NAVIGATING THE CHALLENGES AND STRATEGIES FOR HIGHER EDUCATION INSTITUTIONS IN MAPPING INDUSTRY 4.0 BASED EDUCATION: A PLS-SEM ANALYSIS

Monika Gadre, MIT World Peace University
Aruna Deoskar, International Institute of Management

ABSTRACT

Industry 4.0 is one of the rapidly growing fields in various domains. To fully capitalize on its potential, it's crucial to comprehensively examine the obstacles and confines related to its execution. The advent of Industry 4.0 has triggered a profound metamorphosis across multiple industries, necessitating a paradigm shift in higher education approaches. The research aims to study and identify the opportunities and concerns of various stakeholders viz. universities, students, academicians, and experts from industries, to align their curricula and methodologies with the demands of Industry 4.0 and how best the future workforce be prepared. The hindrances in implementing Industry 4.0 in industries are scrutinized from an educational vantage point. The universities and educational institutes are striving hard to lay a strong foundation for future talents by reforming the existing programs, redesigning the curriculum, establishing strong relationships with alumni and industry, infrastructure development, and most importantly pedagogical methodologies, faculty development through exchange programs, training, projects, etc. The researcher has identified various educational factors and proposed strategies for the successful implementation of Industry 4.0 and offers solutions to bridge the gap between industry demands and academic provisions.

Finally, this study serves as a roadmap for Higher Education Institutions seeking to capitalize on Industry 4.0's potential while addressing its accompanying hurdles. Institutions can effectively shape the future workforce by embracing innovative techniques and developing a comprehensive approach to curriculum design and pedagogy, giving them the skills and mindset required to flourish in the ever-changing terrain of Industry 4.0.

Keywords: Industry 4.0, Higher Education, Challenges, Factors, Strategies.

INTRODUCTION

In earlier times, industries underwent significant impacts due to shifts and advancements, transitioning from traditional manufacturing to technology driven methods of production. These shifts are referred to as industrial revolutions. Similar to the realm of science fiction, our world has encountered three major industrial revolutions in the past and is presently undergoing the fourth. The revolution started with using water and steam to mechanize production known as the 1st Industrial Revolution. The second industrial revolution marked the beginning of mass production with the introduction of electrical power, while the third industrial revolution saw the utilization of electronics and automation Dorleon & Gervais, (2017) Industry 4.0 is considered the pivotal moment to conclude traditional manufacturing. This era blurred the distinction between the physical and virtual realms, giving rise to Cyber-Physical Systems. Oztemel & Gursev (2020) The way things are

Citation Information: Gadre, M & Deoskar, A. (2024). Navigating the challenges and strategies for higher education institutions in mapping industry 4.0 based education: a pls-sem analysis. *Academy of Strategic Management Journal, 23S*(4), 1-10.

getting produced has changed over these four generations of the industry. Unlike its predecessors, Industry 4.0 is driven by an intelligent, interconnected, and omnipresent environment.

The lifecycle of the industry and so the expectations have tremendously transformed. As a consequence of this, specific careers and job roles disappeared. Consequently, to address the growing needs of industry there's a necessity to overhaul the outdated education system. As a result, the skills and knowledge needed for success in this period go far beyond traditional academic fields, necessitating a comprehensive and forward-thinking approach to education.

Furthermore, effective incorporation of Industry 4.0 ideas into education necessitates a comprehensive awareness of the many challenges that accompany such a change, as well as the strategic moves required to successfully navigate these challenges.

The objective of this research paper is to study the complexities of implementing Industry 4.0 oriented education within the framework of Higher Education Institutions (HEI) in India. This study intends to find solutions and best practices that can guide institutions towards effective implementation by exploring the issues that educators, administrators, and policymakers face during this transformative process. This paper is aimed at contributing to the evolving dialogue on how Higher Education Institutions can strategically align itself with the demands of Industry 4.0, fostering the development of a workforce poised to drive innovation and navigate the intricate landscapes of the future through an examination of case studies, empirical data, and scholarly discourse.

This paper illustrates the correlation between various educational aspects and the requirements of Industry 4.0. It proposes necessary adjustments and alignment within the education system to ensure that graduates from different educational institutions are equipped to be globally employable, competitive, and impactful contributors. Individuals must acquire adaptive thinking, cognitive and computational skills, computer literacy, and analytical thinking.

