Systems (n = 8) were cited less frequently. This implies a prioritization of more immediately applicable or visible technologies.

Table 9. Frequency of Human Resource Requirements

| Industry 4.0 Elements | FREQUENCY (N=30) |
|---|---|
| 1. IoT | 22 |
| 2. Digital Twinning | 8 |
| 3. Cyber Security | 16 |
| 4. Factory digitalization | 8 |
| 5. Cyber Physical Systems | 8 |
| 6. Condition-based Monitoring | 9 |
| 7. Artificial Intelligence | 19 |
| 8. Machine Learning | 17 |
| 9. Robotics Process Automation | 10 |
| 10. Neural Networks | 3 |
| 11. Virtual & Augmented Reality | 10 |
| 12. Manufacturing Execution Systems (MES) | 10 |
| 13. Enterprise Resource Planning | 14 |

The high demand for skilled professionals in AI, IoT, and cybersecurity reflects broader industry trends where these tools are increasingly embedded into daily operations. According to Al-Jarrah et al. (2023), technologies that are easier to pilot or deliver measurable ROI tend to receive more focus from HR and training departments. On the other hand, low frequencies for Neural Networks and MES may point to a lack of in-house technical capacity or low perceived urgency for implementation.

This pattern suggests that workforce development in Industry 4.0 is still reactive rather than strategic. Organizations may be investing in technologies they already use or understand, rather than preparing proactively for more advanced systems. As Yadav et al. (2023) explain, this can limit innovation scalability if institutions are not future-proofing their human capital.

To support long-term digital transformation, institutions must not only train for current tools but also anticipate future needs. Singh et al. (2022) highlight the importance of strategic knowledge management to guide workforce evolution. Furthermore, Putra et al. (2022) recommend creating localized training pipelines in partnership with academia and industry to close emerging skills gaps and promote wider readiness.

**Alternative Plans**

Table 10 reveals the technologies where alternative strategies have been considered or implemented. The highest responses were for Artificial Intelligence (n = 22) and IoT (n = 21), followed by Cybersecurity (n = 18) and Machine Learning (n = 16). In contrast, Cyber Physical Systems (n = 7) and Neural Networks (n = 7) were the least mentioned. These frequencies indicate where institutions are most actively seeking or applying workarounds, adaptations, or supportive interventions.

Table 10. Frequency of Alternative Plans

| Industry 4.0 Elements | FREQUENCY (N=30) |
|---|---|
| 1. IoT | 21 |
| 2. Digital Twinning | 11 |
| 3. Cyber Security | 18 |
| 4. Factory digitalization | 11 |
| 5. Cyber Physical Systems | 7 |
| 6. Condition-based Monitoring | 8 |
| 7. Artificial Intelligence | 22 |
| 8. Machine Learning | 16 |
| 9. Robotics Process Automation | 10 |
| 10. Neural Networks | 7 |
| 11. Virtual & Augmented Reality | 12 |
| 12. Manufacturing Execution Systems (MES) | 9 |
| 13. Enterprise Resource Planning | 13 |

This trend suggests that organizations are proactively trying to incorporate widely impactful and accessible Industry 4.0 tools (e.g., AI, IoT) despite facing constraints. These alternative plans may include phased rollouts, external partnerships, low-cost solutions, or capacity-building initiatives. According to Al-Jarrah et al. (2023), such adaptations are common in institutions attempting to digitize incrementally due to limited resources. Similarly, Reischauer (2023) emphasizes that successful digital transformation often depends on adaptive, non-linear strategies rather than uniform technology adoption.

The data imply that organizations are aware of digital transformation demands but may be constrained by financial, infrastructural, or human capital limitations. The presence of alternative plans, particularly for high-impact tools like AI and cybersecurity, points to strategic intent. As Sima et al. (2020) argue, building flexible roadmaps and hybrid solutions enables institutions—especially in developing contexts—to advance digital transformation sustainably. However, the relatively lower responses for advanced systems like Neural Networks suggest that long-term strategies for complex technologies remain underdeveloped.

To ensure continuity and success, alternative planning must be paired with capacity development and policy alignment. As Akpan et al. (2022) and Basl and Doucek (2019) suggest, institutions benefit from pilot testing and knowledge-sharing communities that help localize high-tech innovations. Moreover, Putra et al. (2022) recommend fostering cross-sector collaboration to design adaptable Industry 4.0 integration models that address unique regional and organizational constraints. This not only builds digital resilience but also ensures inclusive innovation across workforce levels.

**Challenges posed for I4.0 adoption**

Table 11 identifies the most frequently reported challenges hindering Industry 4.0 adoption. The top challenge was high cost and financial barriers (n = 27), followed by workforce challenges (n = 20), cybersecurity and data privacy risks (n = 19), and sustainability concerns (n = 17). Other notable challenges included technological uncertainty (n = 16), organizational and cultural barriers (n = 12), and integration with legacy systems and supply chains (n = 11 each).

