# Education 4.0: Gaps Research Between School Formation and Technological Development

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José S. da Motta Reis, Ana C. Ferreira Costa, Maximilian Espuny, Weslei J. Batista, Fernanda E. Francisco, Gildarcio S. Gonçalves, Paulo M. Tasinaffo, Luiz A. Vieira Dias, Adilson M. da Cunha, and Otávio J. de Oliveira

**Abstract**

Industry constantly changes following technological developments and innovation, resulting in changes in productivity, the labor market and education. As a result of this new industrial revolution, developed through digitization and robotics, Education 4.0 tends to combine information available in the real and virtual world. The objective of this paper was to identify research gaps, as well as to make groupings through affinity of themes. The adopted method was a literature review, which served as a basis to identify the gaps of the most relevant publications and their variations indexed in the Scopus database. From the identified gaps, it was possible to compose five groups addressing similar characteristics about Education 4.0.

**Keywords**

Education 4.0 · School formation · Technological development · Artificial intelligence

## 55.1 Introduction

Industry has been constantly affected through technological evolution and innovation, which have led to changes in the production process, the labor market and, consequently, the educational system [1]. In this context, comes the concept of Industry 4.0, born from initiatives adopted by the academic, industry and German government, which aims to increase the competitiveness of the manufacturing sector of this country through the convergence between the industrial production system, information and communication [2].

As a result of this new industrial revolution, developed through digitization and robotics [1], Education 4.0 tends to combine information available in the real and virtual world [2]. With regard to education, it is highlighted that this is one of the sectors that has been most quickly impacted [3], in view of its inspiration in Industry 4.0 and the possibility of developing digital technological skills at all levels, including processes, teaching-learning [4]. However, it should be noted that despite this importance, studies on Education 4.0 can be considered incipient. In this context, the questions that will guide this research work arise: how is the academic scientific production related to "Education 4.0"? What would be the research gaps pointed by researchers of this theme? How can they be grouped?

In order to find an answer to these questions, this research aims to identify research gaps related to Education 4.0, as well as to present a possibility of them being grouped. In order to provide a holistic view of content published and indexed in structured databases, SCOPUS will be used as an object of study. It is noteworthy that SCOPUS currently has the largest database of abstracts and citations, providing a panoramic view of world scientific production in the various areas of knowledge [5]. This research is justified considering that there are few indexed works in structured databases, such as SCOPUS and Web of Science, addressing this theme, which indicates the lack of research on the subject and the need for exploration. of the object of study in the international academic scope.

The research is structured, besides this Introduction, in four more sections. In the second section, will be presented and discussed the subjects Industry and Education 4.0, which were used in the theoretical basis of this study. In the third

J. S. da Motta Reis (✉) · A. C. Ferreira Costa · M. Espuny
W. J. Batista · F. E. Francisco · O. J. de Oliveira
Production Department, São Paulo State University - UNESP, Guaratinguetá, Brazil
e-mail: otavio.oliveira@unesp.br

G. S. Gonçalves · P. M. Tasinaffo · L. A. Vieira Dias · A. M. da Cunha
Computer Science Division, Aeronautics Institute of Technology - ITA, São José dos Campos, Brazil



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section, the methodological procedures adopted during this research work will be described. In the fourth section, the results obtained from the data collection will be presented and discussed. Finally, the research will present the conclusions obtained from the investigation.

## 55.2 Theoretical Background

The innovations generated by education 4.0 go beyond the boundaries of organizations and are identified in education systems. The results are already proven by the creation of jobs that did not exist and the disappearance of some due to robot replacement and process digitization [1]. In this context, Education 4.0 is characterized by the interference of technologies created by industry 4.0 in the teaching process, bringing them into the educational environment [6]. The Industry 4.0 concept is very convenient especially for the basic engineering sciences such as computing, electronics and machine engineering, bringing significant innovations in training suitable and qualified students for the industry [7]. This new teaching model encompasses online activities with its content available on digital platforms and utilization of Artificial Intelligence resources It is noteworthy that the addition of these resources and tools with the change in the teaching methodology are contributing to the improvement of the quality of learning and the development of the teaching-learning skills, abilities and autonomy of the students, improving the students commitment and consequently the performance in the teaching. A collaborative environment is needed among students where, upon completion of activities and challenges, awards are given for completing tasks and feedback for actions taken during the exercises [4].