There is a need to understand and learn how to learn, technology and innovation-based education irrespective of discipline, computational thinking, algorithms, basics of machine learning, tinkering, prototyping, experiential learning, proof of concept, personal learning networks for technology-enhanced, global perspective for the workforce.

There are a lot of unanswered questions in the minds of academicians, students as well as industry experts. But who does the industry hire, does the degree offered is able to create employable individuals? Does industry train the people they hire and for how long? As an employee when and from where can I learn and what exactly should be learned? And how is it measured and evaluated, if the training, skills possessed worth and sufficient to get a job? This paper highlights various aspects so that the stakeholders are well informed and how educational factors can be mapped to Industry 4.0.

In the subsequent sections, primary challenges faced by higher education with respect to Industry 4.0 have been studied. Additionally, we will explore various strategies that institutions can potentially employ to address these hurdles. Our aim in highlighting these pivotal issues is to offer valuable insights that enhance the decision-making procedures and stimulate further exploration into the crucial intersection of education and Industry 4.0.

LITERATURE REVIEW

Challenges in mapping Industry 4.0 based education are explored here, together with education in the era of Industry 4.0 and Strategies for Higher Education Institutions.

Citation Information: Gadre, M & Deoskar, A. (2024). Navigating the challenges and strategies for higher education institutions in mapping industry 4.0 based education: a pls-sem analysis. *Academy of Strategic Management Journal, 23S*(4), 1-10.

Higher Education For Industry 4.0

Industrial revolutions not only changed the products but also influenced the workforce and education. Key technologies like big data, cloud computing, IoT, 3D printing, augmented reality, simulation requires skill sets matching the needs of Industry 4.0. Due to the emerging technological trends, and digitalization, as suggested by the World Economic Forum it is expected that "most professions will be comprised of skills that were not yet thought of as essential to the job today." Gwata, (2019)Therefore there is a dire need to cultivate skills required for the future Fahim et al., (2021)

Aligning curricula with actual industry needs is considered the biggest challenge. Looking at the pace at which there is a change in Fourth Industrial Revolution technologies in the workplace there is a need to repeatedly update and have close communication with the industry. Continuously updated education is the only solution that can help to bridge the industry-academia skill gap and make the workforce future-ready.

Hence, higher education should instil analytical acumen, innovation, and creativity among the budding individuals. Consequently, a critical requirement arises to refine higher education curricula, aiming to nurture students with advanced technological competencies and skills that align effectively with the operational landscape of Industry 4.0.

In the past, there has been a connection between the industrial and educational revolutions, and these two movements have had a considerable impact on one another. The Table 1 below gives a quick overview of the educational revolutions that have happened in tandem with previous industrial revolutions.

Table 1
INDUSTRIAL AND EDUCATIONAL REVOLUTIONS

S. No	Industrial Revolutions	Revolutions in Education
1	Industry 1.0 (18th -19th century)	Creation of formal schooling system Emphasis on basic literacy
2	Industry 2.0 (Late 1800s to early 1900s)	Growth of vocational & technical education to make available competent individuals for specialised jobs
3	Industry 3.0 (Mid 20th century)	A focus on universal public education
4	Industry 4.0(present)	Technology Centric Education Focus on critical thinking, problem-solving, and adaptability. Competency Based Learning
5	Industry 5.0(upcoming)	Personalized learning Collaboration with smart devices

Challenges in Mapping Industry 4.0-Based Education

Swift progression of technologies: Higher Education Institutions (HEIs) struggle to maintain curricula updated with the latest innovations and developments due to Industry 4.0's rapid rate of technological advancement Hernandez-de-Menendez, (2020)

Interdisciplinary nature: Interdisciplinarity is frequently needed to create Industry 4.0 solutions.

Citation Information: Gadre, M & Deoskar, A. (2024). Navigating the challenges and strategies for higher education institutions in mapping industry 4.0 based education: a pls-sem analysis. *Academy of Strategic Management Journal, 23S*(4), 1-10.

In a world that is complicated, interconnected, and changing quickly, it aids in educating learners to prosper. Through the promotion of critical thinking, teamwork, and comprehensive comprehension of diverse subjects, interdisciplinary education endows people with the abilities and perspectives required to deal with the opportunities and challenges of the twenty-first century Xing & Marwala (2017).

Infrastructure: To facilitate the digital shift to Industry 4.0, infrastructure needs to be upgraded.

