Investigating Initiatives to Promote the Advancement of Education 4.0: A Systematic Mapping Study

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Abstract: The digitization of the industry, known as Industry 4.0, is changing the modes of production and service. These changes arouse the need to prepare employees to work on the production lines. In this perspective arise the concept of Education 4.0 to preparing young with the competencies and skills required in the 21st-Century, such as creativity, problem-solving, and mastery of technologies. This paper presents a Systematic Mapping Study that had the aim to identify initiatives in Education 4.0 and Industry 4.0 developed to promote the advancement of education. Following a formal protocol, automatic and manual searches were carried out. Of the 1732 studies returned by automatic and manual searches, 78 were extracted, because it meets the inclusion criteria defined. The results showed that (a) there is a growing interest in this topic in recent years and tends to increase the number of searches due to its value for industry; and (b) there is greater interaction between the university and the industry, which allows the student to gain not only knowledge but also gain valuable experience in the industry. Based on the results, we found that learning in the context of Education 4.0 allows students to have an education more aligned to the contemporary world.

1 INTRODUCTION

Education 4.0 can be defined as a student-centered learning model to prepare young people for the challenges of the 21st Century, how to deal with emerging technological resources and processes (Ciolacu et al., 2017a). Moreover, Education 4.0 is aligned with Industry 4.0 (digitalization of the industry), in which the use of Information and Communication Technology is essential (Winanti et al., 2018), such as robotics, cloud computing, artificial intelligence, among others.

In Education 4.0, it is expected that students are prepared for much more than repetitive activities (Messias et al., 2018). Thus, students need to be prepared to adapt and have a dynamic mindset (Winanti et al., 2018). It is believed that it will be possible to create new technologies and ways of work through 21st-Century skills and competencies, such as creativity, problem-solving and collaboration. For example, a creative individual can invent ways to apply technologies, create new products and services (Makarova et al., 2018). In the Education 4.0, the development of competencies and skills becomes relevant. However, one of the biggest challenges facing Education 4.0 is precisely to adapt the curriculum to work with these skills and competencies. For students to develop these skills and competencies, it is necessary to create learning spaces to allow students to carry out research, solve problems, collaborate with other people and evaluate their actions (Angrisani et al., 2018).

In literature, competencies can be defined as a combination of knowledge, skills, and attitudes (Angrisani et al., 2018). Thus, we understand that competence contains the skill, and can be considered a performance of a type of task that can be achieved from the students' skills. In turn, skills are recognized as a capacity to know make through practical activities (Perrenoud, 1999).

This paper aims to present the results of a Systematic Mapping Study (SMS) about initiatives of

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Education 4.0 and Industry 4.0 to promote the advancement of education. In this way, automatic and manual searches were performed, following the recommendations of Kitchenham and Charters (2007). As one of the data extraction strategies, eight research sub-questions were answered. The respective answers provided an overview of Education 4.0. The results show that (a) there is a growing interest in this topic in recent years and the number of researches increased due to its value to the industry; (b) the teacher is challenged to prepare young people with 21st-Century skills and to work with technological resources and processes; and (c) there is greater interaction between the university and the industry, which allows the student not only to develop knowledge but also to acquire valuable experience in the industry. Besides, this SMS presents new directions and positions on activities in the context of Education 4.0.

This paper is organized as follows: Section 2 shows the research method used for SMS. Section 3 presents a discussion of the results. Section 4 shows threats to validity. Finally, Section 5 presents the final considerations and next steps for the research.

2 RESEARCH METHODOLOGY

The protocol was based on the rules for systematic literature reviews of Kitchenham and Charters (2007). The detailed protocol is available in a technical report through the following link (https://figshare.com/s/2f876265037e0bb84d6a).
The study aimed to identify the initiatives in Education 4.0 and Industry 4.0. The goal was organized according to the GQM (Goal-Question-Metric) paradigm (Basili and Rombach, 1988), as seen in Table 1.

Table 1: The goal of SMS according to GQM paradigm.

