Scientific Mapping of Project Management and Educational Perspectives for Industry 4.0

Dantom Guilherme Helfer, Liane Mahlmann Kipper and Sandra Elisia Lemões Iepsen
Graduate Department in Industrial Systems and Processes
University of Santa Cruz do Sul
Santa Cruz do Sul, Rio Grande do Sul, Brazil
dantom@mx2.unisc.br, liane@unisc.br, siepsen@mx2.unisc.br

Abstract

The research aimed to carry out a scientific mapping, in Scopus and Science Direct, about project management and educational perspectives for industry 4.0. For this was used the method Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). We conduced a systematic literature review on the topics Industry 4.0, project management, skills and engineering education. From the results found, it is highlighted that the project management theme will be very important in view of the new industrial revolution being considered a professional, methodological and operational competence. Authors highlight the importance of the theme for the information technology (IT) sectors facing the transformations caused by the fourth industrial revolution. However, in the area of education, there is a paradigm regarding the project management discipline as it is neglected in engineering courses, not arousing student interest. To minimize this problem, a partnership between governments, universities and companies is mentioned. Another possible solution to reduce this educational gap is the creation of Learning Factories, which enable the union between theory and practice, arousing greater interest of students and assisting in the development of skills required by industry 4.0.

Keywords
Engineering Education, Skill, Industry 4.0, Project Management.

1. Introduction

Projects bring development through the renewal of products and services, changing paradigms and generating sustainability for organizations (Almeida and Neto, 2015). Although, Koke and Moehler (2019) and Silvius (2017) mention that there are still challenges regarding the union between projects and sustainability. San Cristobál (2017) comment that over the years the projects have become increasingly complex. This complexity influences directly the modeling, evaluation and control, affecting time, cost, quality and safety.

The changes are directly linked to projects, and these are linked to the technical and behavioral skills that help in decision making. Balve and Ebert (2019) comment that project management is an area in which academics work only after completing a course. Radujkovic and Sjekavica (2017) claim that project management is inevitable in the current scenario, becoming a required subject in undergraduate (Raoufi et al. 2018). Vila et al. (2017) are concerned with how Project Management has been neglected in engineering courses. Kohdeir (2018) reports that project management at universities faces difficulties since the discipline does not answer the needs required by the industries and also why does not arouse interest of students

Thus, this research aims to carry out a scientific mapping on project management and educational perspectives for industry 4.0. Finding possible gaps and opportunities in project management was also the focus of this research. The development this study was divided into 5 sections, and the first one was presented. Section 2 we describe the theoretical foundation for the better understanding of industry 4.0, project management, skills and engineering education. Section 3 comprises the research methodology. Subsequently the sections 4 and 5 are composed respectively by, results and conclusion.

2. Theoretical foundation

To better understand the topic, a theoretical research was conducted from the themes Industry 4.0, project management, skills and engineering training.

2.1 Indústria 4.0

The fourth industrial revolution, also called intelligent manufacturing, industrial internet or integrated industry, is an emerging theme that tends to affect industries internally changing the way manufacturing and product development, their processing, delivery and payment (Hofmann and Rüsch 2017). Lu (2017) reports that industry 4.0 was born in Germany and is related to new technological concepts. The study by Xu et al. (2018) mentions that information and industrialization techniques have leveraged the progress and evolution of manufacturing technologies. They also report that this whole package of technologies is intended to make Germany the leader of the integrated industry.

Although the literature disagrees on which emerging technologies are needed for Industry 4.0, we cite the most important according studied documents, these being: Internet of Things (IoT) (Zheng et al. 2018; Lu 2017; Zhong et al. 2017; Chen et al. 2017; Rüßmann et al. 2015), Cyber Physical Systms (CPS) (Zheng et al. 2018; Lu 2017; Zhong et al. 2017), Information and Communication Technology (ICT) (Lu 2017; Zhong et al. 2017), Enterprise Architecture (EA) (Lu 2017), Horizontal and Vertical System Integration (EI) (Lu 2017; Rüßmann et al. 2015), Cloud computing (Zheng et al. 2018; Zhong et al. 2017; Chen et al. 2017; Rüßmann et al. 2015), Big Data (Zheng et al. 2018; Zhong et al. 2017; Chen et al. 2017; Rüßmann et al. 2015) and Artificial Intelligence (AI) (Zheng et al. 2018).