Enhancing teachers' competencies: Educators must be prepared to help students meet the challenges of the quickly changing technology environment, which calls for a thorough approach that includes hands-on learning, train the trainer workshops, projects with students and industries, and exposure to real-world applications Amballoor & Naik (2020)

Upgrading curriculum: Universities should develop curricula that strike a balance between fundamental knowledge and developing technology to guarantee that future talent will match industry demands. Furthermore, they should upgrade the curriculum or include new courses such as data analytics, AI design, Internet of Things, robotics, and so on. Mian et al., (2020).

Strategies for Higher Education Institutions

Peer learning: initiatives that support professional development, exchange programmes, group or community-based collaborative learning and skill development among individuals, networking opportunities, and enhancing knowledge and talents overall.

Industry visits: Visits to industries provide insights into how theoretical ideas are put into practise, as well as Exposure to Industry Processes, Professional Learning, Networking Opportunities, and Inspiration for a more comprehensive education that goes beyond lectures and textbooks.

Participation in competitions: Participating in events such as ideation, coding competitions, and hackathons offers individuals a chance to demonstrate their abilities, teamwork, and use of technology. These opportunities for professional and personal development can have a long-lasting effect on the careers and skill development of the individuals involved.

Promoting research: support from institutions and industries for faculty and student research.

Workshops, seminars for students: Designing workshops to give students practical experience, insightful understanding, and exposure to recent trends in technology, the efficient way to close the knowledge gap between academia and industry. These workshops also equip students with relevant knowledge, practical skills, and insights into industry practices, and emerging areas of technology.

Newsletters/ Periodicals/ Journals: participation in publications that feature the newest technological talks and articles.

Exhibitions and roadshows: Technical campuses offer roadshows as a venue for industries to interact with students, advertise, and develop partnerships between industry and academics.

Collaborations with industries: MOU's, collaborations and partnerships with industries offering programs like TCS SANGAM, Inspire – Faculty Partnership Model by Infosys, IBM Software Centre of Excellence (CoE), Infosys Campus Connect Faculty Excellence Awards, EMC Academic Alliance that offer courses to prepare students for successful careers in the new IT landscape. It helps in academic associations and ensure skill enhancement for both students and academicians to confirm that the right skills are taught,

Citation Information: Gadre, M & Deoskar, A. (2024). Navigating the challenges and strategies for higher education institutions in mapping industry 4.0 based education: a pls-sem analysis. *Academy of Strategic Management Journal, 23S*(4), 1-10.

and recent market shifts are addressed. Similarly, programs like Microsoft Ed-Vantage are helpful and give add-on value and strengthen employability skills Balasubramani, (2019).

OBJECTIVES OF THE STUDY

The objective of the study is:

- To explore the factors and attributes affecting higher education from Industry 4.0 perspective.
- To quantitatively assess and map the educational factors with Industry 4.0 requirements.

HYPOTHESIS OF THE STUDY

Ha_1: There is a significant impact of having Industry 4.0 knowledge on teachers' teaching quality.

Ha_2: Industry 4.0 knowledge has a significant impact on teaching-learning pedagogy.

Ha_3: There is a significant impact of updating curriculum on Industry 4.0 practices and knowledge.

RESEARCH METHODOLOGY

The study involves a systematic approach to collecting, analyzing, and interpreting data to address the research objectives. This is conducted in an orderly and transparent manner.

Research Context - In this paper, the researchers try to examine the industry-academia gap for Industry 4.0 and the challenges involved in bridging it. The questionnaire was created for three stakeholder groups, including academicians, students, and industry experts, based on the studied literature. These stakeholders' responses to the questionnaires served as the source of the primary data. This study was carried out to explore the factors and attributes of Industry 4.0 in the Indian educational system.

Sampling - Both primary and secondary data were collected and analyzed in this study.When collecting data from students and academicians, simple random sampling is employed, while judgment sampling is used to select respondents who have a deep understanding and can contribute to in-depth research Gaol et al., (2018).

All these participants belonged to different departments taking up/teaching professional degrees. The total number of survey responses were given by 90 Academicians from Pune city teaching various technical programs, 152 students of various technical programs, 53 Industry Experts.

The scope of the study covered all universities in the Maharashtra regions of Pune and Pimpri Chinchwad. 295 respondents in total, including students, academics, and experts from the industry, responded to the survey.

