

**This is a self-archived version of an original article. This version may differ from the original in pagination and typographic details.**

**Author(s):** Braun, Greta; Rikala, Pauliina; Järvinen, Miitta; Hämäläinen, Raija; Stahre, Johan

**Title:** Bridging Skill Gaps : A Systematic Literature Review of Strategies for Industry

**Year:** 2024

**Version:** Published version

**Copyright:** © 2024 The Authors

**Rights:** CC BY-NC 4.0

**Rights url:** <https://creativecommons.org/licenses/by-nc/4.0/>

**Please cite the original version:**

Braun, G., Rikala, P., Järvinen, M., Hämäläinen, R., & Stahre, J. (2024). Bridging Skill Gaps : A Systematic Literature Review of Strategies for Industry. In J. Andersson, S. Joshi, L. Malmsköld, & F. Hanning (Eds.), Sustainable Production through Advanced Manufacturing, Intelligent Automation and Work Integrated Learning : Proceedings of the 11th Swedish Production Symposium (SPS2024) (52, pp. 687-696). IOS Press. Advances in Transdisciplinary Engineering. <https://doi.org/10.3233/ATDE240209>

# Bridging Skill Gaps - A Systematic Literature Review of Strategies for Industry

Greta BRAUN<sup>a,1</sup>, Pauliina RIKALA<sup>b</sup>, Miitta JÄRVINEN<sup>b</sup>, Raija HÄMÄLÄINEN<sup>b</sup>,  
and Johan STAHRÉ<sup>a</sup>,

<sup>a</sup>*Chalmers University of Technology, Sweden*

<sup>b</sup>*University of Jyväskylä, Finland*

ORCID ID: Greta Braun <https://orcid.org/0000-0002-5654-7000>

**Abstract.** Industries are facing extensive needs for both digital and green transitions. Adding to the challenges, environmental crises, a recent pandemic, and military conflicts are forming a “perfect storm”. Consequently, companies need to rapidly adapt to new requirements and create resilient, sustainable, and human-centric solutions, a combination often called industry 5.0. A highly skilled workforce is required, where “right-skilled” employees will drive successful technology adoption and business transformation. Unfortunately, many companies face skill gaps, causing a slowdown in productivity and sustainable development. Fully bridging the skills gaps is not achievable only through recruiting of young talent. Ongoing demographic changes are causing a decrease in the working population, making hiring harder and increasing industry competition for existing talent. Upskilling existing workforces is a natural solution to bridge the skill gaps. This paper presents the results from a systematic literature review conducted in January 2023 using the PRISMA method. The study included 40 articles and thematically analyzed solutions for bridging skill gaps. Identified solutions address employers, employees, education providers, students, job seekers, researchers, and policymakers. Results highlighted that collaboration between stakeholders potentially helps bridge skill gaps in industry. Employees requiring upskilling need to understand what skills are relevant, and how they can absorb state-of-the-art knowledge and learn new skills. Employers should support their employees, supply relevant resources, and define clear skill requirements. Education providers on the other hand, must adapt to changing industrial business needs and gradually adapt traditional curricula, in parallel with regular education. Academia and industry collaboration is vital. Thus, flexible and rapid training and re-training solutions and approaches are needed, not just on-off activities. The main contribution of this paper is to review actions that employers, employees, education providers, researchers, students, job seekers, and policymakers need to take to bridge skill gaps. This analysis can be used by industrial practitioners, policymakers, and education providers to work with strategies to bridge skill gaps in their business and in their work. The theoretical implication of this work is the acknowledgement of the existing skill gap and the synthesis of actions for stakeholders. The article can be used to set future research directions to get closer insights into the derived challenges and success factors when bridging skill gaps.

**Keywords.** Skill Gap, Industry, Upskilling, Stakeholder collaboration, Workforce.

---

<sup>1</sup> Corresponding Author: Greta Braun, [greta.braun@chalmers.se](mailto:greta.braun@chalmers.se).

## 1. Introduction

In the realm of industry, the advancements of new technologies are key to driving innovation for resilient, human-centric, and sustainable solutions. However, the changing business environment leads to an imbalance between the skills that employers expect and the skills their employees possess. Hence, this imbalance is widely discussed as the skill gap [1-3] leading to a slowdown in the adoption of new technologies and targets [4], hinders the adoption of circular economy [5], and sets back the creation of resilient value chains [6]. In addition, demographic changes lead to a decrease in the working population, and industries are competing for the rare young people [7].