Zheng et al. (2018) and Kipper et al. (2019) and commenting on their research that implements Industry 4.0 requires the union of physical and virtual systems or that make manufacturing processes increasingly intelligent. Mrugalska and Wyrwicka (2016) add that Industry 4.0 will help build a smart network between machines, components, properties, people, production systems and information and communication technology (ICT) throughout the production process resulting in intelligent factories. Zhong et al. (2017) comments that the fourth industrial revolution brings a promise of flexible manufacturing aligned with large-scale personalization so that companies can meet the demands of individualized production of shorter lead times and higher quality. To this end, there should be concern about how project management will be done, considering that common project management practice should be based on 'flexible' projects where flexibility and tolerance for inaccuracy are required (Atkinson et al. 2006).

2.2 Project management

To perform or structure any activity, a method is required (Kipper et al. 2013). Taking this thinking to the project area could not be otherwise, as this is an activity that manages resources, dates and technical requirements (Carvalho 2015, p.22). Having these needs in question, comes the Project Management Institute (PMI), that in the quest to better manage project management launches a document called "A guide to the Project Management Body of Knowledge - PMBOK®". For the PMI (2013) the application of knowledge, techniques, tools and skills to handle a project is called project management. Management is applied and tuned to 47 processes divided into Initiation, Planning, Execution, Monitoring and Control, and Termination groups. Project management has, but is not limited to:

- Identify requirements, needs, concerns, and expectations that stakeholders regarding project planning and execution
- Establishment, maintenance, execution of efficient communications and project added value among stakeholders.
- Stakeholder management seeking to meet project requirements as well as delivery creation and constraint balancing.

The PMI (2013) says that leading a project brings great challenges for managers, for this reason a qualified leadership is essential. Leaders must meet the needs of activities, teams and individuals, set real and attainable boundaries, and ultimately be a facilitating link between the strategic area and the team. The important skills for a project manager go beyond specific. Skills such as management, performance, attitude, leadership and personality are part of the ideal professional. Another point that draws attention is the changes that occur in projects after the start, where all parts must be communicated. Therefore, communication is another essential competency for managers. When it is compromised, there may be problems with delivering stakeholder needs. It is worth remembering that the professionals responsible for the projects must be trained in evaluating scenarios, in order to engage everyone for the proper execution of the work.

Atkinson et al. (2006) note that in project management more sophisticated efforts are needed to recognize and manage important sources of uncertainty. Such efforts need to cover organizational capabilities, including some aspects of the organization's culture and learning. For project management learning should focus on skills development (Drejer 2000; Thomas and Mengel 2008).

2.3 Skill and Engineering Education

Brandão and Bahry (2005) and Fleury and Fleury (2004) say that competence is the set of knowledge, skill and attitudes of an individual, thus making it stand out among the others. Fleury and Fleury (2001) associate competence with: know how to act, mobilize resources, integrate multiple and complex knowledge, learning, engagement, bear responsibility, strategic vision. Wilcox King et al. (2002) mention that most managers recognize the competencies of the company in order to generate competitive advantages. Thus, be aware of existing strengths, as well as areas for development.

De Souza Cruz and Moraes (2013) comment that with the competitive scenario it is necessary for the professional to have technical skills, expertise consistent with the designated and behavioral responsibilities. Dalenogare et al. (2018) recalls that companies need to rethink the way they work, so new skills will be needed, not just for the worker, but for the whole organization. For Fleury and Fleury (2001) skills add economic value to companies as well as social value to people. In this context when developing their skills the professional is investing in himself.

In relation to engineering education Crawley et al. (2014) comment that it is characterized by engineering practice (conception, design, implementation and operation) throughout the production chain. The job of the engineer is to create benefits for people by manipulating materials, energy and information, but for that they need to know beyond theory, what can be acquired through educational labs (Feisel and Rosa 2005). Although engineering curriculum have evolved to meet 21st century requirements, international organizations are still calling for changes to a knowledge-driven learning system and learning processes that support their development (Litzinger et al. 2011). Project based learning is an educational methodology that can assist with this change and skills development. De Los Rios et al. (2010) indicate advantages in the application of this methodology, such as the facilitation of training in technical, personal and contextual competences and that collaborative learning is facilitated by the integration of teaching and research.