## 55.3 Method

Research on the agenda can be classified as basic, exploratory and qualitative approach. As a method, the bibliographic research was adopted and, as a technical procedure, the literature review was chosen. Exploratory research aims to gain greater familiarity with a given phenomenon or gain new insights into the researched theme [8].

Data were collected from the SCOPUS database in July and August 2019, using the descriptors “education 4.0”, “learning 4.0”, “teaching 4.0”, “educating 4.0”, “educational 4.0”, “education OR educating OR learning OR teaching OR educational” and “industry 4.0” OR “industries 4.0” OR “smart manufacturing” OR “smart factory” OR “intelligent manufacturing” OR “manufacturing 4.0” OR “fourth industrial revolution”. For the purpose of this study, we considered the indexed works in the above-mentioned database from 2014 to 2020. It is noteworthy that the data obtained from this investigation were tabulated, treated and will be presented in the next section [7].

## 55.4 Results

The gaps of the most relevant publications on Education 4.0, Industry 4.0 and their Scopus indexed variations were analyzed, based on 28 articles and two reviews. The publications containing the searched terms were published between 2014 and 2020. As it is a recent field of knowledge, of the 30 publications made 12 of them did not obtain citations, according to Table 55.1.

It is noteworthy that no articles produced by the same author were identified in more than one publication, which demonstrates the lack of a reference in this field of knowledge and the originality proposed by the theme. The Journal with the greatest contribution to the most relevant gaps was Procedia Manufacturing.

In relation to the identified gaps, the “Mapping the necessary skills and competences that should be included in the curriculum frameworks for I4.0 training” and “Proposing an educational approach based on the student’s practical experience” were highlighted in 25 citations.

The gaps highlighted elements that contained indications of improvement in technologies, as well as the elements around the improvement of Education 4.0 processes. Importantly, within the identifications, both the need for Education 4.0 to serve as the basis for Industry 4.0, as well as the need for the innovations proposed by Industry 4.0 to make education more contextualized for the world where technologies are essential for the various activities of society. From the identified gaps, it was possible to compose five groups addressing similar characteristics about Education 4.0 that can be seen in Table 55.2.

The first cluster is marked by the importance of the challenges encountered in Education 4.0, in corporate terms, involving sustainability, intellectual capital, innovation and business competitiveness. As for the needs of individuals, it focuses on engagement, motivation, trust and flexibility. Technological solutions are also considered relevant. Environments that can insert these topics promote the insertion of simulation of competitions, as well as stimulate creativity [9].

Stand out in the second cluster, concepts about learning, skill and training [1, 10]. Although the gaps indicated adaptations to specific professions (accounting and nursing), the need to adapt vocational education (both technical and undergraduate) to emerging technologies is evident [11, 12].

The third cluster prioritizes PBL, gamification, and inverted classroom practices. PBL is proposed with an appropriate learning approach to provide an experience that facilitates the development of Industry 4.0 skills and com-

