sciendo

QPI 2020, volume 2, pp. 117-130

USEFULNESS OF PROBLEM BASED LEARNING IN PREPARING ENGINEERS FOR INDUSTRY 4.0: LITERATURE REVIEW

doi: 10.2478/cqpi-2020-0014

Date of submission of the article to the Editor: 01/08/2020
Date of acceptance of the article by the Editor: 03/09/2020

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Abstract: Globalization and scarcity of resources have contributed to the need to meet and exceed customers' higher expectations while reducing the number of employees, workload and consumption of available resources. This situation was initiated by the fourth industrial revolution, hereinafter referred to as "Industry 4.0", which is based on the implementation of modern information technologies, associated with automation, artificial intelligence and a theory called the Internet of Things. All of this is aimed at improving efficiency, faster decision-making, which results in increasing the competitiveness of the company. Changes in the field of robotics, artificial intelligence and automation technologies indicate that with their increasing importance and implementation in organizations, there is a need to introduce new from teaching in the context of preparing engineers to work with new technologies based on cyberspace. The aim of the article is to review the literature on the importance of problematic teaching in the implementation of engineers for faster and more efficient implementation of Industry 4.0 in current production organizations.

Keywords: Industry 4.0, Problem-based learning, Learning organization, Use of PBL in teaching engineers.

1. INTRODUCTION

The increasing globalization and with it the digitalization of the working environment is progressing faster than ever before, leading to the penetration of information and communication technologies into all areas of life and work of modern man. The virtual world, in a way hitherto unknown, is beginning to permeate everyday life, creating Cyberspace, which is becoming the foundation for the future global world, where all devices will create a combined physical and virtual world, the Internet of things, data and services (German Academy, 2012). The direction in which we are now heading is called the fourth industrial revolution, Industry 4.0, that is, overcoming another barrier in which the coexistence of machines, devices and systems becomes a natural step towards the optimal use of human resources, knowledge and experience acquired over the last 300 years counted from the creation of the first steam engine by Thomas Newcomen in 1712 (Bohdal et al., 2014), which became the foundation of the first industrial revolution. The co-existence of machinery and equipment will allow people, objects and systems to be combined to create dynamic working environments that can be optimized in real time and then self-organized. It will also allow for optimization on the basis of previously adopted criteria such as: costs, availability or consumption of available resources (Obermaier, 2017). In the era of industrial revolution 4.0, workers should focus not only on acquiring the set of skills required to do the job, but also on preparing themselves to maintain 'competition with robots'. With the extended implementation of digitization and automation, workers will have to equip themselves with the right skills to 'survive' (Lee, 2013). Cautious selection of employees alone does not guarantee effective action. It will only be possible thanks to an effective focus on what to do and how to do the work. New forms of teaching come with help, which include problematic teaching. Properly implemented and introduced will ensure that the employee will know how to perform the task entrusted to him/her and what to do in a problematic situation, which will not be lacking in the process of implementing new forms of automation and digitization to existing or newly built factories. The goal of a well implemented problem-based learning program should be to provide the employee with a more understandable working environment, thus reducing his or her fears and implementing what the company expects from him or her in order to increase productivity and improve competitiveness in the global market. The experience of many companies shows that even the best training does not guarantee successful implementation of engineers into new realities and does not guarantee that it will be applied to its full extent (Schallock at al., 2018). Therefore, lecturers, trainers, instructors should actively participate in the process of solving the problem, be contemporary "Socrates" of Industry 4.0. They do not suggest solutions, but a series of questions and suggestions to direct employees on specific paths leading to the achievement of a given goal. Just as important as trainers in the process of problem education play also managers, who should support the processes of change in their company, identify areas that should be improved, initiate and implement projects together with employees (Schallock at al., 2018).Problem-based learning is especially important when two separate fields of science and industry meet, such as biotechnology (Skrzypczak-Pietraszek et al., 2017; Skrzypczak-Pietraszek et al., 2018) or material science with the participation of specialists dealing with the analysis of 2D and 3D images (Gądek-Moszczak et al., 2015; Ulewicz and Nový, 2016). This approach is also of particular importance in the analysis of industrial processes and identifying the root causes of failures and non-conformities (Pacana et al., 2014; Nowakowska-Grunt and Mazur, 2016), because formal knowledge must be combined with practical experience.