Bridging skill gaps is high on the agenda of governmental policies. The European Commission [8] is making skills a key point on the innovation agenda and has incentivized projects to bridge the skill gap. In addition, the European Commission coined the new industrial paradigm – Industry 5.0, in which it is highlighted that the development of skills among industry employees should be prioritized [9]. Within this framework of Industry 5.0, the goal is to create a resilient, sustainable, and human-centric industry [10]. The initiative SkillsFuture by the government in Singapore promotes lifelong learning of their citizens, by developing a learning-supporting culture, guiding individuals in their career and training choices, and having an education system that meets workplaces' requirements [11]. The project Ingenjör4.0 in Sweden offers an online upskilling programme to empower engineers with the right skills to drive the digital and sustainable transformation [12].

However, there are many challenges for the stakeholders involved in bridging skill gaps. This paper aims to give an answer to: How can skill gaps be bridged from different stakeholders' perspectives? Therefore, a systematic literature review is conducted to explore the suggested activities to bridge skill gaps and suggest them to stakeholders.

## 2. Theoretical Background

Skill gaps are not a new problem for the industry. In big industrial changes, i.e. the industrial revolutions, new general-purpose technologies were introduced, changing the work of people in the industry and raising questions about the role of humans and the value they bring [13]. The value of accompanying intangibles, such as having the right-skilled workers, in alignment with the introduction of new technologies, needs to be discussed in order to successfully transform the industry [4, 14]. The urgency of bridging skill gaps is visible in the policies brought forward by European and other governments [15, 16].

### 2.1. Skills

The term “skill” has been used to the “ability to apply knowledge and use know-how to complete tasks and solve problems”. The skills required in the industry are diverse, dynamic, and far-reaching skills. Earlier research, for instance, has highlighted skill categories such as hard technical and soft interpersonal skills as relevant and critical [17]. Connected terms are “upskilling” and “reskilling”, used to describe the process of learning new skills with the goal of remaining competitive in a job role or being able to move to another role [9].

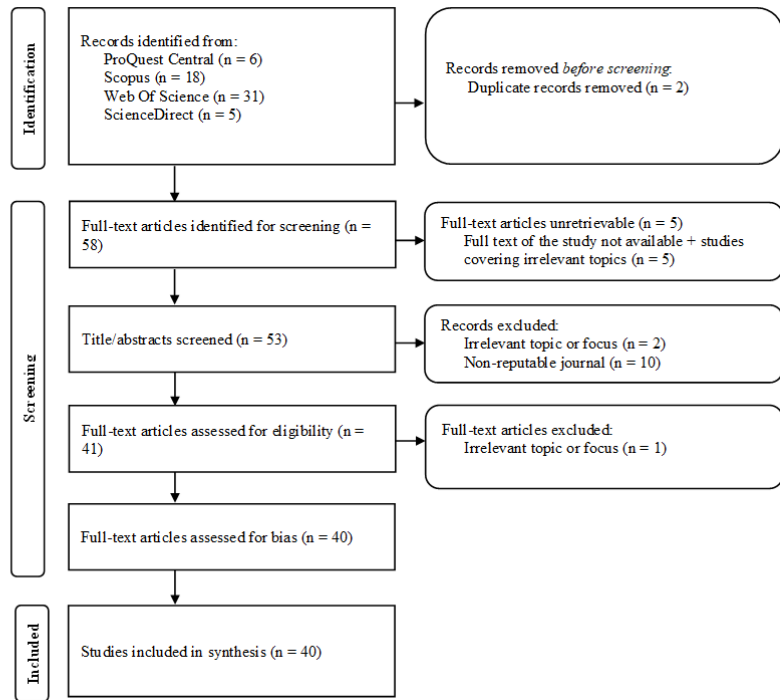
## 2.2. Skill gaps

Skill gaps in the industry emerge when the working environment is changing, e.g. because of technological change [3, 18]. In addition, the sustainable transition of industry leads to an increased need for green skills [19]. Moreover, the demographics are changing, leading to a decrease in people in the working-age [20]. Therefore, companies often lack people with the skills to drive the change they expect [21]. The term “skill gap” has been used in different ways and in combination with the terms “skill shortage”, “skill mismatch”, and “skill surplus [1, 3]. Mainly, the term “skill gap” describes the situation where skills are not supplied satisfyingly by the existing employees [1], hence describes the challenge of not having the right skills with the right people at the right time [3]. Related discussions are about recruiting people with the right skills, often referred to as “skill shortage” [2]. Involved in the description of skill gaps are three main stakeholders – employers, employees, and education provider [3]

Companies and their human resources departments face major challenges and need to implement new strategies to attract, retain, and develop the talents they need [22]. Some mismatch between the supply and demand for skills is typical, especially in the short period. However, persistent skill imbalances, thus gaps, can be very costly for individuals, employers, and society [4]. Skill gaps can lead to e.g., lower job satisfaction, lower productivity, lower innovation and adoption of new technologies [23].