3. Methodology

In order to analyze the scenario of the theme, a scientific mapping was carried out in the Scopus and Science Direct. These databases were chosen for their importance to academia. The Scopus database has 55 million records, more than 21 million titles and 5,000 publishers, and is the largest source for academic abstracts and citations. (Elsevier 2019). The Science Direct database, on the other hand, features a quarter of the world's scientific and technical content and includes nearly 2,500 journals and more than 30,000 books and an estimated 13,400,000 articles. (Elsevier 2019a).

The search was conducted on August 29, 2019. In the search field the following expression was used: "Engineering education" AND "skill" AND "Industry 4.0" AND "Project management". These research was made in "all fields". Only articles published from 2015 to 2019 were selected. The bibliometric research used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al. 2015; Stewart et al. 2015; Mcinnes et al. 2018; Liberati et al. 2009). The method PRISMA It is divided into four phases, concentrating on the way in which the authors perform a systematic analysis of the literature: identification, screening, eligibility and inclusion (Liberati et al. 2009). Second Moher et al. (2009), using this methodology helps authors facilitate readers understanding of how systematic reviews and meta-analyzes are performed.

4. Results and discussions

The Figure 1 shows the research flow and results according to methodology PRISMA.

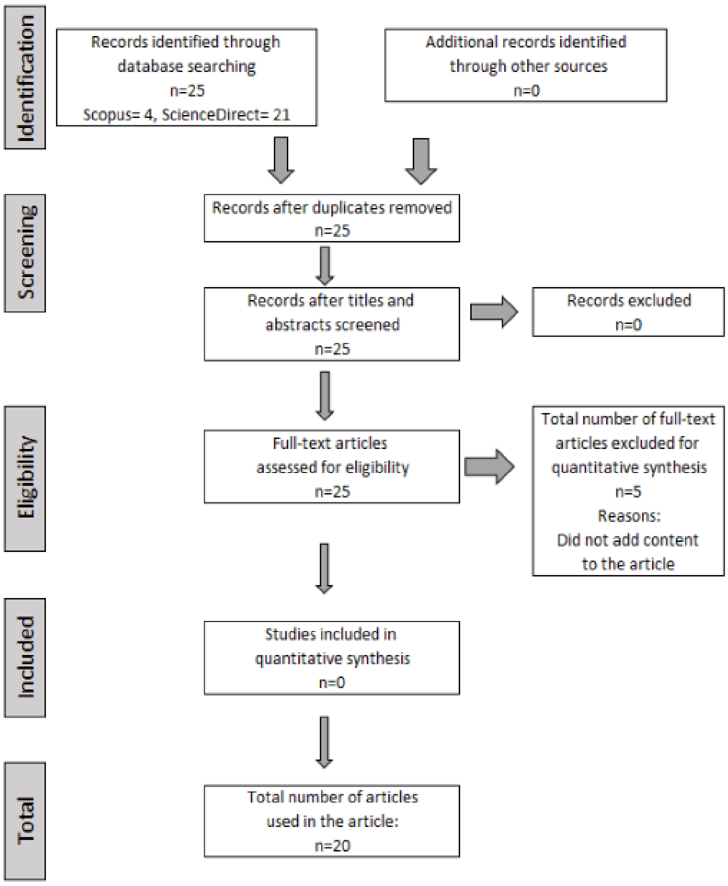

Figure 1. Protocol PRISMA and search results

In the first search conducted with the research themes was located at the data bases Scopus and Science Direct, 25 documents (Apendix 1). In the screening process it was found that there were no duplicate documents. The content was analyzed and it was identified that 5 of these documents did not contribute to the research problem. With the help of Software VOSviewer a word interconnection map was produced for readers to get a better understanding of the topic. Van Eck e Waltman (2009) consider that the VOSviewer is a software which allows the construction, visualization and interpretation of bibliometric maps. The results will be presented in the next item.

From the 25 documents found, Figure 2 was constructed**Erro! Fonte de referência não encontrada.**. For this we use the software VOSviewer. Following we will present the themes with the most interconnected words.