2. LITERATURE REVIEW

For the purposes of the article, a systematic literature review was conducted to search, identify and analyze each study on problematic teaching in the process of using teaching of engineers or production workers. This method allows to clearly determine how and to what extent the review was carried out through its transparency (Karaosman, 2017). The purpose of this review is to determine the current state of science in relation to problematic teaching in the process of educating pupils, students, employees of production plants. To answer the question what we already know about this subject, what we do not know and what should be further researched and described in relation to the problematic teaching process of implementation of a production worker into Industry 4.0. The researched studies are based on web resources of such sites as: Google Scholar, Science Direct, Research Gate.

Problematic teaching is one of many modern teaching methods, therefore the Education databases have been used as basic sources of knowledge. Through online university resources, books, scientific publications and journals have been selected, limiting their scope to the following conditions:

- Published in English,
- Date of publication 2005-2020,
- Full access articles,
- Only reviewed articles (this allowed for the exclusion of low-quality articles).

In planning the review, keywords used to search the databases were identified. These databases were filtered using keywords such as :

- Industry 4.0.
- Problematic learning,
- A learning organization,
- PBL in teaching engineers.

The analysis omits reviews, conference materials, working documents, book reviews and comments. The search was limited to scientific journals in the field of management and teaching. On this basis, 350 publications were selected. After the removal of duplicates, the first selection process was carried out in order to eliminate non-academic articles and those that were not fully available. Then, after the initial selection process, the articles were briefly reviewed, this stage consisted of reading their titles and summaries in order to select those that were directly relevant to the issues analyzed. In this stage, 200 publications were excluded, leaving 150 articles published between 2005 and 2020 and subject to further analysis. Finally, 44 scientific articles were analyzed, which met the above criteria. A detailed description of the systematic literature review is presented in Fig. 1.

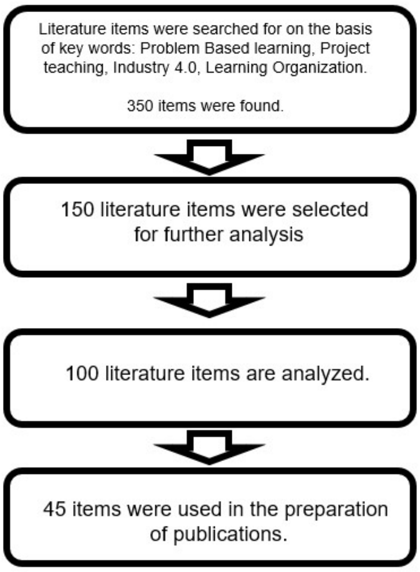

Fig.1. Selection of literature items

3. GENESIS AND CHARACTERISTICS OF PROBLEM BASED LEARNING

Problematic teaching is defined as a teaching philosophy that describes a set of principles and standards necessary for effective teaching (Graff and Kolmos, 2010). These principles can be modelled in any way, depending on the needs and goals to be achieved (Kolmos, 2010). It should also be mentioned that the process of problem based teaching was also strongly analyzed in Polish education. Many studies on problematic education have been produced. The precursors of problematic teaching in Polish education were Wincenty Okoń and his student, the propagator and author of the first study on the effectiveness of problem based learning Czesław Kupisiewicz (Kupisiewicz,1962).

Problem based learning is a concentrated method of learning through experience, i.e. solving an open problem imposed by the teacher, trainer. The main feature of this method is not to perform on a strictly defined method of solving a problem. The goal in itself is to develop the skills and qualities of the person being trained according to the expectations of the teacher, the trainer. This method includes gaining knowledge through action, teamwork and communication (Dolmans and Grave, 2014). This process allows students to develop skills used in their future practice. It strengthens critical appraisal, reproduces reality and encourages continuous learning in a team environment (Okoń, 1964).