## 3. Method

This study has been undertaken as a literature review of full-text articles published in 2012—2022. In this case, the goal of the review was to find out how skill gaps can be bridged. We chose a literature review because literature reviews can critically evaluate data while bringing out positive and valuable results [24]. We followed the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines [25]. Since we included qualitative, quantitative, and mixed-methods studies in the review, we adapted a hybrid approach, i.e., our literature review draws on characteristics of both the narrative and systematic review traditions [26]. A systematic review requires the application of data analysis processes, such as meta-analysis of quantitative data [27]. A systematic-narrative hybrid literature review enabled us to use qualitative methods. Thus, we analyzed the data qualitatively using thematic analysis. We chose thematic analysis because it is a flexible and relatively quick way to highlight similarities and differences between texts and to summarize the key features of the material. Thematic analysis method is an iterative process consisting of the following steps: 1) becoming familiar with the data, 2) generating codes, 3) generating themes, 4) reviewing themes, 5) defining and naming themes, and 6) summarizing (i.e., writing up) [28]. Our search protocols and inclusion/exclusion criteria were based on elements of PRISMA practice. In total, 40 articles met our predefined inclusion criteria, and we analyzed them qualitatively using thematic analysis.



**Figure 1** Flow diagram showing the PRISMA review process (adapted from [25]).

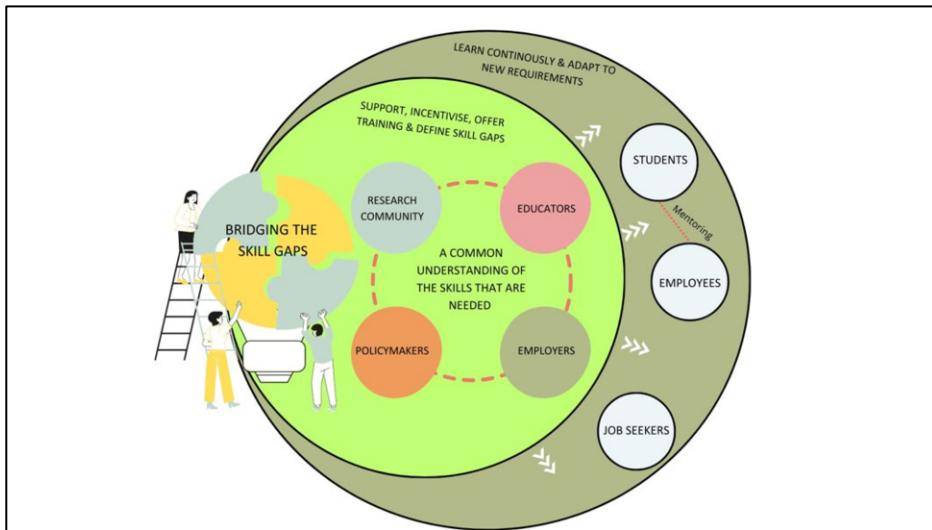
#### 4. Results

This chapter presents the results for the question: How can skill gaps be bridged? The results stem from thematically analyzing the extracted data from 40 articles included in the systematic literature review.

From a holistic perspective, half of the included studies highlight the importance of including different stakeholders and improving partnerships and collaboration between the different stakeholders when tackling skill gaps [29-49]. According to those articles, the stakeholders involved are **employers, employees, students, education, job seekers, policymakers, and researchers**. According to [33], the collaboration between employers and education leads to a common understanding of the skills that are needed in industry, and in that way, training curricula can be aligned. **Figure 2** visualizes the stakeholders and the communication and collaboration between them.

[50] highlights the role of researchers in supporting education providers to improve education curricula, and researchers' role in helping employers to define their skill needs. This, in turn will help education providers to update and improve their training offers according to industry needs [50].

Education providers, employers, and policymakers collaborate to develop a skill strategy [33]. Policymakers incentivize education provider to offer affordable, accessible, and profitable education [51].



**Figure 2** Involved stakeholders and activities in bridging skill gaps in industry.

In the following, the actions needed by different stakeholders to bridge skill gaps according to the included articles are presented.