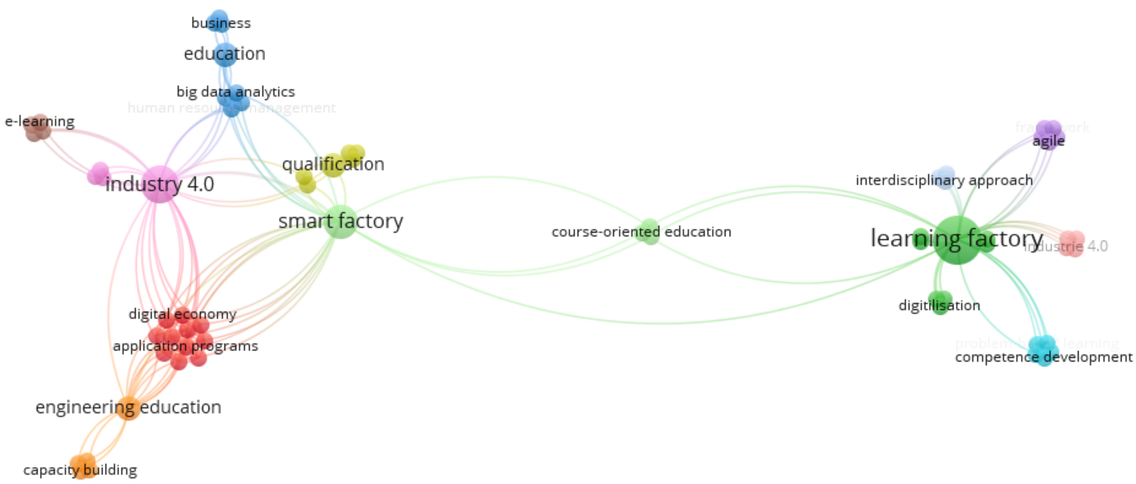

Figure 2. Main interconnection of words

According to **Erro! Fonte de referência não encontrada.**, the bigger the circle, the bigger the approach to the theme is in the documents that fed the software. Learning Factory (LF) was a very quoted word, drawing attention that it was not in the search terms, which evidences its connection in the field of researched themes. The Learning Factories are related to Industry 4.0, skills development and education oriented courses. Other topics include industry 4.0, engineering education, qualification, e-learning and education. If we take into consideration that the terms: “industry 4.0”, “the fourth industrial revolution”, “the 4th industrial revolution”, “smart manufacturing”, “smart production”, “smart factory”, and “smart factories”, are mentioned by Buer et al. (2018) and Liao et al. (2017) as the name of the new industrial revolution, we can say that the Learning Factories contribute directly to the professional development in technical and behavioral areas.

Caruso (2018) mentions in his research that Project Management follows coded formulas and planning and budget routines, often in conflict with the nature of work and ideas from creative industries. Hofmann et al. (2018) adds that project management incorporates all activities in order to achieve a goal, and that the skill set for managers are: vision, software techniques, quality vision and team autonomy. The Project Management is considered a professional competence (Müller-Frommeyer et al. 2017; Bender et al. 2015, apoud Heyse and Erpenbeck 2009), methodological (Buth et al. 2017; Müller-Frommeyer et al. 2017; Bender et al. 2015, apoud Heyse and Erpenbeck 2009) and operational (Lanz et al. 2018).

Vila et al. (2017) comments on the importance that Project Management brings, such as functionality related to business objectives, work breakdown structure definition, task assignments, resource allocation, workflow definition, approvals, configuration and change management, requirements and plan control project. In addition, the Project Manager needs to map the entire collaborative platform plan for ease of use. In conjunction with business management, proper Project Management provides a multicultural and multinational business landscape for technical aspects (Gordon et al. 2018). Pejic-Bach et al. (2019) contributes to research by addressing that project management and supply chain appear together in the area of continuous improvement, lean manufacturing and operational excellence.