To analyze	scientific publications
For the purpose of	to characterize
In relation to	technologies applied in the context of Education 4.0 that promote pertinent competencies and skills of the Industry 4.0
From the point of view of	researchers of Informatics in Education and Computing Education
In the context of	publications available on search engines of digital libraries (SCOPUS, ACM, and IEEE) and manual searches (SBIE and RBIE)

2.1 Research Questions

The SMS's main question is “What initiatives are being proposed in the context of Education 4.0 and Industry 4.0 to contribute to the challenges of the 21st Century?”. In this way, we intend to identify the advances, possibilities, and technologies developed for this context. In sequence, eight research sub-questions (SQs) were defined to categorize the initiatives found. A data extraction strategy was adopted and possible answers were defined for the SQs to facilitate the initiatives' classification (available in the technical report).

2.2 Search Strategy

The selection process for scientific publications involves several sources of information, including online digital libraries, journals, and conferences. For this SMS, a predefined search strategy was used (Kitchenham, 2004). A search strategy allowed maintaining the research's integrity, minimizing bias and maximizing the number of sources examined, such as scope, languages, search string, and selection criteria (available in the technical report).

The selection procedure was organized in 2 stages. In the first stage (1º Filter), each paper's title and abstract were evaluated according to the inclusion and exclusion criteria. In the second stage (2° Filter), a complete reading of the papers that were left in the 1st filter was performed because the strategy of reading only the title and abstract would not be enough to identify whether the paper is indeed relevant to the research context. In both stages, the inclusion and exclusion criteria were used to judge whether papers should finally be included or excluded. This SMS was attended by three researchers. If there were disagreements, it was discussed until a consensus was reached. The data collection period was from January 2015 to December 2018.

2.3 Quantitative of Papers

When the search string was applied in the automatic and manual search sources, 1732 articles were returned, as shown in Table 2. A total of 223 papers were selected during the first filter. The second filter registered 78 selected papers. There were duplicate papers that appeared in more than one digital library. In this case, the repeated paper was considered only once, according to the search order of the sources selected in this SMS, i.e., SCOPUS, ACM, IEEExplore, SBIE, and RBIE, respectively.

All the initiatives of Education 4.0 found in this SMS are represented in Table 3, according to search source and its reference. Due to the number of publications in this SMS, we coded the references (ref01 to ref78) available in a technical report (https://figshare.com/s/2f876265037e0bb84d6a).

Table 2: Total papers selected in the 1st and 2nd filter.

Source	Returned	1º Filter	2º Filter
SCOPUS	725	141	46
ACM	38	3	1
IEEEXplore	152	24	3
SBIE	705	39	20
RBIE	112	16	8
TOTAL	**1732**	**223**	**78**

Table 3: References of Education 4.0 Initiatives.

Source	References
SCOPUS	(ref02); (ref03); (ref04); (ref06); (ref07); (ref08); (ref09); (ref11); (ref12); (ref16); (ref19); (ref20); (ref21); (ref22); (ref24); (ref25); (ref27); (ref28); (ref30); (ref31); (ref36); (ref38); (ref39); (ref40); (ref42); (ref45); (ref46); (ref47); (ref51); (ref53); (ref54); (ref55); (ref57); (ref58); (ref62); (ref63); (ref64); (ref68); (ref71); (ref72); (ref73); (ref74); (ref75); (ref76); (ref77); (ref78).
ACM	(ref13).
IEEEXplore	(ref23); (ref29); (ref34).
SBIE	(ref05); (ref15); (ref17); (ref32); (ref33); (ref35); (ref41); (ref43); (ref44); (ref48); (ref49); (ref52); (ref56); (ref59); (ref60); (ref61); (ref65); (ref67); (ref69); (ref70).
RBIE	(ref01); (ref10); (ref14); (ref18); (ref26); (ref37); (ref66); (ref50).

3 RESEARCH RESULTS

This section presents and discusses the results obtained of 8 sub-questions, i.e., SQ1, SQ1.1, SQ2, SQ3, SQ4, SQ4.1, SQ5, and SQ6. This analysis was peer-reviewed.