The PBL method is based on working in small groups in which their members take on certain more or less formal roles. These roles are often changed and adapted to the actual conditions in which they have to solve a problem, take up the challenge of a given task. The problem-solving method is based on 5 steps, which include (Dahms, 2014):

- step 1 - feeling of difficulty;
- step 2 - formulation of the problem;
- step 3 - searching for solutions, creating hypotheses for potential solutions;
- step 4 - logical and if possible empirical verification of the hypotheses;
- step 5 - observation of the solutions introduced, acceptance or rejection of the solution, which consequently leads to a return to step three or even to step two.

The PBL method is a model example of teaching the seeker, perfectly fitting into the natural phases of human development regardless of age, education or social role. The classes conducted in this method are a natural sequence of consecutive activities, known to us from everyday life, which lead to solving a specific problem. W. Okoń emphasized with a clear emphasis that the final of a well conducted training is the student's ability to apply knowledge in everyday life (Okoń, 1964). The instructor acts as a moderator, guide and trainer, as opposed to traditional teaching, in which the instructor assumes the role of a knowledge transmitter. Once the necessary information has been gathered, students share their thoughts, build up their knowledge and solve the problem (Dahms, 2014). It has been shown that PBL improves students' learning because the problem does not have one correct answer, students use their critical thinking and clinical reasoning skills to find possible alternatives to solve the problem (Hmelo-Silver, 2004). The interest in the situation is triggered by the nature of the problem and acts as a motivating force that forces the learner to engage in self-learning (Schmidth, 2011).

Students work on problems that increase student involvement in learning and motivate students to learn (Allen at al. 2011). As students continue their self-study, their knowledge is constantly modified and improved. In this way, students have the opportunity to build their own professional knowledge and help them to maintain their knowledge building (Allen at al. 2011).

PBL, students reflect on the learning process at different stages of the process (Downing at al., 2011). At the beginning of the problem solving process, students combine their new knowledge with existing information. Then students reflect on the appropriate resources they currently have and need. Finally, students reflect on the strategies used to solve the problem and reflect on them, listing both the advantages and weaknesses of their strategies (Downing at al., 2011). PBL also improves the process of metacognition (Hodges, 2012). It should also be emphasized that working with PBL teaches group collaboration rather than individual competition (Rakhudu, 2011). Another premise of the PBL is that working in small groups helps students distribute the cognitive load among the team and helps students solve a problem in a group that would be difficult to solve alone (Hmelo-Silver, 2004). As a result of group collaboration and individual learning, which equally contribute to the learning process (Meo, 2013).

There are many challenges associated with PBL implementation that are not related to the teaching method itself, but to other factors such as the attitude of lecturers to this form of teaching, leadership, culture and necessary infrastructure. The lecturers' approach to PBL may significantly weaken the learning outcomes, which was perfectly illustrated by Lim in his research, which showed that a certain number of lecturers who were obliged to teach with PBL stated that the only relevant way, according to them, is direct teaching, transmission of information by someone who is an expert on content (Lim,2011). Other instructors, on the other hand, consider PBL to be time-consuming for teachers due to the workload (Ribeiro, 2011). The results also showed that the majority of teachers felt that there was no need to change the lecture-based instructions as both teachers and students were satisfied with the current teaching method. Some teachers claimed that PBL prevented them from sharing their knowledge and experience with students (Rakhudu, 2011), made them passive and caused fears that not all students would be active participants of the group, which obviously excludes a well implemented methodology of problematic teaching (Raftery at al., 2015).

4. INDUSTRII 4.0.

In 1763 James Watt perfected the steam engine built earlier by Thomas Newcomen, giving the beginning of humanity on the way to new discoveries and becoming the nucleus of the first industrial revolution that changed the world forever (Bohdal at al., 2014). After subsequent decades full of stormy changes of new inventions and undertakings, Electricity appeared, which was the foundation of the second industrial revolution (Furmanek, 2018). It brought humanity out of darkness to a world that was no longer limited by the natural cycle of life, day and night. The third step on the road of the uninterrupted industrial revolution was the emergence of new solutions in the field of microelectronics, information technology and production automation. The idea, the concept of Industry 4.0 was first cited in an article written by Lee J., who proposed to define new possibilities for the future German economy. In the article, he presented the assumptions of a modern German production organization, which, according to him, should consist in the future of information systems, controlled machines operating autonomously in an artificial intelligence environment, which will perform self-control, self-configuration and repairs (Lee, 2014).