Many articles suggest activities for **employers** to bridge the skill gaps in their companies. Firstly, the importance of defining clearly current and future skill needs is highlighted [33, 34], and implementing those needs in the company's knowledge management [34]. Further, [50, 52] highlight the importance for employers to do continuous skill gap analysis and work on a workforce development strategy [33, 38]. Moreover, [53] emphasizes the requirement for employers to build and work on a training culture to eliminate any discrimination and ensure social inclusion [29]. Further, it is mentioned by [29, 31-33, 35, 50, 51, 53, 54] that employers have a responsibility to support the training, upskilling, and reskilling of their workforce, and integrate work-based learning [41] to bridge the skill gap. [44] highlights several actions for employers to bridge the skill gap: training the existing workforce but also increasing the pipeline for recruiting people from different industries and other countries. [47] points out these two actions as well, and in addition, suggests increasing workers' wages. Also, employers should offer internships [45], drive mentorship programmes between their employees and university students [42], and provide apprenticeship programmes for students [41]. Lastly, [55, 56] ask employers to require learning that is tailored to their employees' needs and to the workplace, use talent-matching platforms [29], and seek a gap-driven learning approach [31], to be able to bridge the skill gap.

However, the authors in the included studies require action from **employees, job seekers, and students** to bridge the skill gap. [45] points out the importance of students being aware of the changes happening in industry and self-assessing their gaps to plan their learning. Further, [51] highlights the importance of the employees' ability to and interest in change and acknowledges that nowadays, employees will endeavour on a lifelong learning journey. Even if employers, education providers, and other stakeholders can support the learning, in the end, it's the individuals themselves who learn. Hence, one clear action for employees is to upskill themselves [31, 33]. In addition, [42] suggests

mentoring programmes to support students in entering industry and developing their skills.

According to the included articles, another important stakeholder group is the **education providers**. For them too, the authors in the included articles point out actions to address bridging skill gaps in industry. [43, 45, 46] demand collaboration with employers from education providers, to develop their curricula in alignment with what industry needs. As mentioned by [57], education providers have a responsibility to ensure a high-quality education delivery, implementing new, innovative learning methods such as gamification [38]. In addition, education providers can offer personalized learning according to learners' skill gaps and approaches to learning [58]. In line with that, many articles emphasize the importance of practice-oriented, hands-on, interactive learning experiences, such as learning factories, work-integrated learning programmes, and work-based learning [40, 42, 55, 56, 59, 60] by e.g., apprenticeships, hands-on workshops on trending topics becoming more important in the company and participation in online training [29]. However, [46] points out that education shouldn't be too narrowly tailored to prepare for certain job workplaces or jobs since it makes the use of this particular education quite inflexible. They further explain that it's beneficial to have a holistic understanding of the area where the learners will work later.

In contrast to that, [55] points out that education providers should tailor their teaching and learning methods to the needs of the learner. [55] has suggestions on the design of the learning platform itself, e.g. having communication channels between learners and teachers and discussion forums. Lastly, [42, 43, 53] call attention to the teaching of soft skills, in addition to the technical skills that are taught, to be employable in industry. [53, 59] ask education providers to include green skills in their teaching to support sustainable development.

In some of the included studies, actions for policymakers are recommended. For example, [44] requires **Policymakers** to incentivize employers to support skill development, upskilling, and proactively plan the workforce of the future. In addition, [43] asks policymakers to analyze skill gaps, formulate policies, and propose strategies for the involved stakeholders. Moreover, the importance of discussing strategies for developing children's skills in preparation for what is needed in industry is highlighted by [51] and attracting new people to industry is mentioned by [54]. Lastly, [51] points out the responsibility of policymakers to make sure that everyone has access to education and that it's affordable. [32, 35] further bring in databases and trend radars as a possibility to foresee future skill needs and be proactive in policymakers' development strategies.

Lastly, some articles included in the study point out the role of **researchers** to bridge the skill gap. According to [55], researchers could help align industry's needs with the training that is offered by education. [34] suggests researchers to develop skill frameworks with the skills related to new jobs. Further, researchers could do workshops with organizations to understand the employers' needs, understand the skill gap, and work on skill development strategies [43]. In addition, creating skill typologies to understand regional needs is highlighted by [61]. Also, [62] suggest that researchers could create a framework to guide learners in finding the right training. Finally, [63] propose that researchers should gather best practices and present them to practitioners.