**Table 55.1** Scientific gap of 30 most cited works

| Title | Authors | Source | Scopus citacion | Scientific gaps |
|---|---|---|---|---|
| Requirements for education and qualification of people in Industry 4.0 | Benešová A., Tupa J. | Procedia Manufacturing | 32 | Map the necessary skills and competences that should be included in the curriculum for training I4.0 |
| Learning factory: The path to Industry 4.0 | Baena F., et al. | Procedia Manufacturing | 25 | Propose an educational approach based on student practical experience |
| Industry 4.0 learning factory didactic design parameters for industrial engineering education in South Africa | Sackey S.M., Bester A., Adams D. | South African Journal of Industrial Engineering | 10 | Identify solutions to the challenges that prevent universities from teaching and practicing I4.0 |
| Project-based collaborative engineering learning to develop Industry 4.0 skills within a PLM framework | Vila C., et al. | Procedia Manufacturing | 9 | Propose PBL models from applications that accelerate student learning curve |
| Do Web 4.0 and Industry 4.0 imply Education X.0? | Demartini C., Benussi L. | IT Professional | 8 | Align stakeholder interests for better teaching and learning |
| The psychosocial and cognitive influence of ICT on competences of STEM students | Flogie A., Lakota A.B., Aberšek B. | Journal of Baltic Science Education | 7 | Insert educational technologies and measure their impact on student skill development |
| A scoping review on digital English and Education 4.0 for Industry 4.0 | Hariharasudan A., Kot S. | Social Sciences | 7 | Map the impacts of education 4.0 to meet the challenges of Industry 4.0 |
| External partnerships in employee education and development as the key to facing Industry 4.0 challenges | Stachová K., Papula J., Stacho Z., Kohnová L. | Sustainability | 5 | Assess the new role of human resources in industries 4.0 |
| Learning outcomes for training program by CDIO approach applied to mechanical industry 4.0 | Le T.Q., Hoang D.T.N., Do T.T.A. | Journal of Mechanical Engineering Research and Developments | 5 | Identify difficulties and failures in learning models that develop students' skills and competences |
| Building CDIO approach training programmes against challenges of industrial revolution 4.0 for engineering and technology development | Vu T.L.A. | International Journal of Engineering Research and Technology | 5 | Lay out deployment standards for Education 4.0 application |
| On the state of free and open source E-learning 2.0 software | Kose U. | International Journal of Open Source Software and Processes | 4 | Evaluate the effects of Web 4.0 on e-learning platforms |
| Using industry 4.0 technologies to support teaching and learning | Wanyama T. | International Journal of Engineering Education | 3 | Enhance virtual environments through stakeholder collaboration |
| A reference system of smart manufacturing talent education (SMTE) in China | Zhang X., et al. | International Journal of Advanced Manufacturing Technology | 1 | Propose metrics to measure student performance in hands-on Education 4.0 classes |
| Industry 4.0: Employers' expectations of accounting graduates and its implications on teaching and learning practices | Ghani E.K., Muhammad K. | International Journal of Education and Practice | 1 | Compose strategies for applying Industry 4.0 concepts and practices in accountant training |
| Integration of 3D printing and industry 4.0 into engineering teaching | Chong S., et al. | Sustainability | 1 | Map improvements in sustainability education through I4.0 applications |
| Educational robotics as part of the international science and education project "Synergy" in realizing the social needs of society on the road to the industrial revolution industrial 4.0 | Khomchenko V.G., Gebel E.S., Peshko M.S. | EAI Endorsed Transactions on Energy Web | 1 | Propose guidelines for implementing robotics in Education 4.0 |
| The possible effects of 4th industrial revolution on turkish educational system | Tanriogen Z.M. | Egitim Arastirmalari - Eurasian Journal of Educational Research | 1 | Investigating Industry 4.0 technology influences affect student performance |
| Rethinking Thai higher education for Thailand 4.0 | Buasuwan P. | Asian Education and Development Studies | 1 | Map the difficulties teachers and institutions will face when migrating to Education 4.0 |

(continued)