The essence of the fourth revolution is the cyber physical space created by hardware, software, network and, of course, people (Baldassari, 2018). It was the cyber physical space that became the foundation and the main difference between the previous revolutions. It allowed for changes that have not been experienced by man in any of the revolutions described before. The concept of Industry 4.0 is mainly based on intelligent network systems that carry out self-regulatory production based on mutual communication of people, machines and equipment (Kovacs, 2014). Figure 2 presents the development of industrial revolutions over the past 100 years.

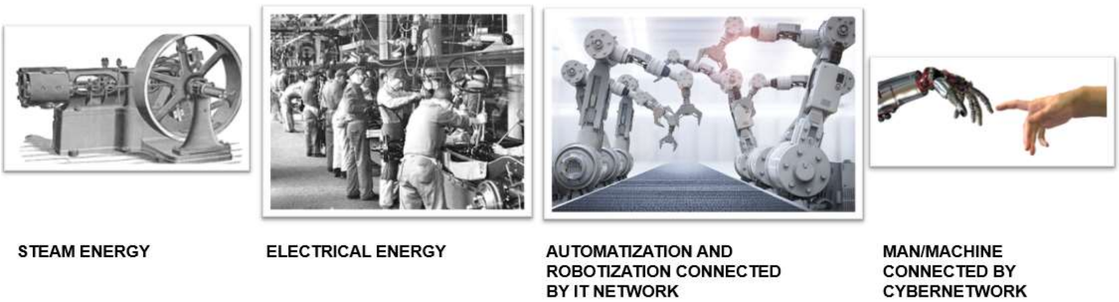

Fig.2. The development of the industrial revolution over the years

Industry 4.0 significantly affects the production environment, causing radical changes in the execution of operations. As opposed to conventional forecast-based production planning. The future entails the creation of production plans in real time, with dynamic self-optimization (Sanders at al., 2016). Such production management is facilitated by the rapidly decreasing cost of the given IT equipment. The creation of the "cloud" means that data is theoretically available anywhere, and the proliferation of laptops, tablets and smartphones means that anyone can access the data. Widespread trends have made information virtually free and available in real time. This is important for how it is collected and used. The network has made it possible to connect virtually all the media, machines and devices around us (Baldassari at al., 2018). Generating, transferring, processing and analysing large data sets in real time - online has laid the foundations for new interactions in the real and virtual world. It has also directly changed the organization of the value chain in a manufacturing company. The pace of technological development has led to the moment when the computing power of super computers has increased by more than 3,500 % over 18 years, from 2000 to 2018 (Zielewski at al., 2017). Indeed, Moore's right to double the computing power of computers every 2 years until it reaches its physical limits has been confirmed (Sienkiewicz, 2015). Special attention should also be paid to data storage costs, which have decreased by about 100 % over the last 17 years. The increase in the generated data caused that it is estimated that more than 80% of the data in the world's history was created in the years 2015-2018, as a consequence of which the number of devices connected to the network also increased. In 2020, there may be over 50 billion of them, i.e. 9 times more than human beings on Earth (Zielewski at al., 2017). No one is surprised anymore by the development of artificial intelligence and machines that can use machine learning algorithms to predict, make decisions or prevent consequences caused by wrong decisions.

The fourth revolution is the material and immaterial space that allows for the development of technologies that so-far were only in the sphere of dreams, mathematical deductions and hypotheses of scientists. This revolution is autonomous cars, drones and robots connected by a computer network. Chat bots communicating with people, replacing assistants and henchmen. Figure 3 shows the relationships and data flow creating Industries 4.0.