A study in India found that industries expect students (professionals) to have knowledge in Project Management as they undergo constant transformations in pursuit of greater competitive advantage (Buth et al. 2017) highlighting the importance this skill (Pejic-Bach et al. 2019). Pejic-Bach et al. (2019) highlighting the Project Management importance for Industry 4.0 implementation. This revolution will bring many robots into the process, which reinforces the thinking of Benesová and Tupa (2017) that programmers will need to possess this skill in their qualification. It is also emphasized that this competence is more expected in information technology (IT) sectors than in other sectors (Siddoo et al. 2019). Kleinschmidt (2019) highlights the importance of this skill for engineers. To develop this skill, Louw and Droomer (2019) speak of the inclusion of Learning Factories could help develop the skills of engineering student. Kemény et al. (2016) reinforces too that Learning Factories simplify or reduce complex, large-scale production processes and provide safety for activities and learning.

Nyemba et al. (2019) comments that training in projects in the industry, brings an increase in problem solving skills, helps in the development of functional skills (Lanz et al. 2018). Bilge and Severengiz (2019) mention the importance of qualifying industrial engineering courses and the implementation of a game methodology and integration between company-school (student-professionals). This integration is one way to design sustainable factories and transform processes using Project Management. Ahmad et al. (2018) say that the Learning Factories improve students knowledge by conecting theory and practice, helping to bridge the educational gap about lean manufacturing. The account of Alberta Learning Factory (AllFactory), discusses that project-based experiential learning environment facilitates student development in interdisciplinary Project Management.

Block et al. (2018) in their research comment that Learning Factories approach knowledge in a practical way for students as well as instigate creative thinking through holistic approaches. Salah and Darmoul (2018) in their case study present complex design tasks and reconfigurable manufacturing system operations (RMS). From this Project Management methodology, students are urged to design, implement, evaluate performance, and operate a reconfigurable manufacturing, which means opening their minds to complex topics, modular, flexible systems, and interoperability in the design and operation of fabrication computer systems. Müller-Frommeyer et al. (2017) conclude that the union of Learning Factory and didactic concepts promote professional / methodological, social and personal skills, enabling autonomous but goal-oriented development. Buth et al. (2017) report that gap between academia and industry can be minimized through Learning Factories.

5. Conclusion

This research aimed to carry out a scientific mapping on project management and educational perspectives for industry 4.0. Such an approach has raised important findings.

The Project Management is directly linked to industry 4.0 as it will transform the entire production process. Transformations require projects, and knowing how to manage them is of paramount importance at a time when change is a constant. This brings us to a critical point, because as addressed the Project Management discipline is neglected in undergraduate courses, not meeting industry requirements and not arousing the interest of universities and students, which goes against expectations and requeriments of industry.

Finally, authors suggest the implementation of Learning Factories as a learning facilitator, working on Project Management in a real environment. Changes in academic curricula in search of skill-cutting, such as problem-solving skills, functional, professional / methodological, social and personal skills development, are also required. A didactic methodology with practices tends to arouse more interest from students than just classroom theory.

The authors also suggest partnerships between universities (with the application of active learning methodologies), with government that should provide funding, and with companies by training students to meet the required needs. Applying serious games in sustainable manufacturing areas via digital transformation can also be a study factor.

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References

Ahmad, R., et al., Alberta Learning factory for training reconfigurable assembly process value stream mapping, *Procedia Manufacturing*, v. 23, p. 237-242, 2018.
Almeida, N. O., and Neto, R. O., *Gestão profissional do portifólio de projetos: Maturidade e indicadores*, 1. Ed. Rio de Janeiro: Brasport, 2015.
Atkinson, R., Crawford, L., and Ward, S., Fundamental uncertainties in projects and the scope of project management, *International journal of project management*, *24*(8), 687-698, 2006.
Balve, P., and Ebert, L., Ex Post Evaluation of a Learning Factory–Competence Development Based on Graduates Feedback, *Procedia Manufacturing*, v. 31, p. 8-13, 2019.
Bender, B., et al., Learning Factory 2.0–Integrated View of Product Development and Production, *Procedia CIRP*, v. 32, p. 98-103, 2015.
Benešová, A., and Tupa, J., Requirements for education and qualification of people in Industry 4.0, *Procedia Manufacturing*, 11, 2195-2202, 2017.Bilge, P., and Severengiz, M., Analysis of industrial engineering qualification for the job market, *Procedia Manufacturing*, v. 33, p. 725-731, 2019.
Block, C., Kreimeier, D., and Kuhlenkotter, B., Holistic approach for teaching IT skills in a production environment, *Procedia Manufacturing*, v. 23, p. 57-62, 2018.
Brandão, H. P., and Bahry, C. P., Gestão por competências: métodos e técnicas para mapeamento de competências, *Revista do Serviço Público*, v. 56, n. 2, p. 179-194, 2005.
Buer, S.-V., Strandhagen, J. O., and CHAN, F. TS., The link between Industry 4.0 and lean manufacturing: mapping current research and establishing a research agenda, *International Journal of Production Research*, v. 56, n. 8, p. 2924-2940, 2018.
Büth, L., et al., Bridging the qualification gap between academia and industry in India, *Procedia Manufacturing*, v. 9, p. 275-282, 2017.
Caruso, L., Digital innovation and the fourth industrial revolution: epochal social changes?, *Ai & Society*, v. 33, n. 3, p. 379-392, 2018.
Carvalho, F. C. A. D., *Gestão de projetos*. *São Paulo*, 2015.