**Table 55.1** (continued)

| Title | Authors | Source | Scopus citacion | Scientific gaps |
|---|---|---|---|---|
| Organizational learning paths based upon industry 4.0 adoption: An empirical study with Brazilian manufacturers | Tortorella G.L., et al. | International Journal of Production Economics | 0 | Assess the impacts of I4.0 technologies on operational performance in developed countries |
| Designing a project for learning Industry 4.0 by applying IoT to urban garden | Hormigo J., Rodríguez A. | Revista Iberoamericana de Tecnologias del Aprendizaje | 0 | Assess the benefits of implementing project-based learning (PBL) in e-learning environments |
| Teaching English in the industry 4.0 and disruption era: Early lessons from the implementation of SMELT I 4.0 DE in a senior high lab school class | Suherdi D. | Indonesian Journal of Applied Linguistics | 0 | Identify the challenges of Education 4.0 for teachers and propose improvements in their curriculum |
| The significance of photographic education in the contemporary creative industry 4.0 | Azahari M.H., Ismail A.I., Susanto S.A. | International Journal of Innovative Technology and Exploring Engineering | 0 | Map the barriers of photographic teaching and practice at all levels of the education system |
| Virtual reality-based engineering education to enhance manufacturing sustainability in industry 4.0 | Salah B., et al. | Sustainability | 0 | Propose guidelines for education and training in preparing Industry 4.0 engineers and operators |
| Designing learning-skills towards industry 4.0 | Umachandran K., et al. | International Journal of Computer Integrated Manufacturing | 0 | Map new applications of Industry 4.0 in teaching and learning methodologies |
| Flipped classroom for doctoral students: Evaluating the effectivness | Volchenkova K.N. | Vysshee Obrazovanie v Rossii | 0 | Identify the barriers to reverse classroom implementation in Education 4.0 |
| The role of serious games, gamification and industry 4.0 tools in the education 4.0 paradigm | Almeida F., Simoes J. | Contemporary Educational Technology | 0 | Map the technologies applied to I4.0 that enable the improvement of teaching 4.0 |
| The potential of ICT in blended learning model toward education 4.0 need analysis-based learning design for ELT | Badaruddin, Noni N., Jabu B. | Asian EFL Journal | 0 | Measure improvement in student performance using blended learning |
| Research, technology, education & scholarship in the fourth industrial revolution [4IR]: Influences in nursing and the health sciences | Diño M.J.S., Ong I.L. | Journal of Medical Investigation | 0 | Identify and analyze the benefits of implementing Industry 4.0 technologies in nursing education |
| Socio-technical imaginary of the fourth industrial revolution and its implications for vocational education and training: a literature review | Avis J. | Journal of Vocational Education and Training | 0 | Identify barriers for current students in interacting with Industry 4.0 within education |
| The effectiveness of blended learning: A case study | Anaraki F. | ABAC Journal | 0 | Map the good practices of hybrid education and propose an effective methodology for its implementation in Education 4.0 |

petencies. Gamification uses elements found in games fostering situations of conflict, cooperation, interaction under rules clarified previously to those involved. The inverted classroom consists of the student's performance of school activities at home and the completion and/or completion of the school environment under the supervision of the teacher [6, 13, 14].

The fourth cluster addresses the importance of technology in the context of Education 4.0. There is a significant lag in the school environment, especially in early childhood education, a delay of 15–20 years, which makes the issue of monitoring Industry 4.0 technologies far from reality [15]. In this cluster, the importance of using applications in the school environment is also mentioned. When applied in the academic field, it is possible to present a real scenario for students to solve, although implementation difficulties are lacking in the pro-activity of teachers and course coordinators. For the experiences of this classroom approach to have better references, a larger range of tabulations of unsuccessful experiences are required to be reported to the academic community [6].