3.1 Publication Year

The selected studies were published from 2015 to 2018. Education 4.0 was mentioned the first time in 2015 (Ciolacu et al., 2017b). From 2015 onwards, the term 4.0 gained space in discussions between teachers, managers, and specialists in education in general. In Brazil, it was noticed that since 2017, educational institutions' websites started to discuss, reflect and encourage practices with the thematic 4.0, such as the Technological Institute of Aeronautics (ITA, 2017). Besides, Brazilian events start to disseminate the ideas and challenges of Education 4.0, as the Education 4.0 Seminar in Curitiba (Curitiba, 2018). Therefore, it is believed that this discussion may have helped to increase the number of publications on this topic. According to the studies selected in this SMS, it was noticed that in 2017 there was a greater increase in the number of publications related to Education 4.0 in the world This growth may mean greater interest in this topic and its impacts on society.

3.2 Application Context (SQ1)

The results related to SQ1 show that 80.77% of initiatives of the Education 4.0 were developed in the academy, implying that most studies on training for 21st-Century skills and competencies are produced in educational institutions. Therefore, academia has played a relevant role in preparing students for the challenges of the 21st-Century.

Learning in the context of Education 4.0 allows students to have an education more aligned with the contemporary world. Consequently, it allows for greater chances of employability in the profile of the current industry. In this perspective, a didactic training approach was found to narrow the relationship between theory and practice in the classroom. The initiative indicates the insertion of short theoretical parts with longer practical parts. A strategy used offers students more opportunities to change the production process (ref63).

In contrast, it was found that 15.38% of the initiatives are developed in the industry. Therefore, some companies already understand the concept 4.0 and conduct training with their employees to meet the needs of Industry 4.0. In this sense, an appropriate technology was identified for carrying out training, especially for small and medium-sized companies. The methodology is developed according to five factors, such as time (a basic unit takes about half an hour), input content (which type of information needs to be provided to students), approach, output (expected results), and documents (collection of experience acquisition). The steps of the proposed methodology enable the development of holistic training that can improve employees' learning experience and conduct systematic training (ref75).

Finally, it was identified that 3.85% of the publications represent initiatives initiated in the academy and completed in the industry, allowing students to have a greater experience. Thus, the connection between the university and the industry allows the student to develop knowledge and gain valuable experience. This practice benefits the student because many jobs require experience and practical skills (ref73).

3.2.1 Application at the Academy (SQ1.1)

As the SMS's goal is to promote educational advancement, we sought to identify within SQ1 which levels of education address the context of Education 4.0. The SQ1 has a sub-question SQ1.1 that deals with the context of application in the academy since most of the selected studies are aimed at educational institutions. The results of SQ1.1 indicate that 67.69% of technologies for Education 4.0 were developed in Higher Education, followed by 30.77% of Basic Education and 1.54% of Technical Education. Despite the few studies found in basic education research, some authors reported the importance of alignment between school and university (ref53). Therefore, some researchers recognize the importance of aligning education levels, ranging from Basic Education to Higher Education.

In general, it was perceived that Education 4.0 seeks to improve teaching and learning processes such as the relationship between school and university, the links between students and teachers with 21st-Century skills and competencies.

3.3 21st-Century Skills and Competencies (SQ2)

In Education 4.0, the need to develop students' skills and competencies becomes one of the priorities because it allows preparing more autonomous, responsible, creative, and apt young people to deal with the challenges of the 21st Century. The results for SQ2 show that 34 publications addressed the Collaboration, i.e., ability to work as a team to achieve a common goal; 32 of the papers discussed the Problem-solving, i.e., ability to find solutions to specific problems; 17 papers addressed the Creativity, i.e., ability to invent, create and innovate processes and products; 15 papers showed Communication, i.e., ability to communicate effectively and understand teammates; 11 papers discussed Computational Thinking, i.e., ability to solve problems in a structured way from the fundamentals of computing; 11 papers addressed the Autonomy, i.e., ability to act by the own means; 9 papers addressed the Innovation, i.e., ability to think and develop new things; 9 papers discussed the Decision-Making, i.e., a cognitive ability that results from choosing an option among several possibilities; 9 papers discussed the Learn to learning, i.e., active action to learn new content, to know how to do something or to know a new area of knowledge; and 6 papers addressed the Leadership, i.e., ability to position yourself with authority.