Chen, B., et al., Smart factory of industry 4.0: Key technologies, application case, and challenges, *IEEE Access*, v. 6, p. 6505-6519, 2017.

Crawley, E. F., et al., The CDIO approach, In: Rethinking engineering education, *Springer*, Cham. p. 11-45, 2014.

Dalenogare, L. S., et al., The expected contribution of Industry 4.0 technologies for industrial performance, *International Journal of Production Economics* 204 (2018): 383-394, 2018.

de Los Rios, I., et al., Project–based learning in engineering higher education: two decades of teaching competences in real environments, *Procedia-Social and Behavioral Sciences* 2.2, 1368-1378, 2010.

de Souza Cruz, M. T., and de Moraes, I. M. M., Empreendedorismo e Resiliência: mapeamento das competências técnicas e comportamentais exigidas na atualidade, *Pensamento & Realidade*, *28*(2), 2013.

Drejer, A., Organisational learning and competence development, *The learning organization*, *7*(4), 206-220, 2010.

Elsevier 2019, Scopus, Available in: http://www.americalatina.elsevier.com/sul/pt-br/science_direct_periodicos.php, Access in: 16 april. 2019.

Eelsevier, 2019a Science Direct, Available in: http://www.elsevier.com/solutions/scopus Access in: 27 octobeer, 2019.

Feisel, L. D., and Rosa, A. J., The role of the laboratory in undergraduate engineering education, *Journal of Engineering Education*, v. 94, n. 1, p. 121-130, 2005.

Fleury, M. T. L., and Fleury, A., Construindo o conceito de competência, *Revista de administração contemporânea*, *5*(SPE), 183-196, 2001.

Fleury, M. T. L., and Fleury, A. C. C., Alinhando estratégia e competências, *Revista de administração de empresas*, v. 44, n. 1, p. 44-57, 2004.

Gordon, S., Ryan, A., and Loughlin, S., Meeting The Needs of Industry in Smart Manufacture–The Definition of a New Profession and a Case Study in Providing the Required Skillset, *Procedia Manufacturing*, v. 17, p. 262-269, 2018.

Hofmann, E., and Rüsch, M., Industry 4.0 and the current status as well as future prospects on logistics, *Computers in Industry*, v. 89, p. 23-34, 2017.

Hofmann, C., et al., Development of an agile development method based on Kanban for distributed part-time teams and an introduction framework. *Procedia Manufacturing*, v. 23, p. 45-50, 2018.

Kemény, Z., et al., Complementary research and education opportunities—a comparison of learning factory facilities and methodologies at TU Wien and MTA SZTAKI, *Procedia CIRP*, v. 54, p. 47-52, 2016.

Kipper, L. M., et al., Scopus scientific mapping production in industry 4.0 (2011–2018): a bibliometric analysis, *International Journal of Production Research*, p. 1-24, 2019.

Kipper, L. M., Nara, E. O. B., and Mendes, F. I., Gestão por processos aplicada à gestão de projetos: uma metodologia para gerenciamento de projetos na indústria, *Sistemas & Gestão*, v. 8, n. 4, p. 402-414, 2013.