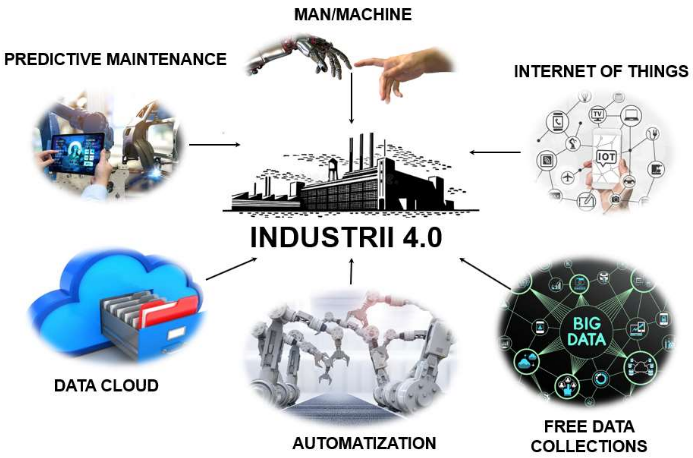

Fig.3. Factories of the future in the industry 4.0

Brynjolfsson and McAfee, claim that this time the current revolution will bring us not only the automation of physical work that the third industrial revolution has brought about, but above all "computers and other digital technologies will do with the work of our brains what the steam engine and its successors have done with the work of our muscles"(Brynjolfsson, 2014). It should be noted that connectivity and data availability alone did not increase productivity because, contrary to appearances, ease of access to data overwhelmed workers with a lot of data. Employees focusing on a large amount of information started to omit relevant data. The interpenetrating real and virtual worlds have had and are having a significant impact on production and decision-making processes.
Key for today's entrepreneurs, engineers, professionals and employees has become Alvin Toffler's saying that "The illiterates of the 21st century will not be those who do not know Excel or cannot program, but those who cannot learn, unlearn and relearn" (Chan, 2010).

5. USE OF PROBLEM BASED LEARNING IN THE PROCESS OF IMPLEMENTATION INTO INDUSTRY 4.0

There is no clear answer whether the problematic teaching method can become a panacea for problems related to the implementation of Industry 4.0 in modern production facilities. To offer any solution that could accelerate the implementation of engineers to new professional realities created by the current world of cyberspace and dynamically progressing automation and robotization (Graff and Kolmos, 2007). The very essence of PBL has been repeatedly described and discussed. Different opinions on the effectiveness of PBL as a teaching and learning methodology have emerged (Hmelo-Silver, 2004). Hmelo-Siver C. in his study "What do you know about problem based learning? Current staus and future perespctive", he described 5 advantages of using problem-based learning in the engineering community (Hmelo-Silver, 2004):

- it helps to acquire flexible knowledge.
- it effectively develops problem solving skills.
- Creates independent learning of skills.
- Effectively strengthens the ability to cooperate.
- Internally motivates.

Many studies have confirmed the advantages of PBL, although there has been little research on PBL's approaches to Industry 4.0 and its application to the quicker adaptation of employees to new realities of work. Research on medical, engineering and scientific education is widely documented, but there is a lack of research on the application of PBL to the realities of Industry 4.0 (Chan, 2010). On the basis of his research on a group of engineers, Chan K.G. has unequivocally determined that the use of teaching techniques such as problem and design teaching resulted in increased motivation to learn, creating better hypotheses, which became the basis for quicker reaching the goal and solving the problem/challenge (Othman at al., 2007). This is also confirmed by China C. and Chia G.L.'s research, claiming that problem-solving teaching methods including problem identification by students were more effective and thus shortening the time to introduce new knowledge in the process of teaching engineers (Chin at al., 2010). Students also became more involved in learning and became more creative and critical (Savitri at al., 2016). On the other hand, Graph and Colmos were convinced that PBL also contributes to the strengthening of interdisciplinary knowledge and skills. It has the potential to increase the cognitive competitiveness of individuals by eliminating barriers that may inhibit work processes and encourages students to use relevant and meaningful information in the actual situation (Graf and Kolmos, 2007).

Problem based learning was born out of cognitive science, based on the simple premise that problems should not precede answers. The learning process begins with the presentation of an engaging problem, question or riddle to the student. Students discover course concepts for themselves by exploring the problem. However, participating in an educational event and researching it often provides an impulse to engage content and develop skills, as experts do in practice (Chan, 2010).