Table 11. Frequency of Challenges

| **Challenges posed for I4.0 adoption** | **FREQUENCY (N=30)** |
|---|---|
| 1. High Cost and Financial Barriers | 27 |
| 2. Integration with legacy systems | 11 |
| 3. Cybersecurity and data privacy risks | 19 |
| 4. Condition-based Monitoring | 5 |
| 5. Workforce challenges | 20 |
| 6. Organizational and cultural barriers | 12 |
| 7. Technological uncertainty | 16 |
| 8. Supply chain integration | 11 |
| 9. Sustainability concerns | 17 |

These frequencies reflect a multidimensional barrier landscape where economic limitations and human capital readiness are primary constraints. The dominance of cost-related concerns aligns with findings from Al-Jarrah et al. (2023), who emphasized that financial strain remains the most persistent deterrent in technology adoption for institutions in emerging economies. Workforce-related concerns, including skill gaps and resistance to change, mirror those highlighted by Sima et al. (2020), particularly in academic and public-sector organizations where upskilling may lag behind technological progress.

The data indicate that Industry 4.0 adoption is not simply a technological issue, but a structural and cultural one. Cybersecurity risks and technological uncertainty suggest fear of unintended consequences or a lack of expertise to manage complex systems. Meanwhile, cultural resistance and legacy infrastructure act as invisible brakes on innovation. As Reischauer (2023) notes, digital transformation requires not only tools but trust, agility, and leadership to navigate change effectively.

To overcome these layered challenges, a holistic and strategic response is needed. Akpan et al. (2022) recommend fostering public–private partnerships to reduce costs through shared investments and infrastructure. Meanwhile, Singh et al. (2022) argue that building organizational knowledge systems and change management protocols can ease transitions and reduce resistance. Additionally, Putra et al. (2022) emphasize the role of adaptive leadership and localized digital strategies that align with institutional capacities and socio-economic contexts.

Moreover, Form 1 presents qualitative narratives from respondents describing firsthand experiences in adopting Industry 4.0 technologies. The most cited challenges include limited financial resources, lack of infrastructure and skilled personnel, cybersecurity concerns, and resistance to change. Respondents also mentioned unstable internet connections, legacy systems, and insufficient institutional prioritization. In response, solutions included training initiatives, gradual technology rollouts, external funding, BYOD (Bring Your Own Device) policies, and seminars to boost digital awareness.

Form 1. Specific challenges the workplace encountered in adopting Industry 4.0 technologies, and what alternative strategies or solutions have been implemented

| |
|---|
| *Budget (Respondent 1)*<br><br>*Challenges in adopting Industry 4.0 would be the availability of resources/facility and experts on this fields. (Respondent 2)*<br><br>*The main challenge really is the adaptation of the available technologies that would help the institution and its stakeholders in terms of improving the services that will lead to more income for the company. (Respondent 3)*<br><br>*Cost of services and equipment, skills. Adressed by going back to slow basic protocols. (Respondent 4)*<br><br>*I think the institution has very capable people for this technology, however, I do not think the school is financially capable as of the moment. (Respondent 5)*<br><br>*Our workplace encountered several challenges in adopting Industry 4.0 technologies, including high implementation costs, a noticeable skills gap among staff, cybersecurity concerns, and difficulties integrating new systems with existing legacy infrastructure. (Respondent 6)*<br><br>*High Cost and Sustainability (Respondent 7)*<br><br>*Adopting Industry 4.0 technologies is currently not a priority of the company, Hence, I can't give a specific answer to this question. (Respondent 8)* |

*One of the key challenges we've encountered is the lack of standardization across client systems. Each client often uses different platforms, tools, and has unique requirements, making it difficult to implement a one-size-fits-all solution. To address this, we've adopted a flexible and collaborative strategy by partnering with SaaS companies, primarily startups that can offer customized and agile solutions tailored to each client's specific needs. This approach allows us to implement specialized processes efficiently while staying adaptable to evolving client demands and technological advancements. (Respondent 9)*

*Availability of resources, and awareness and proper training on the utilization of technology integration into teaching learning process are the common challenges in our department. So, our department cascaded a training for teachers in using technology integration. ((Respondent 10)*

*Our workplace faced high costs, limited technical skills, and resistance to change in adopting Industry 4.0. To address this, we conducted staff training, sought expert support, and implemented technologies gradually. (Respondent 13)*

*Adamant of the Industry 4.0 of the workforce. Maybe provide seminar and training for the workforce to be aware of the importance of integrating industry 4.0 to the university and be future proof with the preparation of future of works and complementing the technology with the needs of the academe seamlessly. (Respondent 15)*