## 5. Discussion

The results from this study stem from systematically reviewing literature about bridging skill gaps in industry, and then thematically analyzing the extracted data from the included articles. The thematic analysis illustrates that many actions need to be taken to bridge skill gaps. The included articles propose actions for different stakeholders, whereof one is highlighted most often: collaboration between stakeholders. However, there is no clear roadmap on how to bridge skill gaps, and the descriptions of the actions in the included articles fall short, making it hard to understand how these activities successfully can be implemented. However, the collection of these actions could be the start to evaluate the impact of those actions and to investigate how to pursue the activities. Therefore, this study contributes to a synthesis of proposed actions. These are addressed towards employees, employers, education, policymakers, job seekers, students, and researchers.

As highlighted at the beginning of this paper, this is an important study that gives insights into a relevant topic. Skill gaps need to be bridged in order to achieve sustainability goals [5] and adopt new technologies [4]. The results can be used to understand what actions are being done, but also what actions are needed, as the included articles propose.

The authors are aware of the possibility of biased decisions in conducting this study. To prevent bias from taking over, three researchers independently selected and analyzed the data. Then, two of the researchers thematically analyzed the data and compared their results, to finally come to a common understanding of the results.

There are potential limitations to this study. The proposed actions for stakeholders to bridge skill gaps haven't been validated and are solely recommendations based on the experience and research of the authors of the included studies. What we have collected is their estimation, based on their research, about skill gaps and what they suggest doing to tackle skill gaps.

In the future, the actions of the involved stakeholders should be validated. Further, research is needed to promote best practices in bridging skill gaps. There is a need to understand what impacts those actions have and how they should be carried out to have a successful outcome.

## 6. Conclusion

The growing demand for employees who elevate sustainable and resilient industrial solutions has generated a need for new skills at a rapid pace. Hence, there is a skill gap among employees that hinders them from flourishing towards the expected goals. In addition, the demographic change leads to a decline in people entering industry. Therefore, there is a need to implement strategic actions to bridge this skill gap. This study contributes with a synthesis of actions for the proposed stakeholders: employers, education, employees, policymakers, and researchers. By carrying out a literature review, data from 40 articles was collected and thematically analyzed to present and organize the actions that the research community proposes to bridge skill gaps.

One dominant action crystallized: collaborating and creating partnerships among these stakeholders. In particular, employers should collaborate with education, researchers, and policymakers. In addition to collaborating with other stakeholders, there are actions proposed to each stakeholder. Among others, employers should work on a



skill strategy, support the upskilling of their workforce, and define clear requirements of their skill needs towards education providers. Education providers should deliver highly relevant training by understanding industry needs and implementing innovative learning methods. Employees, students, and job seekers should keep themselves updated with the changes impacting their work or future work, and take initiative in learning new skills, as lifelong learning becomes the new normal. Policymakers can find the right incentives for the stakeholders to take action, foresee skill needs, and motivate children and other groups to join industry. Lastly, the research community should support the collaboration of stakeholders, create skill frameworks for changing jobs, and carry out workshops with employers and employees to understand skill gaps.

### Acknowledgments

The authors gratefully acknowledge the support of Chalmers' Area of Advance Production.