E-learning within the academic environment, especially at universities, is of great use in preparing educational institutions for challenges regarding enrollment goals, as well as making the study environment more student-friendly. What makes this relationship more conducive to students is the flexibility that digital tools provide in accessing content, adjusting the pace of study according to the specific needs of each university student [16]. The five mentioned groups can cover the most important aspects that Education 4.0

**Table 55.2** Scientific gap groups

| Macro grouping | Scientific gaps |
|---|---|
| Mapping and assessment of Education 4.0 challenges and solutions for Industry 4.0 | Identify solutions to the challenges that prevent universities from teaching and practicing I4.0 |
| | Map the impacts of education 4.0 to meet the challenges of Industry 4.0 |
| | Assess human resource challenges in preparing relocated employee training to adapt to Industry 4.0 technologies |
| | Map improvements in sustainability education through I4.0 applications |
| | Identify student barriers to interaction with Industry 4.0 within education |
| Pedagogical alignment with Education 4.0 | Map the necessary skills and competencies that should be included in curricula for I4.0 training |
| | Align stakeholder interests for better teaching and learning |
| | Compose strategies for applying Industry 4.0 concepts and practices in accountant training |
| | Identify the challenges of Education 4.0 for teachers and propose improvements in their skills |
| | Map the barriers of photographic teaching and practice at all levels of the education system |
| | Analyze the benefits of implementing Industry 4.0 technologies in nursing |
| | Propose models for standardizing the deployment of Education 4.0 |
| | Propose metrics to measure student performance in hands-on Education 4.0 classes |
| Analysis of new teaching approaches in Education 4.0 | Systematize school content through gamification strategies |
| | Propose an educational approach based on student practical experience |
| | Propose PBL models from applications that accelerate student learning curve |
| | Identify the barriers to reverse classroom implementation in Education 4.0 |
| | Evaluate the benefits of implementing project-based learning (PBL) in e-learning environmentsProp models of PBL from applications that accelerate student learning curve |
| Use of Industry 4.0 technologies in Education 4.0 | Insert educational technologies and measure their impact on student skill development |
| | Propose guidelines for implementing robotics in Education 4.0 |
| | Investigate the influences of Industry 4.0 technologies on student performance |
| | Map the difficulties teachers and institutions will face when migrating and adopting Education 4.0 |
| | Assess the impacts of I4.0 technologies on performance and operational training in developed countries |
| | Map new applications of Industry 4.0 in teaching and learning methodologies |
| | Map the technologies applied to I4.0 that enable the improvement of teaching 4.0 |
| Organization and updating of digital platforms for Education 4.0 | Evaluate the effects and benefits of Web 4.0 on e-learning platforms |
| | Enhance virtual environments through stakeholder collaboration |
| | Measure improvement in student performance using blended learning |
| | Map the good practices of hybrid education and propose an effective methodology for its implementation in Education 4.0 |

demands on education stakeholders (emphasizing students, school staff and teachers), as well as on the resources needed for its implementation and success, prioritizing technological infrastructure and human resources.

## 55.5 Conclusion

This study aimed to identify research gaps related to the Education 4.0 theme, as well as to present a grouping of the findings according to their similarities. There was a need for synergy between Education 4.0 and Industry 4.0, as well as the importance of education becoming more contextualized in an environment where technologies are essential for the diverse activities of society.

The groups of gaps that could be constituted were: mapping and evaluation of challenges and solutions; pedagogical alignment, analysis of new teaching approaches; use of Industry 4.0 technologies in Education 4.0 and organization and updating of digital platforms.

The most relevant academic contribution that could be obtained through these studies was the perception that this field of knowledge is apparently distant from its maturation, because the amount of articles produced was insignificant, and many of the articles that made up the list have not yet been cited. Another contribution was the possible trends that were identified in the study, mainly supported by the five delimited groups. Regarding the applied contribution, there was a great need for technical training and alignment among the various stakeholders present in education, so that technology can in fact add to the productivity of those at the forefront of educational institutions (staff and teachers), as well as more satisfactory student performance.

As a suggestion for future studies, comparative cases are suggested in which two distinct groups of students may receive pedagogical content in different situations: one group under e-learning tools, gamification or even applications, while a second group had access to the same content, although without any apparatus available to the first group, according to the more traditional teaching-learning relationships adopted in the last century.

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