Besides, we present a list of the other skills and competencies identified in this SMS with the number of papers citing it. The skills and competencies are: Responsibility (4 papers): ability to perform tasks with commitment and seriousness; Information proficiency (4 papers): ability to handle data; Critical thinking (4 papers): ability to judge and reflect on what you believe or what you should do; Entrepreneurship (3 papers): ability to plan, coordinate and develop projects, services or businesses; Technology domain (3 papers): ability to deal with emerging technological resources; Knowledge acquisition and transfer (3 papers): ability to plan, specify, and share knowledge; Metacognition (3 papers): self-awareness, knowledge of the learning process; Scientific skills (3 papers): ability to deal with research processes; Flexibility (3 papers): ability to adapt to changes; Resilience (2 papers): ability to deal with adverse situations; Adaptability (2 papers): ability to adapt as needed; Logical reasoning (2 papers): cognitive ability to solve problems; Networking (1 paper): ability to relate and create business opportunities; Motivation (1 paper): capacity of motivation to achieve your goals; Empathy (1 paper): ability to understand the other person's feeling or reaction by imagining themselves in the same circumstances; Self-discipline (1 paper): ability to put yourself in discipline (1 paper), Interpretation (1 paper): ability to understand clearly the sense of a problem; and Ethics and Morality (1 paper): ability to act with integrity and good conduct.

3.4 Emerging Technologies (SQ3)

In Industry 4.0, automation and computerization of companies are perceived. Thus, one of the required skills is to know how to use technologies to support the industry in this transformation process. This SMS sought to investigate which emerging technologies are being disseminated in Industry/Education 4.0.

The results of SQ3 revealed that the majority of papers addressed Programming (18). This technology was presented in 18 publications, and it is one of the most used technologies today, being associated with the development of important 21st-Century skills, such as problem-solving, computational thinking, and logical reasoning. In this SMS, some ways of working with the programming with students were identified to develop skills and competencies. Thus, it was observed that the teaching of programming can be organized in 2 phases: theory and simulation. In the 1st phase, instruments and materials can be used to support the teaching, as tutorials. In the 2nd phase, a tool can be inserted to support the teaching and learning processes of programming (ref41).

In addition, other technologies were mentioned in the selected papers, such as Robotics (17): development and use of robots; 3D printing (12): additive manufacturing process where a three-dimensional model is created by successive layers of material; Gamification (11): using game techniques to captivate people through challenges and rewards; Cloud computing (11): computing services, including servers, storage, databases, among others, that contribute to virtualization and availability of resources and materials for teachers and students through the internet; Augmented Reality (9): integration of virtual elements to real-world visualizations; Internet of Things (9): the digital interconnection of everyday objects with the Internet; Virtual Reality (7): interface between a user and an operating system through 3D graphics or 360º images; Virtual Learning Environment (7): environments that assist in setting up courses on the Internet; Simulation (6): software capable of reproducing a process or operation in the real world; Big Data (5): the knowledge of how to deal with large data sets; Multimedia Resources (5): a range of materials such as sounds, images, texts, and videos; Cyber-Physical Systems (4): a system composed of collaborative computational elements to control physical entities; and Unplugged Computing (3): teaching computing without using computers. Also, other technologies have been identified in SMS, but less frequent, such as Artificial Intelligence (2): use of the computer to automate common tasks performed by humans; Intelligent Teletutor (2): computational environments used in metacognitive training; Chatbot (2): a computer program that uses artificial intelligence to imitate conversations with users; Massive Open Online Course (2): open course accessible through virtual learning environments; Machine learning (1): data analysis method that automates the construction of analytical models; Learning Manager System (1): platforms that use students, manage and monitor the classroom; Learning objects (1): any digital resource that can support the teaching and learning processes; Social Networks (1): environment composed of people or organizations, connected by one or more types of relationships; and Storytelling (1): storytelling to streamline and disseminate knowledge.

