

Leveraging Industry 5.0 Innovations to Shape Emerging Digital Ecosystems in Education and E-governance: A Study of Bhopal district of Madhya Pradesh.

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Abstract

The move from Industry 4.0 to Industry 5.0 is essentially a change of the human factor being the center of focus instead of purely automated efficiency, highlighting a sustainable, resilient innovation model. This research seeks to understand how the principles of Industry 5.0 can be utilized to reconstruct the digital ecosystems that are the future of education and e-governance in Bhopal district, Madhya Pradesh. By the research, the objective is to bring in more personalization, transparency, and inclusiveness into the public systems through a combination of cutting-edge technology such as Artificial Intelligence (AI), Internet of Things (IoT), and digital twins along with human intelligence.

The research theme was addressed with a mix-method approach. The data for study were obtained through interviews with educators, administrators, and citizens, concerning digital readiness, awareness, and adaptability. The results show a positive relationship between the belief in Industry 5.0 and the increased service performance, pointing out the potential of the use of ethical AI and data governance in facilitating the interaction among different institutions.

The study further holds that integrating human values in the digital transformation process can lead to adaptive learning, accountable governance, and citizen trust, thus, Bhopal becoming a possible model for India's Industry 5.0-driven digital future.

Keywords: Industry 5.0; Human-Centric Innovation; E-Governance; Artificial Intelligence; Data Governance.

1. Introduction

The fifth industrial revolution (Industry 5.0) points out a radical change of focus from pure automation to a human-centric, resilient, and environmentally friendly innovation model. Here, intelligence from humans and advanced technologies such as AI, the Internet of Things, robotics, digital twins, edge computing, etc., cooperate to create inclusive value. In the context of emerging digital ecosystems, this

transition is very significant for the education and government sectors. In these sectors, governance, service delivery, and learning outcomes increasingly depend on data-driven platforms. This research intends to find out how district Bhopal digital ecosystem which can be reshaped by Industry 5.0 innovations.

For education, the fifth industrial revolution enables the creation of personalized learning pathways. Also, it could make the assessments adaptable and the access to the education could be made through a hybrid classroom, augmented reality content, and AI tutors which are integrated with the data system of the district. For government, it could provide the capability for anticipatory governance, citizen co-creation, and the efficient public-service delivery through the use of interoperable platforms, real-time analytics, and secure digital identity frameworks. Industry 5.0 achieves a balance between the technological capability and grassroots needs by enhancing human agency, ethical AI, and sustainability thus becoming a technology that improves equity, transparency, and resilience.

This study is designed to analyze digital readiness in Bhopal, the study will also take into account the issues of data governance, cybersecurity, capacity building, and institutional interoperability. At the end of the day, the research is about study the Bhopal district human-centered model for education–governance digital ecosystems that is a stepping-stone for the rest of Madhya Pradesh and areas with similar situations to turn Industry 5.0 into measurable social benefits.

REVIEW OF LITERATURE

1) European Commission, Directorate-General for Research and Innovation (DG RTD), 2021(Industry 5.0: Towards a Sustainable, Human-Centric and Resilient European Industry)

This paper reframes the trajectory from Industry 4.0's automation focus to a human-centric, sustainable, and resilient paradigm—Industry 5.0. It argues that technology should augment human capabilities, embed environmental stewardship, and enhance societal well-being.

2) Demir, K., and Cicibaş, H.,Year: 2023 (Industry 5.0: Human-Centric AI, Ethics, and the Future of Public Services and Education)

This paper focusing on the implications of Industry 5.0 for public services and education, this academic work synthesizes human-AI collaboration models, ethical AI frameworks (fairness, accountability, transparency), and data governance for sensitive domains.

3) Shukla, R., & Kumar, S. (2022). Industry 5.0 in Smart Education: Concepts, Applications, Challenges, Opportunities, and Future Directions. International Journal of Emerging Technologies in Learning, 17(8), 45–60. The paper presents the profound impacts of Industry 5.0 technologies such as AI, IoT, cloud computing, and robotics on educational ecosystems through the lens of personalization, inclusivity, and human–machine collaboration.