Savitri B., Biplob R., Fariza S., claimed that PBL is also useful in the process of improving engineers' skills such as management, cooperation and communication, because the need to solve the problem encouraged cooperation, teamwork. In situations where a group of students emerged, they had to share their responsibilities and select a leader, which resulted in the development of their soft skills (Savitri at al., 2016). Other more or less intended learning outcomes of problem-oriented teaching of engineers in the process of transformation to industry 4.0 are also worth considering (Baldassari and Roux, 2018):

- ability to work on projects.
- ability to work in a team.
- Independent learning.

Hmelo-Silver argued that future engineers in the face of transformation should regulate their own cognitive processes, adapting them to the requirements of the situation and the goals they pursue in it in order to identify what they do not "know and need to learn more about the solution to the problem (Hmelo-Sillver, 2004). Implement the new situation more quickly and take control of it. Identify more accurately the learning problems associated with the hypotheses by developing a well-defined starting point for your hypothesis in the plan you generate and incorporating new information into the problem solving. Ninan N., using the case study method, monitored and documented the results of pioneering research by students who undertook an entrepreneurship program designed using PBL. They found that PBL emphasized active learning by solving problems from the "real world. A multi-solutions approach is likely to have an advantage if it is considered a pedagogical strategy for teaching engineers their adaptation to the dynamically changing work and living environment (Ninan at al., 2019). Studies conducted by Ninan N., Roy C.,J., Thomas M.,R. on the PBL method have shown that students have been able to take a more proactive role in learning, have been more willing to develop self-management skills for their own learning and have been more independent in exploring and expanding their knowledge (Ninan at al., 2019). Kivel R.J.'s research has also shown that PBL teaching can become both fun and difficult for students. They also stressed that they value communicative and interactive educational activities more than the traditional teaching method conducted by means of lectures (Kivela and Kivela, 2015).

Brownell J., on the other hand, claimed that PBL uses the synergy between cognitive, emotional and behavioral learning. Although management education usually favors cognitive learning, affective learning is equally important. PBL helps students to appreciate multiple perspectives, recognize irrational elements of decision making and address ethical issues. Together, cognitive and emotional learning form the basis for a third essential element: behavioural learning (Mohd, 2010). According to Posner, to integrate new concepts into existing trends . According to Posner, in order to integrate new concepts into existing teaching trends, a thorough restructuring of the entire knowledge structure is necessary. For students to be ready for restructuring, four conditions must be met:

- dissatisfaction with existing concepts plus comprehensibility,
- credibility,
- the superiority of the new concept.