3.5 Ways of Working (SQ4)

The results of this sub-question show that the most used form of work to support the training of students and professionals is methodology. One of the methodologies identified in this SMS was STEM (an acronym for working in areas such as Science, Technology, Engineering, and Mathematics). This methodology was used to link the university with high schools to prepare a workforce to fill in the gaps of skills focused Industrial Internet of Things (ref53).

Also, 22 methods were found, such as CMTrain, used for professional training (ref58); PICE, used to improve the innovation process (ref77); MINTReLab-MOOC, created to integrate theory with practice (ref28); MEF, created to insert computational resources in Physics classes (ref31); DMA, used to assess the level of digital maturity in the industry (ref24); TTD, used in training for decision making (ref47); EPF, used to teach programming in elementary schools (ref38); VET, used to support educational vocation and vocational training (ref78); CSCW, used to support Computer Supported Collaborative Work (ref74); SCRUM, used to support project management and planning (ref13); SAHI, used to support Intelligent Hybrid Learning (ref29); CHPL, used to support problem-based cooperative learning (ref34), among others.

Eleven models were found, such as PILOT, used to combine online learning and offline training (ref75); ILM, Intelligent Laboratory Model, supported by educational technologies) (ref08); DM, Didactic Model inspired by the Learning Factory (ref62); CM, Collaborative Model based on innovation (ref30); and MI, Model to Integrate the pillars of Industry 4.0 in engineering education (ref20). Besides, 8 Learning Factories were found aimed at enabling industrial production at universities. In sequence, 7 approaches were identified, such as DITA, used to guide the production, selection, filtering, and sampling of content for a business team (ref42); BW, used to investigate the modification of Behavior the Work (ref07); PSSC, used as a Potential Solution to the Social Changes brought about by industry 4.0 (ref68); AAP, used to assist in articulating ideas, organizing steps for skill development (ref71); AAI, created to support training in Industry 4.0 (ref36); LCA, used to assist in the Sustainable Manufacturing Life Cycle Assessment (ref51); and APC, used to support Practice and Collaboration in the development and use of applications (ref17).

Besides, 7 applications were found, such as Collabora, an environment developed to support the evaluation of collaboration in the discipline of Statistical Probability (ref33); T-mind, an application designed to stimulate Computational Thinking skills through Gamification (ref49); The last tree and Treasure hunt, two games developed for exercise Computational Thinking playfully (ref35; ref52); Toth, a recommendation system developed to support Project Based Learning activities and also to assist the Collaboration between students (ref01); PAT2Math, an intelligent tutoring system designed to assist students in solving mathematical equations and encouraging Metacognition skills (ref37).

In sequence, 5 types of categories were created, such as categorization of competencies and skills and general features related to Education 4.0 (ref04; ref21; ref22; ref25; ref54). Also, 4 technologies are related to Adapting the Curriculum for Education 4.0 (ref06; ref10; ref16; ref40), 4 are processes, being 2 are used to identify and work with critical competencies in companies (ref39; ref19); and 2 are to facilitate the skills of Problem Solving and Computational Thinking (ref05; ref56).

Finally, 3 Frameworks were found, such as P21, used to encourage Life skills and Innovation skills (ref55); CTE, used to support Career and Educational Training (ref73); R&D, used to produce a digital artifact, from the skills and competencies (ref64). In sequence, 2 are related to the Teaching Factory created to support students in the development of useful skills for a career in manufacturing; 2 methods developed to support programming teaching and encourage Computational Thinking skills; 1 Project developed to promote interdisciplinary work on Industry 4.0 topics; 1 FabLab carrying out curricular and extracurricular activities, focusing on cooperative work, gamification and learning by doing; and 1 questionnaire to identify non-technical skills in the profile of software engineers.

3.5.1 Active Learning Methodology (SQ4.1)

In addition to SQ4, this SMS also had the sub-question SQ4.1 that sought to investigate pedagogical approaches worked in the context of Education 4.0. Active methodologies are educational practices that encourage students to participate in activities that lead to reflection, questioning, the search for understanding concepts, and how to apply them in a real context. Therefore, active methodologies can allow more dynamic, interactive, and student-centered classes, where 21st-Century skills can be worked on (ref01). In active learning, both teachers and students are active actors in the process (ref18).