*As a teacher, the specific challenges that my workplace encountered in adopting the Industry 4.0 technologies are the limited financial resources as we are in the private school sector as well as the cybersecurity concerns for we are teaching young people in elementary level. The alternative strategies or solutions that have been implemented to address these challenges are having training not just for the teachers, but also for the students about cybersecurity for them to be knowledgeable enough about the cyber hygiene policies. Also implement BYOD (Bring Your Own Device Policies) when needed as well as staggered technology adoption. ((Respondent 16)*

*In our case since our work merely focused on booking transactions, bundling vouchers/liquidations/collections, and scanning documents, we don't really rely on advancing our technology/technologies use in the office, but as for my observation, some of my colleagues had a hard time dealing basic word/excel. Also, not all of us in our section has their own computer, basically the program installed in our computer is only the ""E-ngas"" for booking transactions purposes only. (Respondent 17)*
.
*Lack of knowledge in emerging technologies and resistance to change. The solution was, introduced the emerging technologies to the faculties and staffs and provided the knowledge that they have to learn. (Respondent 19)*

*"Educate learners how to use it properly. Need to be implemented some kind of seminar or immersion to demonstrate the proper way and useful way to use technologies." (Respondent 21)*

*"Im a new employee and in the stage of banking station somehow been amaze to the new integration of technology that I might not encounter in my student life.for now that's not consider a barrier it's learning" (Respondent 22)*

*Internet connection (Respondent 23)*

*Connection Stability (Respondent 25)*

*lack of readily available, skilled workforce capable of managing and utilizing new technologies like Iot and all. (Respondent 26)*

*Unstable internet connection; availability of resources like robotics (Respondent 27)*

*Lack of funds. We just maximize whatever is available. (Respondent 28)*

*"Cyber security and data privacy risks-We ensure that our documents and any data will be fully secured by limiting the people who can access it" (Respondent 29)*

*Majority of the challenges in adopting 4.0 technologies is brought by the scarcity of resources. To address these challenges, sourcing out of resources outside the institution had been initiated such as looking for external funds. Funding and readiness of the workforce in the integration. (Respondent 30)*

These real-world accounts emphasize that digital transformation in many workplaces—particularly academic and public institutions is often hindered not by willingness but by practical constraints. High costs were echoed by the majority, aligning with the survey data from Table 11 and the findings of Al-Jarrah et al. (2023), who highlighted cost as a leading barrier in developing nations. Workforce-related issues, such as low digital skills or tech aversion, also surfaced repeatedly confirming Sima et al.'s (2020) view that human capital is as critical as hardware in Industry 4.0 transitions.

What's striking is the resourcefulness of respondents in navigating these constraints. Rather than stalling, many workplaces improvised adaptive strategies cascading internal trainings, partnering with SaaS providers, or phasing in tools. This aligns with Reischauer's (2023) notion of "digitally induced resilience," where institutions adapt flexibly based on local capabilities. The responses suggest that despite lacking ideal conditions, the intent to innovate is present—but must be matched by systemic support.

To sustain these grassroots efforts, institutions need structured digital capacity-building programs, leadership advocacy, and access to external expertise. As Singh et al. (2022) and Putra et al. (2022) propose, strategic knowledge-sharing and community-based digital ecosystems are key enablers for scaling these early initiatives. Moreover, national policies such as those in the Philippines' AI Roadmap (DTI, 2024) should go beyond infrastructure and address the social dimensions of digital transformation, including equity, mindset shifts, and inclusive access.

## CONCLUSION AND RECOMMENDATION

The findings of this study reveal a transitional digital landscape among professionals in Mindanao, particularly within academic institutions, where awareness and utility of Industry 4.0 technologies are moderate, but adaptability is notably high. This suggests that while technological infrastructure and comprehensive usage remain limited, there is a strong willingness and capacity among individuals and organizations to embrace digital transformation. Artificial Intelligence, IoT, and Cybersecurity emerged as the most familiar and utilized technologies, yet challenges such as high costs, workforce skill gaps, and infrastructural limitations persist.

Despite these barriers, institutions are demonstrating adaptive responses through phased implementations, capacity-building programs, and alternative digital strategies. These results underscore the need for a more strategic and inclusive approach to Industry 4.0 adoption. Institutions may invest in long-term capacity-building initiatives, develop training pipelines for emerging technologies, and promote internal innovation through supportive leadership and policies.

Policymakers may likewise prioritize not only infrastructure development but also workforce readiness and institutional support. Future research is encouraged to explore the longitudinal impacts of digital adaptation and to examine how different organizational cultures and sectors influence technology integration. Furthermore, with the right support systems, institutions in developing regions can transition from digital resilience to digital leadership in the Industry 4.0 era.

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