Khodeir, L. M., Blended learning methods as an approach to teaching project management to architecture students, *Alexandria engineering journal*, v. 57, n. 4, p. 3899-3905, 2018.

Kleinschmidt, J. H., Teaching internet of things for engineering courses: A project-based cooperative approach, *The International Journal of Electrical Engineering & Education*, p. 0020720919867437, 2019.

Koke, B., and Moehler, R. C., Earned Green Value management for project management: A systematic review, *Journal of Cleaner Production*, 2019.

Lanz, M., et al., A concept and local implementation for industry-academy collaboration and life-long learning, *Procedia Manufacturing*, v. 23, p. 189-194, 2018.

Liao, Y., et al., Past, present and future of Industry 4.0-a systematic literature review and research agenda proposal, *International journal of production research*, v. 55, n. 12, p. 3609-3629, 2017.

Liberati, A., et al., The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration, *PLoS medicine*. v. 6, n.7, 2009.

Litzinger, T., et al., Engineering education and the development of expertise, *Journal of Engineering Education,* v. 100, n. 1, p. 123-150, 2011.

Louw, L., and Droomer, M., Development of a low cost machine vision based quality control system for a learning factory, *Procedia Manufacturing*, v. 31, p. 264-269, 2019.

Lu, Y., Industry 4.0: A survey on technologies, applications and open research issues. *Journal of Industrial Information Integration*, v. 6, p. 1-10, 2017.

Mcinnes, M. D., et al., Preferred Reporting Items for a Systematic Review and Meta-analysis of Diagnostic Test Accuracy Studies: The PRISMA-DTA Statement, *Journal of the American Medical Association*. v. *319,* n. 4, p. 388-396, 2018.

Moher, D., et al., Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement, *Annals of internal medicine*, *151*(4), 264-269, 2009.
Müller, R., and Turner, R., Leadership competency profiles of successful project managers, *International Journal of project management*, *28*(5), 437-448, 2010.
Mrugalska, B., and Wyrwicka, M. K., Towards lean production in industry 4.0, *Procedia Engineering*, v. 182, p. 466-473, 2017.
Müller-Frommeyer, L. C., et al., Introducing competency models as a tool for holistic competency development in learning factories: Challenges, example and future application, *Procedia Manufacturing*, v. 9, p. 307-314, 2017.
Nyemba, W. R., et al., A systems thinking approach to collaborations for capacity building and sustainability in engineering education, *Procedia Manufacturing*, v. 33, p. 732-739, 2019.
Pejic-Bach, M., et al., Text mining of industry 4.0 job advertisements, *International Journal of Information Management*, 2019.
Pmi, Pmbok Guide, *Um guia do conhecimento em gerenciamento de projetos*, Pennsylvania: Project Management Institute, 2013.
Radujkovic, M., and Sjekavica, M., Project management success factors, *Procedia engineering*, v. 196, p. 607-615, 2017.
Raoufi, K., et al., Benchmarking Undergraduate Manufacturing Engineering Curricula in the United States, *Procedia Manufacturing*, v. 26, p. 1378-1387, 2018.
Rüßmann, M., et al., Industry 4.0: The future of productivity and growth in manufacturing industries, *Boston Consulting Group*, v. 9, n. 1, p. 54-89, 2015.
Salah, B., and Darmoul, S., Engineering Technology Education Based on the Reconfigurable Manufacturing Paradigm: A Case Study, *Procedia Manufacturing*, v. 23, p. 87-92, 2018.
San Cristóbal, J., Complexity in project management, *Procedia computer science*, v. 121, p. 762-766, 2017.
Siddoo, V., et al., An exploratory study of digital workforce competency in Thailand, *Heliyon*, v. 5, n. 5, p. e01723, 2019.
Silvius, G., Sustainability as a new school of thought in project management, *Journal of cleaner production*, v. 166, p. 1479-1493, 2017.
Stewart, L. A., et al., Preferred reporting items for a systematic review and meta-analysis of individual participant data: the PRISMA-IPD statement, *Journal of the American Medical Association*, v. 313, n.16, p. 1657-1665, 2015.
Thomas, J., Mengel, T., Preparing project managers to deal with complexity–Advanced project management education, *International journal of project management*, *26*(3), 304-315, 2008.
Van Eck, N., and Waltman, L., Software survey: VOSviewer, a computer program for bibliometric mapping, *Scientometrics*, v. 84, n. 2, p. 523-538, 2009.
Vila, C., et al., Project-based collaborative engineering learning to develop Industry 4.0 skills within a PLM framework, *Procedia Manufacturing*, v. 13, p. 1269-1276, 2017.
Xu, L. D., XU, E. L., and LI, L., Industry 4.0: state of the art and future trends, *International Journal of Production Research*, v. 56, n. 8, p. 2941-2962, 2018.
Zheng, P., et al., Smart manufacturing systems for Industry 4.0: Conceptual framework, scenarios, and future perspectives, *Frontiers of Mechanical Engineering*, v. 13, n. 2, p. 137-150, 2018.
Zhong, R. Y., et al., Intelligent manufacturing in the context of industry 4.0: a review, *Engineering*, v. 3, n. 5, p. 616-630, 2017.
Wilcox King, A., FOWLER, S., and ZEITHAML, C., Competências organizacionais e vantagem competitiva: o desafio da gerência intermediária, *Revista de Administração de empresas*, v. 42, n. 1, p. 1-14, 2