The results for this sub-question pointed out that 15 publications are related to Project-Based Learning. This methodology consists of an educational strategy or methodology to promote the contextualized and planned accomplishment of tasks that usually involve real situations (ref01). In this SMS, 15 studies described on Problem-Based Learning characteristics. This methodology is composed by the use of real-world problems to encourage students to develop critical thoughts and problem-solving skills, acquiring knowledge about essential concepts in the studied area (ref56). Besides, 13 studies that address by Collaborative Learning were selected. This methodology is characterized by teamwork, where the teacher can stimulate attendance and observe the pace of learning, and use his authority in the classroom to encourage independence (ref70).

In sequence, other active learning methodologies were identified, such as Computer-Supported Collaborative Learning (3): the science that studies how people can learn in groups with the help of computers, having a relationship with Collaborative Learning mentioned previously (ref33); Blended Learning (2): combination of online and offline learning (ref23); Flipped classroom (2): a complete inversion of the teaching model, being one of the variations of blended learning (ref29); Enterprise-Centered Learning (2): use of real processes and problems directed to the context of the company (ref16); Scenario-Based Learning (2): a practical approach that allows students to work with simulations of real-life situations and allows them to acquire knowledge (ref78); Simulation-Based Learning (2): unlike Scenario-Based Learning, there is the use of software to reproduce real situations to be worked on (ref41); Case-Based Learning (2): a strategy that uses real cases to allow students to make decisions and get acquainted with the characters and circumstances in order to present a solution (ref29); Inquiry-Based Learning (1): a strategy to actively engage the student with an idea or topic in a discussion initiated by the teacher after an explanation (ref71); Digital Game-Based Learning (1): a strategy to focus on the design, development, use, and application of games in education (ref51); Design Thinking (1): set of ideas and insights to address problems related to future information acquisition, knowledge analysis, and proposed solutions (ref13); Problem-Based Corporate Learning (1): an industry-focused problem-solving strategies (ref34); Challenge-Based Learning (1): a strategy to provoke questions and exercise the ability to find an answer (ref29); Creative Learning (1): a strategy to develop, experiment and characterize methodologies and learning environments capable of promoting creativity (ref15); and Assisted Learning (1): the teacher provides the students with targeted guidance, offering tips and assistance (ref43).

3.6 Technical and/or Pedagogical Support (SQ5)

The results of this sub-question show that 39.74% of publications, both students and professionals are guided during activities, whether to solve problems, use new technology or complete a challenge. It was observed that the teacher acts as a facilitator and must be available for complex issues (ref29; ref23). Besides, facilitators must support students in terms of motivation and improve their communication and teamwork skills and provide adequate support so that students can build new knowledge and improve their metacognitive skills (ref34).

However, 60.26% of the papers identified in this SMS do not comment about the participation of the facilitators. This implies that most publications still do not discuss the role, importance, and difficulties in this facilitator in the Education 4.0 scenario, even that this professional has a relevant role within the process. The facilitator motivates, encourages, and makes your students learn more and better.

In general, given the challenges of the 21st Century and that Revolution 4.0 brings, it may be of interest to the facilitator to know the possibilities of the new emerging technologies used as an educational support channel. Therefore, researchers indicate the need to conduct studies about this professional because they need to be reinvented and challenging in their work due to changes.

3.7 Types of Analyses

About SQ6, it was observed that 32.05% of the studies present quantitative analyzes, 8.97% qualitatively and 7.69% are analyzed both quantitatively and qualitatively. However, it was noticed that most publications do not have experimental studies. Thus, 51.28% of these initiatives have not been evaluated or they are position papers, i.e., papers with the trend and consolidated theoretical foundation.

In this SMS, it was noticed that Education 4.0 starts to gain prominence, becoming a term discussed by the scientific community. Although, some studies only present the use of emerging technologies and/or skills development of the 21st Century, without the presence of the term Education 4.0. In general, the need to experience what has been discussed and produced for Education 4.0 is recognized. Thus, it will be possible to verify the impacts and difficulties of inserting technologies in the teaching and learning processes, taking into account the teacher and student.