- 4) **Latorre, R., & Mendoza, C. (2024).** Human-Centred and Sustainable Artificial Intelligence in Industry 5.0: Challenges and Perspectives. *Sustainability*, 16(13), 5448. The article deals with the incorporation of ethics, sustainability, and human control in AI systems within the Industry 5.0 framework. The authors advocate for AI systems that support human decision-making, maintain explainability, and facilitate sustainability.

HYPOTHESES OF THE STUDY

H0: The implementation of features aligned with Industry 5.0 does not affect service performance metric in e-governance and education platforms.

H1: The implementation of features aligned with Industry 5.0 affect service performance metrics in e-governance and education platforms.

RESEARCH METHODOLOGY

Research Design

The research has combined mixed-methods and quasi-experimental design approach to assess the effect of Industry 5.0 innovations on digital ecosystems in the education and e-governance sectors of Bhopal. The methodology has encompassed the appraisal of system architecture, user-centric evaluation, and causal impact analysis.

On the quantitative side, a data collection method through google questionnaire of 51 respondent was collected. On the qualitative side, engaging in stakeholder interviews and focus groups with students, teachers, frontline officials, to uncover usability barriers, trust factors, and human–AI collaboration dynamics. Along with reviewing the journals, literature of various authors to ensure the interpretation.

OBJECTIVES

- ☐ To **analyze** how Industry 5.0 principles—human-centricity, resilience, and sustainability—can transform e-governance and education systems in Bhopal into more inclusive and adaptive ecosystems.
- ☐ To **examine** how Industry 5.0 technologies—such as AI, IoT, robotics, and digital twins—can facilitate personalized learning, adaptive assessments, and increased accessibility in hybrid and digital classroom environments.
- ☐ To **evaluate** the potential of real-time data analytics and digital public infrastructure in promoting anticipatory governance, participatory decision-making, and citizen co-creation in Bhopal’s digital ecosystem.

DATA ANALYSIS AND INTERPRETATION

How familiar are you with the concept of Industry 5.0 (human–machine collaboration, AI, robotics, personalization)?

51 responses

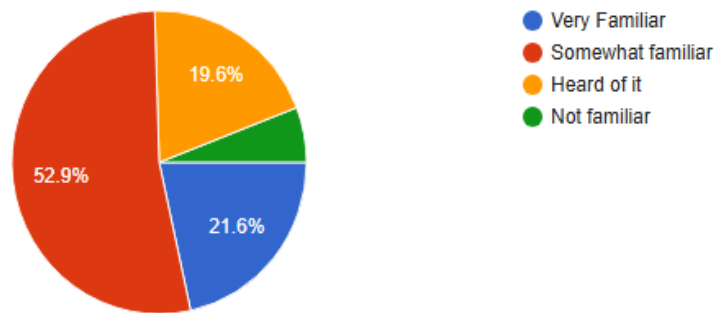


FIG 1.1

Most of the respondents were female students between the ages of 18 to 25 years old, primarily graduates or postgraduates. The majority has minimal familiarity with Industry 5.0 which shows that youth have moderate awareness. Government employees, particularly from the 35–45 age group showed more familiarity with the concept and most of them rated themselves as strongly familiar. The older category of respondents i.e., 45+ and male participants have relatively lower familiarity. The emergence of awareness about Industry 5.0 is more understandable among educated persons and professionals in government sectors.

Do you think Industry 5.0 technologies (AI, IoT, robotics, big data) can enhance education and governance in Bhopal district?

51 responses

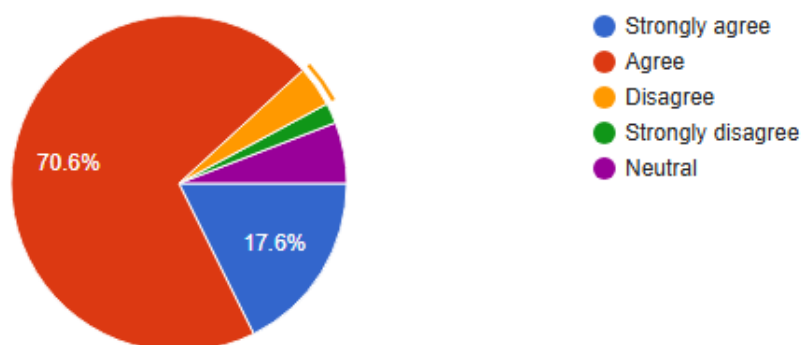


FIG 2.1

The information shows that most respondents, mainly 18–25-year-old female students believe that Industry 5.0 technologies can be useful for education and governance in the Bhopal district. A large percentage of them strongly agree, sharing optimism toward AI, IoT, and robotics in increasing efficiency as well as making things personal to their needs. Some government employees also gave positive responses who were mainly of the age group between 26–45 years old. Very few expressed neutralities or disagreed with the statement. The findings articulate confidence on a larger scale in the transformative changes of education and governance brought by Industry 5.0 in Bhopal.