### References

- [1] McGuinness S, Pouliakas K, Redmond P. SKILLS MISMATCH: CONCEPTS, MEASUREMENT AND POLICY APPROACHES. *Journal of Economic Surveys*. 2018;32(4):985-1015. doi: <https://doi.org/10.1111/joes.12254>.
- [2] Quintini G. Right for the Job: Over-Qualified or Under-Skilled? OECD Publishing, Paris: 2011.
- [3] Rikala P, Braun G, Järvinen M, Stahre J, Hämäläinen R. Understanding and measuring skill gaps in Industry 4.0 — A review. *Technological Forecasting and Social Change*. 2024;201:123206. doi: <https://doi.org/10.1016/j.techfore.2024.123206>.
- [4] Bokrantz J, Skoogh A, Berlin C, Wuest T, Stahre J. Smart Maintenance: an empirically grounded conceptualization. *International Journal of Production Economics*. 2020;223:107534. doi: <https://doi.org/10.1016/j.ijpe.2019.107534>.
- [5] Jaeger B, Upadhyay A. Understanding barriers to circular economy: cases from the manufacturing industry. *Journal of Enterprise Information Management*. 2020;33(4):729-45. doi: 10.1108/JEIM-02-2019-0047.
- [6] Chari A, Niedenzu D, Despeisse M, Machado CG, Azevedo JD, Boavida-Dias R, et al. Dynamic capabilities for circular manufacturing supply chains—Exploring the role of Industry 4.0 and resilience. *Business Strategy and the Environment*. 2022;31(5):2500-17. doi: <https://doi.org/10.1002/bse.3040>.
- [7] European Commission S-G. European Commission Report on the Impact of Demographic Change. eurostat: 2020.
- [8] European Commission. A new European innovation agenda. In: Innovation D-GfR, editor.: Publications Office of the European Union; 2022.
- [9] Breque M, de Nul L, Petridis A. Industry 5.0 - Towards a sustainable, human-centric and resilient European industry. Policy brief European Commission. 2021.
- [10] Leng J, Sha W, Wang B, Zheng P, Zhuang C, Liu Q, et al. Industry 5.0: Prospect and retrospect. *Journal of Manufacturing Systems*. 2022;65:279-95. doi: <https://doi.org/10.1016/j.jmsy.2022.09.017>.
- [11] Tan C. Lifelong learning through the SkillsFuture movement in Singapore: challenges and prospects. *International Journal of Lifelong Education*. 2017;36(3):278-91. doi: 10.1080/02601370.2016.1241833.
- [12] Braun G, Stahre J, Rosén B-G, Bokinge M. Ingenjör4.0 – A National Upskilling Programme to Bridge Industry's Skill Gap. *Procedia CIRP*. 2023;120:1286-91. doi: <https://doi.org/10.1016/j.procir.2023.09.164>.
- [13] Autor DH. Why Are There Still So Many Jobs? The History and Future of Workplace Automation. *Journal of Economic Perspectives*. 2015;29(3):3-30. doi: 10.1257/jep.29.3.3.
- [14] Brynjolfsson E. The Productivity Paradox of Information Technology. *Commun ACM*. 1993;36:66-77. doi: 10.1145/163298.163309.
- [15] European Commission. The future of work. What this policy is, strategy, funded projects, latest news. 2023 [cited 2023 20 june]. Available from: [https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/future-work\\_en](https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/future-work_en).