Biographies

Dantom Guilherme Helfer is an undergraduate Industrial Engineering student at the University of Santa Cruz do Sul (UNISC). During graduation has engaged in researches about Lean systems of production and industry 4.0: skills and technologies for sustainability. Has experience in scientific research due junior researcher experiences at program of post-graduation in systems and industrial process (PPSPI), where has developed research projects in the areas skills for Industry 4.0 and to project management. Currently, finishing the project course, whose theme refers to the implementation of Value Stream Mapping and Theory of constraints in a screw company.

Sandra Elisia Lemoes Iepsen is graduated in Production Engineering the University of Santa Cruz do Sul (UNISC). MBA in. Knowledge Administration and Management. Master student of the postgraduate program Master in Industrial Systems and in the research line of Monitoring, Simulation or System and Process Optimization. During this period been produced documents focused on skills management for Industry 4.0.

Liane Mahlmann Kipper is full Professor at the University of Santa Cruz do Sul (UNISC) and Coordinator of the Master in Industrial Systems and Processes from 2013 to 2015. She works in the Graduate Program in Systems and Industrial Processes in the areas of knowledge management, innovation and creativity, and in process management and research methods and techniques developing activities mainly on the following topics: process improvement, lean systems: innovation, creativity, product development and knowledge protection; and in process and technology management for process optimization and improvement. Has experience in Physics, focusing on Mechanics, Thermal Sciences, Optics and Experimental Physics. From 1995 until 2009 he worked with university management, especially in the research and postgraduate areas. Currently working with undergraduate courses in the technological area of UNISC and with the Master in Industrial Systems and Processes in the areas of process management and knowledge management.

Apendix 1. Articles located in Scopus and Science Direct databases

Article	Author/Date
A systems thinking approach to collaboration for capacity building and sustainability in engineering education	Nyemba et al. (2019)
Development of a low cost machine vision based quality control system for a learning factory	Louw and Droomer (2019)
Analysis of industrial engineering qualification for the job market	Bilge and Severengiz (2019)
Development of an agile development method based on Kanban for distributed part-time teams and an introduction framework	Hofmann et al. (2018)
Meeting The Needs of Industry in Smart Manufacture – The Definition of a New Profession and a Case Study in Providing the Required Skillset	Gordon et al. (2018)
Ex Post Evaluation of a Learning Factory – Competence Development Based on Graduates Feedback	Balve and Ebert (2019)
Holistic approach for teaching IT skills in a production environment	Block et al. (2018)
Alberta Learning Factory for training reconfigurable assembly process value stream mapping	Ahmad et al. (2018)
A Method for Improving Production Management Training by Integrating an Industry 4.0 Innovation Center in China	Yang et al. (2018)
Engineering Technology Education Based on the Reconfigurable Manufacturing Paradigm: A Case Study	Salah and Darmoul (2018)
A concept and local implementation for industry-academy collaboration and life-long learning	Lanz et al. (2018)
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