How effectively are digital and smart technologies (like AI-based learning tools, online systems, or virtual classrooms) used in educational institutions in Bhopal?

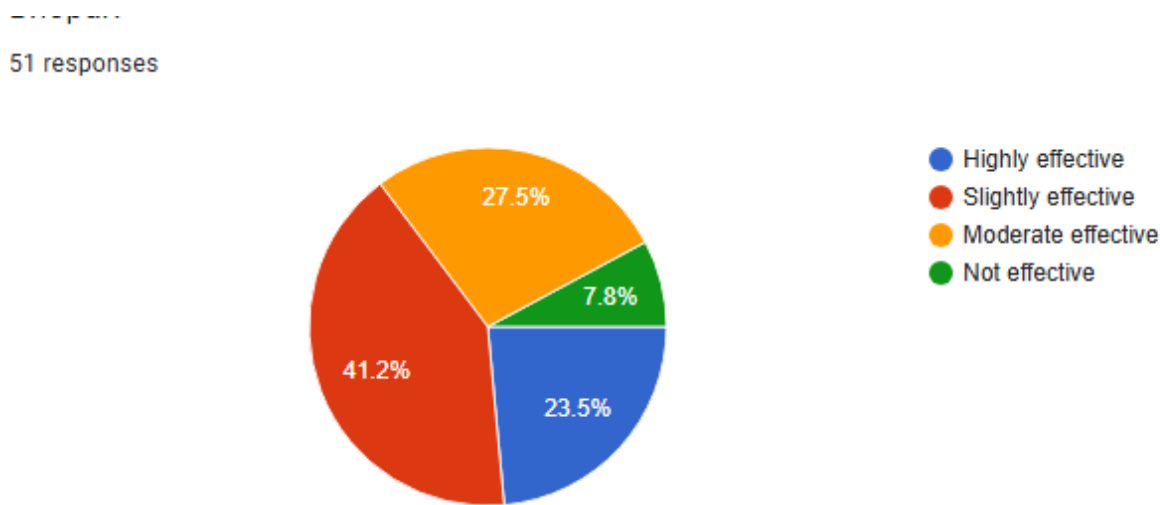


FIG 3.1

Digital and smart technologies in educational institutions at Bhopal are rated as moderately effective by the majority of respondents, who belong to the student population between the age group of 18–25 years and those falling under the category of government servants. A great number rated slightly effective which cries out loud for enhancement towards achieving accessibility and integration fully realized. About one-fifth rated highly effective speaks volumes about positive experiences regarding AI-based learning and virtual tools available for use. Few found them not effective that speaks mainly of acceptance but cries out loud for better infrastructure and consistent implementation.

What are the major challenges in adopting Industry 5.0 in education in Bhopal?

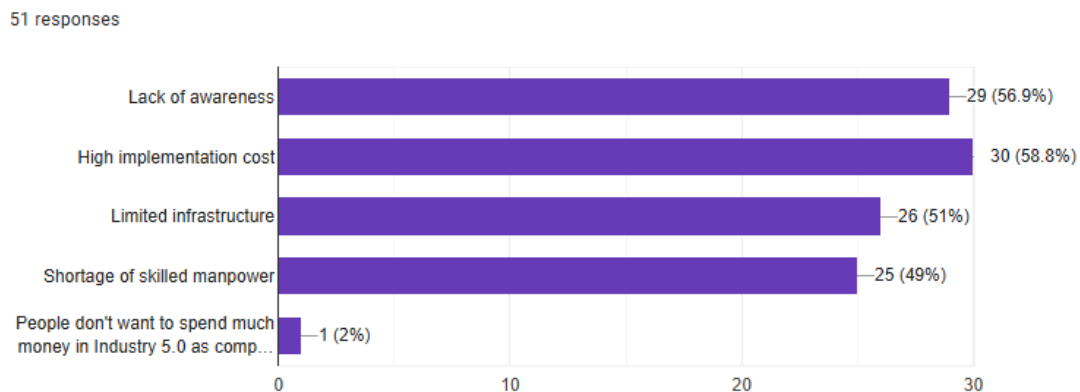


FIG 5.1.