- [16] Government of Singapore. SkillsFuture Singapore 2023 [cited 2023 19]. june]. Available from: <https://www.skillsfuture.gov.sg/>.
- [17] Ferreira C, Robertson J, Pitt L. Business (un)usual: Critical skills for the next normal. *Thunderbird International Business Review*. 2023;65(1):39-47. doi: <https://doi.org/10.1002/tie.22276>.
- [18] Patacil F, Tablatin C. Exploring the importance of soft and hard skills as perceived by IT internship students and industry: A gap analysis. *Journal of Technology and Science Education*. 2017;7:347. doi: 10.3926/jotse.271.
- [19] World Economic Forum. Future of Jobs Report. 2023.
- [20] Haskel J, Martin C. Do Skill Shortages Reduce Productivity? Theory and Evidence from the United Kingdom. *The Economic Journal*. 1993;103(417):386-94. doi: 10.2307/2234777.
- [21] World Economic Forum. Future of Jobs Report. World Economic Forum. 2020.
- [22] Deloitte. Global Human Capital Trends  
The new organization: Different by design. 2016.
- [23] Marcolin L, Quintini G. Measuring skill gaps in firms: the PIAAC Employer Module. 2023. doi: <https://doi.org/10.1787/903c19c9-en>.
- [24] Knopf JW. Doing a Literature Review. PS: Political Science & Politics. 2006;39(1):127-32. Epub 2006/02/13. doi: 10.1017/S1049096506060264.
- [25] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. doi: 10.1136/bmj.n71.
- [26] Turnbull D, Chugh R, Luck J. Systematic-narrative hybrid literature review: A strategy for integrating a concise methodology into a manuscript. *Social Sciences & Humanities Open*. 2023;7(1):100381. doi: <https://doi.org/10.1016/j.ssaho.2022.100381>.
- [27] Magarey JM. Elements of a systematic review. *International Journal of Nursing Practice*. 2001;7(6):376-82. doi: <https://doi.org/10.1046/j.1440-172X.2001.00295.x>.
- [28] Braun V, Clarke V. Using thematic analysis in psychology. *Qualitative Research in Psychology*. 2006;3:2:77-101. doi: 10.1191/1478088706qp063oa.
- [29] Cukier W. Disruptive processes and skills mismatches in the new economy. *Journal of Global Responsibility*. 2019;10:211-25.
- [30] Qiu M, Xu Y, Omojokun EO. TO CLOSE THE SKILLS GAP, TECHNOLOGY AND HIGHER-ORDER THINKING SKILLS MUST GO HAND IN HAND. *Journal of International Technology and Information Management*. 2020.
- [31] Li G, Yuan C, Kamarthi S, Moghaddam M, Jin X. Data science skills and domain knowledge requirements in the manufacturing industry: A gap analysis. *Journal of Manufacturing Systems*. 2021;60:692-706. doi: <https://doi.org/10.1016/j.jmsy.2021.07.007>.
- [32] Akyazi T, Goti A, Oyarbide-Zubillaga A, Alberdi E, Carballado R, Ibeas R, et al. Skills Requirements for the European Machine Tool Sector Emerging from Its Digitalization. *Metals*. 2020;10(12):1665. PubMed PMID: doi:10.3390/met10121665.
- [33] Akyazi T, Goti A, Oyarbide A, Alberdi E, Bayon F. A Guide for the Food Industry to Meet the Future Skills Requirements Emerging with Industry 4.0. *Foods*. 2020;9(4):492. PubMed PMID: doi:10.3390/foods9040492.
- [34] Anshari M, Hamdan M. Understanding knowledge management and upskilling in Fourth Industrial Revolution: transformational shift and SECI model. *VINE Journal of Information and Knowledge Management Systems*. 2022;2022. doi: 10.1108/VJIKMS-09-2021-0203.
- [35] Arcelay I, Goti A, Oyarbide-Zubillaga A, Akyazi T, Alberdi E, Bringas P. Definition of the Future Skills Needs of Job Profiles in the Renewable Energy Sector. *Energies*. 2021;14:2609. doi: 10.3390/en14092609.
- [36] Husin MH, Ibrahim NF, Abdullah NA, Syed-Mohamad SM, Samsudin NH, Tan L. The Impact of Industrial Revolution 4.0 and the Future of the Workforce: A Study on Malaysian IT Professionals. *Social Science Computer Review*. 2023;41(5):1671-90. doi: 10.1177/08944393221117268.
- [37] Romero Gázquez J, Delgado M, Ortega Gras JJ, Garrido-Lova J, Gomez Gomez MV, Zbiec M. Lack of skills, knowledge and competences in Higher Education about Industry 4.0 in the manufacturing sector. *RIED Revista Iberoamericana de Educación a Distancia*. 2021. doi: 10.5944/ried.24.1.27548.
- [38] Romero-Gázquez JL, Cañavate-Cruzado G, Bueno-Delgado MV. IN4WOOD: A Successful European Training Action of Industry 4.0 for Academia and Business. *IEEE Transactions on Education*. 2022;65(2):200-9. doi: 10.1109/TE.2021.3111696.
- [39] Abbasi F, Chaudhry A, Bibi N. Analysis of skill gap for business graduates: managerial perspective from banking industry. *Education + Training*. 2018;60. doi: 10.1108/ET-08-2017-0120.
- [40] Akdur D. Skills Gaps in the Industry: Opinions of Embedded Software Practitioners. *ACM Transactions on Embedded Computing Systems*. 2021;20:1-39. doi: 10.1145/3463340.