DATA ANALYSIS

Data analysis was conducted using statistical methods to identify educational factors and attributes.

Table 2
MEASUREMENT SUMMARY OF EDUCATIONAL FACTORS AND ATTRIBUTES

S.No	Constructs	Statements under study	Factor Loadings	Cronbach Alpha	Composite Reliability	AVE

Citation Information: Gadre, M & Deoskar, A. (2024). Navigating the challenges and strategies for higher education institutions in mapping industry 4.0 based education: a pls-sem analysis. *Academy of Strategic Management Journal, 23S*(4), 1-10.

1	Quality of Teaching Staff	Competency Project guidance Practical knowledge lndustrv proiects	0.861 0.744 0.851 0.808	0.838	0.889	0.668
2	Teaching Pedagogy	Project based Practical tasks Self-study modules Case Based MCQ Presentation Group Activities Model design	0.681 0.792 0.689 0.796 0.648 0.802 0.654 0.777	0.878	0.902	0.537
3	Quality of Curriculum	Subjects taught Course content Coverage Continuous update Learning outcome	0.682 0.804 0.808 0.829 0.742	0.836	0.882	0.6
4	Industry 4.0 Knowledge	Internet of Things Cyber Security Big Data & Analytics Simulation Horizontal & Vertical Integration 3D Printing Cloud Computing Augmented Reality/ Virtual Reality Artificial Intelligence Robotics	0.915 0.872 0.885 0.887 0.871 0.763 0.822 0.813 0.785 0.721	0.951	0.958	0.698

The Table 2 above summarises the extracted measurements for factor loadings, Cronbach Alpha, Composite Reliability, and Average Variance Extracted. In terms of Cronbach Alpha, the elements' total value exceeds 0.60, which above the permissible level,

Citation Information: Gadre, M & Deoskar, A. (2024). Navigating the challenges and strategies for higher education institutions in mapping industry 4.0 based education: a pls-sem analysis. *Academy of Strategic Management Journal, 23S*(4), 1-10.

showing excellent internal consistency within the constructs. Composite Reliability shows an overall value of over 0.70 for the entire construct, ensuring internal consistency. The statement value for factor loadings surpasses 0.60, which is deemed satisfactory. Additionally, the total value of constructs is above 0.50 when calculating Average Variance Extracted which indicates Convergent Validity exists. (The extent to which the construct converges to explain the variance of its items).