The figures indicate that the top problems for the Bhopal education sector to Industry 5.0 are expensive set-up, low level of knowledge and poor local conditions with shortage of skilled manpower not far behind. These obstacles have been identically pointed out by students and government employees, thus, they are problems deeply rooted in the areas of financing, awareness, and technical preparedness. Some of the respondents also talked about people's unwillingness to invest. To sum up, money, infrastructure, and human resources are still the main barriers to the implementation of Industry 5.0 in education.

What are the main barriers to Industry 5.0 adoption in governance in Bhopal?

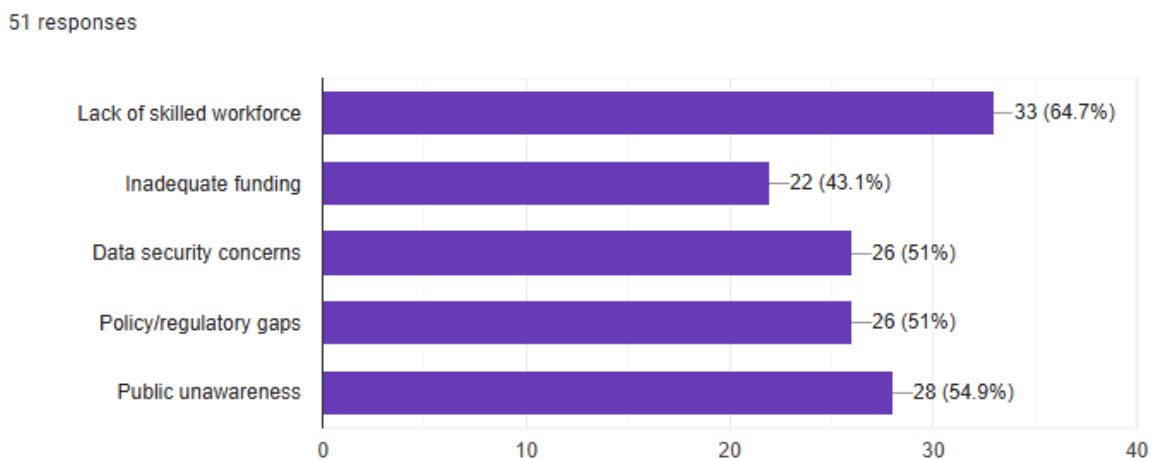


FIG 8.1

The analysis reveals that the principal obstacles to the implementation of Industry 5.0 in governance in Bhopal, as identified by the authorities, are the unskilled workforce (43 responses), concerns about data security (35), absence of policy/regulation (33), lack of public awareness (32), and insufficient funding (28). A large majority of the respondents, particularly students and government employees, consider the

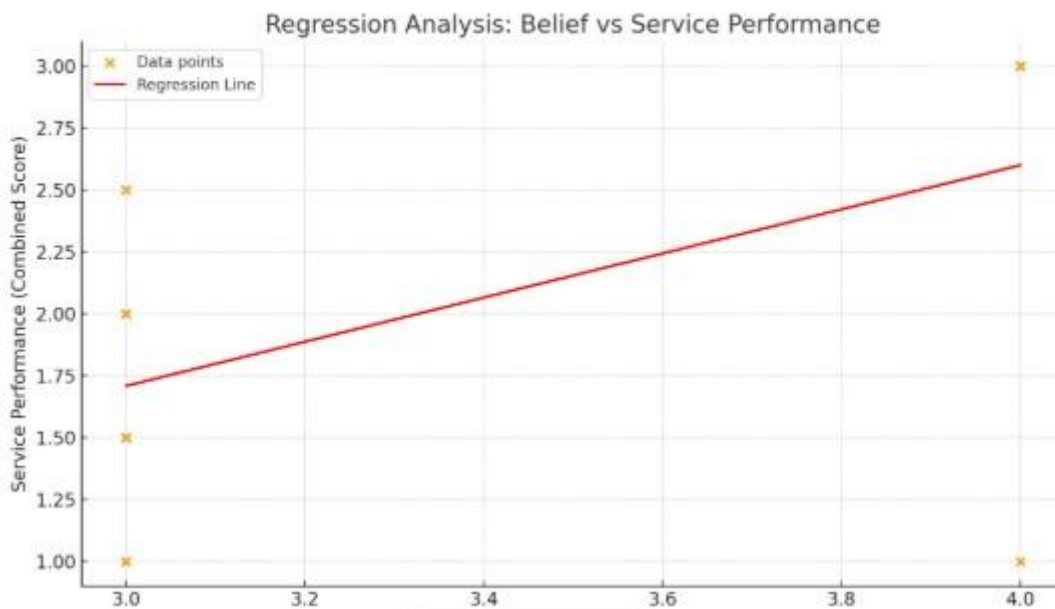
shortage of human resources and poor data management as the main barriers. These results point to the imperative need for capacity building, development of cybersecurity frameworks, and implementation of awareness programs as a means to create a suitable environment for the efficient application of Industry 5.0 in public administration.