4 THREATS TO VALIDITY

As with all SMS, some threats can affect valid results (Pinheiro et al., 2018). Therefore, we identified threats as publication bias, identification of studies, and the process of data selection and extraction. We sought to mitigate them while conducting this SMS to reduce possible risks.

Publication Bias. Mapping studies can suffer the effects of selective results through digital libraries. The selected results are related to the non-coverage of a given reality, as national. Thus, we also chose to research the main Brazilian bases of Computers in Education and Informatics in Education. So that they can quantify the results and advances of Education 4.0 both nationally and internationally.

Identification of Studies. Another risk is the exclusion of relevant studies that address the characteristics and principles of Education 4.0, despite not mentioning the term. To mitigate this risk, we carefully opened the selection filter to be as inclusive as possible, considering not only the main concepts but studies that dealt with active learning with emerging technologies, development of skills and competencies, and training of professionals for Industry 4.0, i.e., subjects related to Education 4.0 identified in primary studies.

Selection and Extraction of Study Data. The threats to carry out the selection and extraction of data have been reduced through the definition of the inclusion and exclusion criteria and the data extraction strategy. First, we produced a rigid protocol for selecting studies. Subsequently, the researchers carried out the selection in pairs, discussing the selection until a consensus was established. The selection strategy allowed to maintain the research's integrity, minimize the bias, and maximize the number of sources examined. However, when extracting data, we realized that relevant information was not always explicitly presented in the papers. Thus, in some cases, this information had to be inferred. However, this inference was made by the first author and carefully reviewed by the co-authors based on the information provided in the papers. In general, the data extraction strategy facilitated the application of data extraction criteria for all selected papers and allowed their classification.

5 CONCLUSIONS AND FUTURE WORK

This paper shows the results of a Systematic Mapping Study (SMS) that aimed to identify initiatives in Education 4.0 applied to promote the advancement of Industry 4.0. From a formal protocol, automatic and manual searches were performed, making 5 search sources. Of the 1732 papers returned, 78 met the inclusion criteria and were extracted. The protocol was defined and documented according suggested by Kitchenham and Chartes (2007). One of the data extraction strategies was to answer 8 research sub-questions. The respective answers obtained in each sub-question provided an overview of Education 4.0.

The results showed that: (SQ1) there is a greater tendency for initiatives in Higher Education, certainly, because researchers work at this level of education; (SQ1.1) there is a lack of initiatives in Basic Education, precisely at the level of fundamental education for the integral development of the student. The development of students in multiple dimensions such as social, emotional, intellectual, among others, is considered as integral development; (SQ2) skills are necessary for integral student development; (SQ3), emerging technologies are required in industry and can enable valuable experiences when used in academia; (SQ4) there are several possibilities for changing technologies and cultivating 21st-Century skills in the classroom; (SQ4.1) there is a tendency towards to use of methodologies that explore the protagonism of the student; (SQ5) there are few initiatives that discuss teacher participation in the learning process. Besides, few studies addressed the challenges of the teacher in the scenario of Education 4.0; and (SQ6) few experimental studies on Education 4.0 were performed.

This SMS had as the main question: "What initiatives are being proposed in the context of Education 4.0 and Industry 4.0 to contribute to the challenges of the 21st Century?". Based on the results, it is possible to say that the initiatives that promote Education 4.0 are those that: (a) seek the protagonism of the student; (b) incentive active learning; (c) propose practical activities; (d) develop 21st-Century skills; and (e) enabling experience with emerging computing resources and processes. These characteristics were also noticed in studies carried out in the industry, promoted for professional training.

Overall, it is possible to indicate that education focused on Education 4.0 can provide students with education more aligned to the contemporary world, in addition to enabling greater chances of employability in Industry 4.0. As future work, we intend to extend automatic and manual searches to identify studies of the years 2019 and 2020. Besides, the intention is to analyze international papers separately from national ones to facilitate the interpretations and conclusions of the different contexts identified in the SMS. Another flow of future research, already in progress, is developing strategies to help the teacher prepare classes in the Education 4.0 format, taking into account the SMS findings.

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