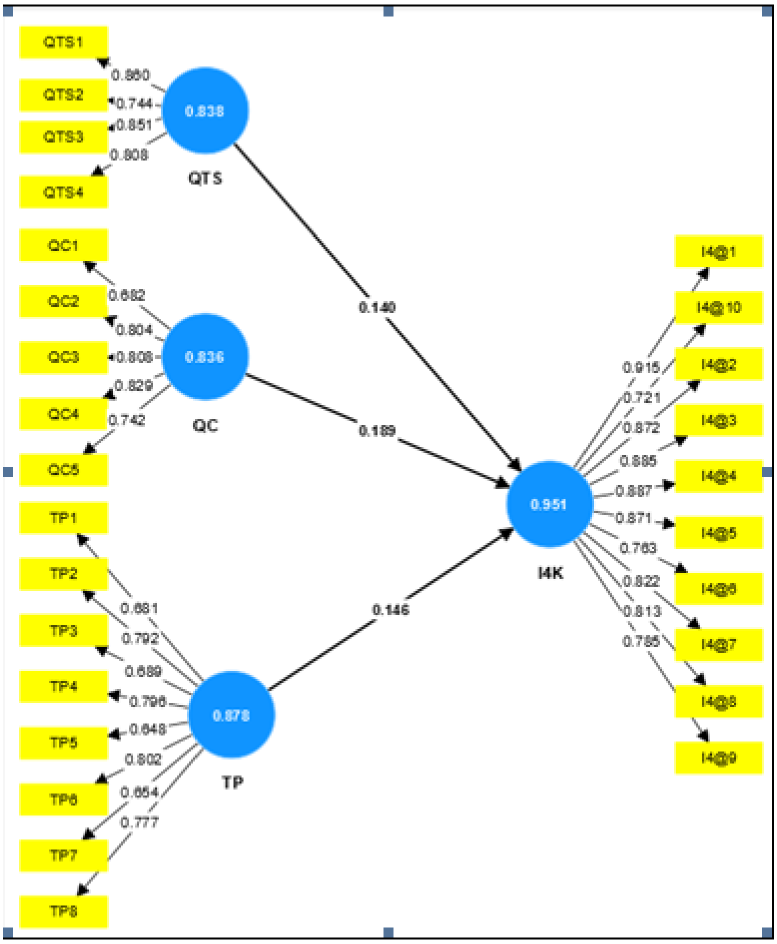

FIGURE 1
STRUCTURAL EQUATION MODELING

Table 3 SUMMARY OF HYPOTHESIS RESULTS			
S.No	**Association of constructs under study**	**p value**	**Result**
H_{a1}	Quality of Teaching Staff →Industry 4.0 Knowledge	0.002	Supported
H_{a2}	Teaching Pedagogy →Industry 4.0 Knowledge	0.004	Supported
H_{a3}	Curriculum Updation → Industry 4.0 practices and knowledge	0.001	Supported

The Table 3above summarizes that the structural equation modelling fits and is accepted in all cases of correlation Table 4.

Table 4

EQUATION MODELLING		
S. No	**Particulars**	**Remarks**
1	Curriculum Integration of Industry 4.0 Technologies	Universities are taking steps to incorporate Industry 4.0 technology into their curricula. IoT, AI, robotics, and data analytics courses are confirmed by about 66.4% of students, showing a pro-active response to Industry 4.0 demands.
2	Curriculum Development & Adaptation	34% of institutions regularly update curriculum to match the rapidly changing technology landscape indicating adapting to Industry 4.0 demands.
3	Industry academia Collaboration for Faculty Development and Training	The survey highlighted the importance of faculty development for successful Industry 4.0 teaching. According to 83.8% of respondents, ongoing training and workshops significantly enhanced their ability to teach Industry 4.0 subjects.
4	Challenges and Barriers to Student Engagement	Data showed a rising trend in partnerships between higher education and industry, fostering a dynamic learning environment that transformed academic knowledge into practical skills through experiential learning.
5	Evaluation and Assessment	When given the opportunity to work on practical projects utilizing Industry 4.0 technologies, 35.8% of students said their knowledge had improved.
6	Best Practises and Global Perspectives	Concerns raised by 78.2% of surveyed institutions included a lack of updated infrastructure and limited access to cutting-edge technologies.
7	Curriculum Integration of Industry 4.0 Technologies	To assess students' comprehension and application of concepts, 32.1% of institutions reported using a combination of traditional exams and project-based evaluations.
8	Curriculum Development and Adaptation	58.7% of respondents reported engagement with foreign universities, provide essential lessons for developing effective Industry 4.0 curricula and pedagogical techniques.

FINDINGS

This section summarizes the important findings of the study, with an emphasis on the analysis and interpretation of the data collected with respect to the research objectives and questions.

The findings of this study emphasize the continued efforts of higher education institutions to deal with the challenges of Industry 4.0-based education. Integration of cutting-edge technology, adjustments to the curriculum, enhancement of faculty skills, and the establishment of strategic partnerships emerge as critical strategies in equipping students to meet the evolving demands of the workforce.

CONCLUSION

In conclusion, the research paper delves into the intricate landscape of higher education institutions as they navigate the challenges and develop strategies to effectively incorporate industry 4.0 principles into their educational paradigms. The revolutionary potential of Industry 4.0 is obvious, offering students unmatched opportunities to gain the skills and knowledge necessary to excel in the rapidly advancing technological landscape.

throughout the study, we examined multifaceted obstacles that higher education institutions face, including the need to match curriculum with industry 4.0 expectations, faculty development, technical infrastructure enhancement, and promoting industry-academic collaboration. these difficulties highlight the transition's complexity while also emphasizing the urgency and need of accepting change. To map Industry 4.0-based teaching successfully,

Citation Information: Gadre, M & Deoskar, A. (2024). Navigating the challenges and strategies for higher education institutions in mapping industry 4.0 based education: a pls-sem analysis. *Academy of Strategic Management Journal, 23S*(4), 1-10.

educational institutions must take a comprehensive approach that includes curriculum change, pedagogical innovation, and the creation of a dynamic learning environment. In addition, cultivating a culture of continuous learning, adaptability, and multidisciplinary cooperation will aid in developing students to be agile problem solvers and lifelong learners.