The engineering knowledge is probably richer in structure. According to De Jong and Ferguson-Hessler, physical knowledge requires additional dynamic action-oriented structures to solve problems: knowledge that says what concepts, laws etc. can be used in a specific situation and how. The psychology of learning applied in the strict/technical field also sees learning as a constructive action. At first glance, especially in difficult abstract subjects such as mathematics and physics, it seems that telling students is more effective than letting them out to solve a problem. Harel and Kaput emphasize how important it is even to construct one's own language of notation in mathematics before using conventional notation. They point to the beneficial effect of collaborative learning in this process (Chan, 2010). In engineering, professional problem solving is of a different nature than in other scientific fields. The solution of a design problem involves the process of analysis, modelling, experimentation and realization, in which many choices have to be made. Developing new products and methods and applying existing knowledge in new situations is a key activity of engineers. Another important difference between engineering and other scientific disciplines is the time scale of the actual problem-solving process: designing a bridge takes more time than making a diagnosis, for example. In big engineering problems, smaller problems of mathematics, physics, etc. are embedded. Solving mathematical problems in engineering requires knowledge of mathematical concepts, ability to solve techniques and insight into relations between them (Mohd, 2010). Many aspects of mathematical problem solving of this kind can be learned very well in group work alternately with individual problem solving and interaction with the teacher. In addition to solving problems on their own, students must also observe realistic expert problem-solving to see strategies and heuristics in action (Mohd, 2010). In an era of increasing globalization and digitization, the use of software and computer applications has become a standard, which makes insight more important than the ability to solve technical problems. However, this requires additional training in the use of these tools. As we have seen earlier, in solving physics problems in engineering, heuristics is less important, but it is more important to know the situations in which specific concepts and algorithms should be applied (Abersek, 2018). Part of solving engineering problems also involves "translating" physical problems into mathematical models. These embedded problems in mathematics and physics often have a smaller time scale compared to the PBL process, and the problems are of monodisciplinary origin. In conclusion, the acquisition of professional problem solving skills is very important in engineering education, but the PBL approach is insufficient and should be complemented by problem solving activities on a smaller time scale as well as on a larger time scale (Walsh, 2017). For smaller problems, group work with targeted individual or interactive tasks and teacher-led discussions are appropriate. PBL is possible as a partial strategy, in particular to demonstrate the context of the application in the early stages of the curriculum. For learning to solve large engineering problems, project work seems more appropriate as the time scale and scope of project activities better reflects reality (Walsh, 2017). Socio-emotional aspects are equally important in project work and PBL, but technical-organizational aspects are more important in project work. This makes the project work more interesting for engineering professionals. It states that lecturers in scientific and professional fields are more likely to use formal, didactic teaching methods and that they are less liberal in their approach to student learning. The conceptual models used in the teaching of engineers are an adaptation of the Crossan model or 4I: intuition, interpretation, integration, institutionalization, and feedback. In this model it is assumed that all activities undertaken within the framework of learning organization are important for Industry 4.0, in particular: management intuition, empowerment of employees, work in project teams, flexible organizational structure, horizontal communication, prevention of deviations, creativity, innovative competences and problem solving skills (Jenkin, 2013). Industry 4.0 gives organizations the opportunity to question the assumptions about how they have always acted in their organizations. In this context, leadership plays a decisive role in initiating change. This is in line with the findings of Vera and Crossan, who emphasize the importance of strategic leadership. The proposed conceptual model can be useful for further analysis and research on the importance of organizational learning for Industry 4.0 (Jenkin, 2013; Ślusarczyk, 2018). With its help, management staff can analyze the organization's readiness to implement Industry 4.0. This can facilitate decision-making in the context of adopting and implementing Industry 4.0 and provide guidance for transforming organizational learning into tangible benefits. Above all, the implementation of Industry 4.0 requires management support, which encourages workers to seek new solutions to problems and engage in innovative behavior, including the use of Industry 4.0 [5]. Secondly, the framework of shared knowledge developed in the organization leads to the development of common meaning, consistent interpretation of problems and behaviours towards problems encountered by the organization. This importance results from a number of agreements generally accepted by employees (Baldassari and Roux, 2018). Thirdly, teamwork and cooperation of employees in solving problems accelerate decision-making processes and facilitate learning and innovation (Baldassari and Roux, 2018). Fourthly, a flat organisational structure accelerates the flow of information, contributes to the independence of employees and increases the opportunities for employees to participate in discussions on Industry 4.0 and in decision making (Ninan, 2019).

6. CONCLUSION

Today's organizations are under strong competitive pressure to improve efficiency and meet the ever-increasing demand from customers who have highly personalized expectations for innovative products at competitive prices. This requires organizations to reduce costs, improve efficiency by increasing the level of integration, communication and collaboration between business processes, which in turn involves adopting innovative solutions.

The emergence of Industry 4.0 is the answer, a kind of 'panacea', to the dynamics and complexity of adopting these new and rapidly developing concepts. However, Industry 4.0 is a revolution in itself that demands a new, more thorough form of commitment from companies. The literature of the topic clearly indicates that only the learning organization will be able to take full advantage of the opportunities of the dynamically entering into our cyber-world, where all operations will take place here and now, in an "Online" mode. This paper uses publications in English from international educational databases, which have been used to demonstrate that problem-based learning has many positive learning outcomes. Above all, it supports the key skills of future engineers in order to ensure optimal use of engineering skills. These include skills such as critical thinking, clinical reasoning, group collaboration, problem solving, building professional knowledge, self-study and self-motivation to learn.

The PBL has shown positive learning outcomes in many countries around the world, which shows that this teaching method can be applied in different conditions if, of course, this form of learning is well planned and implemented. The publication also showed that there are still very few publications on the use of problem-based learning in the process of introducing engineers to the new realities of Industry 4.0 and this may be a starting point for further analyses of the importance of problem-based learning for Industry 4.0.

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