- [41] Arthur-Mensah N. Bridging the industry–education skills gap for human resource development. *Industrial and Commercial Training*. 2020;52(2):93-103. doi: 10.1108/ICT-11-2019-0105.
- [42] Ayodele T, Adegoke O, Kajimo-Shakantu K, Olaoye O. Factors influencing real estate graduates soft skill gap in Nigeria. *Property Management*. 2021;ahead-of-print. doi: 10.1108/PM-08-2020-0051.
- [43] Ayodele T, Oladokun T, Kajimo-Shakantu K. Employability skills of real estate graduates in Nigeria: a skill gap analysis. *Journal of Facilities Management*. 2020;ahead-of-print. doi: 10.1108/JFM-04-2020-0027.
- [44] Chang-Richards A, Wilkinson S, Seville E, Brunsdon D. Effects of a major disaster on skills shortages in the construction industry: Lessons learned from New Zealand. *Engineering, Construction and Architectural Management*. 2017;24:2-20. doi: 10.1108/ECAM-03-2014-0044.
- [45] Do H-D, Tsai K-T, Wen J-M, Huang SK. Hard Skill Gap between University Education and the Robotic Industry. *Journal of Computer Information Systems*. 2023;63(1):24-36. doi: 10.1080/08874417.2021.2023336.
- [46] Moore T, Morton J. The myth of job readiness? Written communication, employability, and the ‘skills gap’ in higher education. *Studies in Higher Education*. 2017;42(3):591-609. doi: 10.1080/03075079.2015.1067602.
- [47] Sharma K, Oczkowski E, Hicks J. Skill Shortages in Regional Australia: A Local Perspective from the Riverina. *Economic Analysis and Policy*. 2016;52. doi: 10.1016/j.eap.2016.08.001.
- [48] Richa S, Paul J, Tewari V. The soft skills gap: a bottleneck in the talent supply in emerging economies. *The International Journal of Human Resource Management*. 2021;33:1-32. doi: 10.1080/09585192.2020.1871399.
- [49] Zheng J, Shi Q. An Empirical Study on Cross-Border E-Commerce Talent Cultivation Based on Skill Gap Theory and Big Data Analysis. *Journal of Global Information Management (JGIM)*. 2022;30(7):1-32. doi: 10.4018/JGIM.292522.
- [50] Butt J. A Conceptual Framework to Support Digital Transformation in Manufacturing Using an Integrated Business Process Management Approach. *Designs*. 2020;4(3):17. PubMed PMID: doi:10.3390/designs4030017.
- [51] Novakova L. The impact of technology development on the future of the labour market in the Slovak Republic. *Technology in Society*. 2020;62:101256. doi: <https://doi.org/10.1016/j.techsoc.2020.101256>.
- [52] Adepoju O, Aigbavboa C. Assessing knowledge and skills gap for construction 4.0 in a developing economy. *Journal of Public Affairs*. 2020;21. doi: 10.1002/pa.2264.
- [53] Carlisle S, Zaki K, Ahmed M, Dixey L, McLoughlin E. The Imperative to Address Sustainability Skills Gaps in Tourism in Wales. *Sustainability*. 2021;13(3):1161. PubMed PMID: doi:10.3390/su13031161.
- [54] Ho PHK. Labour and skill shortages in Hong Kong’s construction industry. *Engineering, Construction and Architectural Management*. 2016;23(4):533-50. doi: 10.1108/ECAM-12-2014-0165.
- [55] Moldovan L. State-of-the-art Analysis on the Knowledge and Skills Gaps on the Topic of Industry 4.0 and the Requirements for Work-based Learning. *Procedia Manufacturing*. 2019;32:294-301. doi: <https://doi.org/10.1016/j.promfg.2019.02.217>.
- [56] Maheso N, Mpofu K, Ramatsetse B. A Learning Factory concept for skills enhancement in rail car manufacturing industries. *Procedia Manufacturing*. 2019;31:187-93. doi: <https://doi.org/10.1016/j.promfg.2019.03.030>.
- [57] Babic M, Billey A, Nager M, Wuest T. Status Quo of Smart Manufacturing Curricula offered by ABET accredited Industrial Engineering programs in the US. *Manufacturing Letters*. 2022;33:944-51. doi: 10.1016/j.mfglet.2022.07.115.
- [58] Francalanza E, Borg J, Rauch E, Putnik G, Alves C, Lundgren M, et al. Specifications for a Digital Training Toolbox for Industry 4.0. *FME Transactions*. 2021;49:886-93. doi: 10.5937/fme2104893F.
- [59] Oldford E, Willcott N, Kennie T. Can student managed investment funds (SMIFs) narrow the environmental, social and governance (ESG) skills gap? *Managerial Finance*. 2022;48(1):57-77. doi: 10.1108/MF-07-2021-0317.
- [60] van Romburgh H, van der Merwe N. University versus Practice: A Pilot Study to Identify Skills Shortages That Exist in First-Year Trainee Accountants in South Africa. *Industry and Higher Education*. 2015;29(2):141-9. doi: 10.5367/ihe.2015.0244.
- [61] Morris D, Vanino E, Corradini C. Effect of regional skill gaps and skill shortages on firm productivity. *Environment and Planning A: Economy and Space*. 2020;52(5):933-52. doi: 10.1177/0308518x19889634.
- [62] Oladokun TT, Olaleye A. Bridging skill gap in real estate education in Nigeria. *Pacific Rim Property Research Journal*. 2018;24(1):17-34. doi: 10.1080/14445921.2017.1409153.
- [63] Royle J, Laing A. The digital marketing skills gap: Developing a Digital Marketer Model for the communication industries. *International Journal of Information Management*. 2014;34(2):65-73. doi: <https://doi.org/10.1016/j.ijinfomgt.2013.11.008>.