The report outlines strategies such as multidisciplinary collaboration, experiential learning, and utilizing emerging technologies such as artificial intelligence as powerful instruments for bridging the gap between traditional educational models and the demands of Industry 4.0. Institutions must also connect with industries proactively, developing partnerships that promote information exchange, research cooperation, and internship opportunities, ensuring that education is aligned with real-world industrial practices.

In essence, successfully integrating Industry 4.0 principles into higher education involves a paradigm shift that will necessitate collaborative efforts from educators, administrators, students, and industries alike. Institutions may effectively equip their students with the skills, competencies, and attitudes required to thrive in the dynamic landscape of the fourth industrial revolution by embracing innovation, adjusting curricula, and embracing a growth mindset.

It is apparent that the road to map Industry 4.0 based education is still ongoing. The terrain will continue to change, bringing with it new problems and possibilities. Higher education institutions must stay adaptable, open to change, and dedicated to the concepts of innovation, collaboration, and quality. Only in this way will they be able to ensure that their graduates are well-prepared to drive technical innovations, lead industries, and meaningfully contribute to setting the trajectory of the fourth industrial revolution and beyond.

While this study is interesting, it does have certain limitations. In this study, for example, a random and judgement sampling strategy was used to get the responses from stakeholders. Given that the research was limited to the Pune and Pimpri Chinchwad Region, the scope of the findings is constrained. As a result, future research must take a cross-cultural approach when exploring the challenges and opportunities associated with the impact of Industry 4.0 adoption in Higher Education Institutions (HEIs).

REFERENCES

Amballoor, R. G., & Naik, S. B. (2020, December). Ecosystem Preparedness & Learning 4.0: A Case Study of Higher Education Scenario in Goa. In *2020 9th International Conference System Modeling and Advancement in Research Trends (SMART)* (pp. 442-447). IEEE.

Balasubramani, R. (2019). Participation of Industry in Curriculum Design and Development. *Journal of Engineering Education Transformations*, *33*(1).”

Dorleon, G., & Gervais, S. (2017). Industry 4.0-What we need to know. *International Francophone Institute for Computer Science*.

Fahim, A., Addae, B. A., Ofosu-Adarkwa, J., Qingmei, T., & Bhatti, U. A. (2021). Industry 4.0 and higher education: an evaluation of barriers affecting master’s in business administration enrolments using a grey incidence analysis. *IEEE Access*, *9*, 76991-77008.

Gaol, F. L., Napitupulu, T. A., Soeparno, H., & Trisetyarso, A. (2018, September). Learning framework in the industrial age 4.0 in higher education. In *2018 Indonesian Association for Pattern Recognition International Conference (INAPR)* (pp. 227-232). IEEE.

Gwata, M. (2019). To flourish in the Fourth Industrial Revolution, we need to rethink these 3 things. In *World Economic Forum* (No. 05, p. 08).

M. Hernandez-de-Menendez, R. Morales-Menendez, C. A. Escobar, and M. McGovern, “Competencies for Industry 4.0,” *Int. J. Interact. Des. Manuf.*, vol. 14, no. 4, pp. 1511–1524, 2020.

Mian, S. H., Salah, B., Ameen, W., Moiduddin, K., & Alkhalefah, H. (2020). Adapting universities for sustainability education in industry 4.0: Channel of challenges and opportunities. *Sustainability*, *12*(15), 6100.

Oztemel, E., & Gursev, S. (2020). Literature review of Industry 4.0 and related technologies. *Journal of intelligent manufacturing*, *31*(1), 127-182.

Xing, B., & Marwala, T. (2017). Implications of the fourth industrial age on higher education. *arXiv preprint arXiv:1703.09643*.

Received: 02-Apr-2024, Manuscript No. ASMJ-23-14506; **Editor assigned:** 04-Apr-2024, PreQC No. ASMJ-23-14506(PQ); **Reviewed:** 17-Apr-2024, QC No. ASMJ-23-14506; **Revised:** 22-Apr-2024, Manuscript No. ASMJ-23-14506(R); **Published:** 28-Apr-2024

Citation Information: Gadre, M & Deoskar, A. (2024). Navigating the challenges and strategies for higher education institutions in mapping industry 4.0 based education: a pls-sem analysis. *Academy of Strategic Management Journal, 23S*(4), 1-10.