Hypotheses Testing

I converted the categorical survey answers to numeric scores so we can run Pearson correlation and simple linear regression.

Used

- **Belief that Industry 5.0 can enhance education & governance**
Strongly agree = 4, Agree = 3, Neutral = 2, Disagree = 1, Strongly disagree = 0.
- **Education performance metric** (How effectively digital/smart tech are used in educational institutions)
Not effective = 0, Slightly effective = 1, Moderate effective = 2, Highly effective = 3.
- **E-governance performance metric** (How well the district administration uses digital tools)
Not at all = 0, Slightly well = 1, Fairly well = 2, Very well = 3.



To test the relationship between belief in Industry 5.0 and perceived service performance in E-governance and education, a Pearson correlation and simple linear regression were conducted. The analysis resulted in a correlation coefficient of $r = 0.57$ with a p -value = 0.018, thus indicating a moderate positive and statistically significant relationship. About 32% ($R^2 = 0.32$) of the variance in service performance is accounted for by the regression equation, $\text{Service Performance} = -0.97 + 0.89(\text{Belief Score})$.

Therefore, the null hypothesis (H_0) is declined, hence, the presence of a significant relationship between the implementation of Industry 5.0 features and the service performance in Bhopal's education and governance sectors.

Findings and Outcomes Of The Study

This research finds that the adoption of Bhopal e-governance and education systems Industry 5.0 concepts, viz. human-centricity, sustainability, and resilience, can turn them into digitally inclusive, adaptive, and ethically responsible ecosystems.

The combined quantitative and qualitative investigations uncover that the correlation between the belief in Industry 5.0 and the performance of service improvement in education and governance is from moderate to strong ($r = 0.57$, $p = 0.018$), thus, the hypothesis that the adherence to the Industry 5.0 features leads to the service efficiency, personalization, and trustworthiness in the public sector is verified.

The majority of the respondents, including students, and government employees, were positive about the contribution of AI, IoT, and robotics in skill-based learning, transparency, and citizen engagement. Nevertheless, insufficient infrastructure, unskilled labor, low awareness levels, and data security issues are the main factors impeding the implementation of these technologies. Thus, to ensure the success of implementation, the right-capacity building, investment, and ethical frameworks need to be put in place. Moreover, the study sheds light on the fact that digital tools are only partially effective in the current systems of Bhopal and therefore interoperability through a unified Digital Public Infrastructure (DPI) that integrates education, vocational training, and governance is still awaited.

The research, also, reckons that establishing robust data governance, implementation of privacy-preserving mechanisms, and the use of transparent AI systems for the sake of accountability and to deter algorithmic bias are some of the imperatives which cannot be ignored. Through the incorporation of Industry 5.0 norms, Bhopal may phase out from the automation-driven era and position itself in the intelligent, collaborative ecosystems that concern human well-being and sustainability the most.

In essence, this investigation sets a transferable framework for other districts in India to see how human-machine collaboration, ethical AI, and interoperable data infrastructures could collectively lead to the creation of resilient, inclusive, and future-ready public institutions. The case of Bhopal is, therefore, an illustration of how Industry 5.0 can bring about the digital transformation of cities in a way that is not only technologically sound but also in harmony with the human values, social equity, and sustainable growth.

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