Mapping the desirable management engineer's competencies

Mapeamento das competências desejáveis aos engenheiros de gestão

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RESUMO

Objetivo: Há uma demanda no desenvimento da qualidade da formação dos engenheiros. Contudo, surge uma questão: quais são as competências desejáveis aos engenheiros de gestão? Este artigo apresenta as competências recomendadas aos engenheiros de produção. Medodologia: O método utilizado envolveu uma revisão sistematizada de 42 artigos indexados nas bases Scopus e WOS em busca de competências do engenheiro de gestão. As competências encontradas na literatura foram então comparadas com aquelas listadas por associações de engenharia. Resultados: Foi encontrato um conjunto de 29 competências recomendadas aos engenheiros de gestão nos artigos analisados. Somente 23 competências são mencionadas em associações de engenharia, tais como: ABET, IEA, NAE e NBA. Também foi possível observar uma ênfase nas habilidades comportamentais. Originalidade: Esse artigo preenhe uma lacuna no tema, já que não foi encontrado na literatura um trabalho que compare as competências encontradas na literatura com aquelas listadas por associações de engenharia. Implicações para teoria e prática: Os resultados podem ser valiosos para pesquisadores em educação na engenharia e profissionais que atuam no ensino superior como suporte para trabalhos no desenvolvimento da carreira dos estudantes de engenharia de gestão.

Palavras-chave: engenharia de produção, desenvolvimento profissional, educação na engenharia, desenvolvimento de currículos.

ABSTRACT

Paper aims: There is a demand for quality development in forming engineers. However, a question is still alive: what are the competences cited as desirable for management engineers? This article presents the competencies for management engineers. Research Method: The method used was a systematic review covering 42 articles published in journals indexed in Scopus and WOS looking for management engineering competencies. The competencies mapped in the literature were then compared with those listed by engineering associations. Main Findings: It was found a set of 29 competencies mentioned in the articles analyzed as desirable ones for management engineers. Only 23 are also mentioned by professional associations that defines engineering competences, alike: ABET, IEA, NAE and NBA. It is also possible to observe an emphasis on awareness skills. Originality: This article covers a gap in the subject, once it was not found in the literature a previous work that compare the competencies mapped in the literature with those listed by engineering associations. Implications for theory and practice: The results should be worthy for both: engineering education researches and higher education professionals as support for their work in developing the professional career of management engineering students.

Keywords: production engineer, professional development, engineering education, curriculum development.

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Introduction

Global engineers need to be equipped with competencies, skills, abilities and knowledge to deal in the world of work. There are articles published in the academy that highlight the need to the development of alumni' competences in engineering education. (Manzoor et al., 2017; Kulkarni et al., 2017; Podges & Kommers, 2016; Iman & Tasadduq, 2012; Savage et al., 2007).

Lima et al. (2012) and Gereffi et al. (2008) agree that engineers must develop competencies as the ability to manage projects, work in teams, communicate effectively both oral and written with others, think creatively, deal with lack and complexity of information, and have a holistic view of the sectors. These requirements pose new challenges to engineering education models and the necessity to identify these competencies.

According to Boud et at. (2009), it is vital to know the competencies of the management engineer and upgrading its skills to build up a better workforce. Professionals skills are updated from time to time, and management engineering programs need to be aligned with market demands. The students need to acquire appropriate competencies for a labor market in constant change.

The need to develop the professionals' competencies, skills and abilities is not new, there are articles who claim for that. However, there is no paper comparing the competencies cited in the academic literature with those of engineering support and credit entities.

The question of this paper is: what are the competencies of the management engineer mentioned in the academic literature? Do they adhere with the competencies listed in engineering support and credit entities? The purpose of this article to respond that is mapping the competencies for management engineers identified in the academic literature and compares with those listed by engineering support and credit entities.

Some may wonder why this work brings the skills of the management engineer, Custovic (2015) asserts that all engineers should take into account the competencies of the management engineer. In a complementary way Ram et al. (1999) claim that many skills of this modality of engineering are vital to all engineers. Taking into account the exposition by these authors, this article was based on the look for competences of this modality of engineering.

Boud et al. (2009) say that these professionals have to be prepared for a labor market in which they can be expected to acquire appropriate skills that are suitable for different sectors, countries and cultures. The results are valuable as they ensure that the professional profile of a management engineering graduate represents the global and not regional competencies.

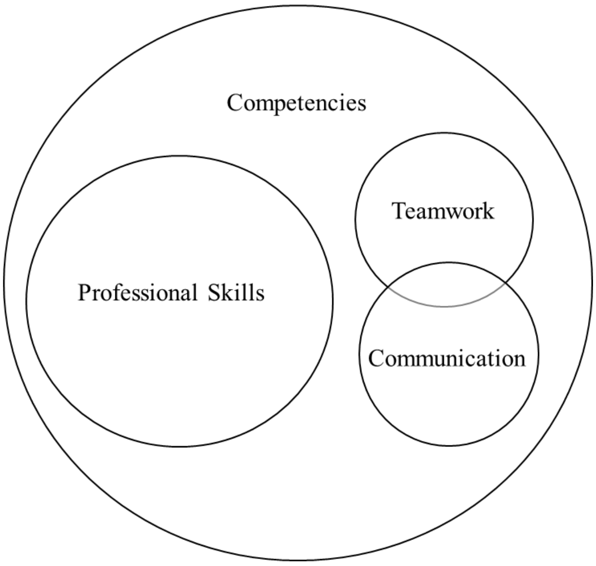
Literature Review

Competencies

According to Lima et al. (2012), engineering education has focused its attention on the development of competencies. A much-used approach to the development of these competencies today is the outcome-based learning, on what Iman & Tasadduq (2012) affirm that is to improve the learning of students. The meaning of outcome describes what students are expected to know in the marketplace, and there are related to the skills, knowledge, and behaviors that students acquire as they progress through the engineering program. In outcome-based learning, the results presented by the students, composed of a set of competencies are the point of the learning process.

The set of skills, knowledge, and behaviors are also called competencies, Borchardt et al. (2009) point out that there are related to performance, and the process of competence generation occurs dynamically. Crawley (2001) states that competencies allow a person to perform a given activity. They encompass both the professional skills needed for problem solving, knowledge discovery and systemic thinking, as well as the interpersonal skills that involve communication and teamwork. According to Figure 1.

Figure 1
View of Competencies



Note. Adapted of Crawley (2001)

Page & Stanley (2014) and Shuman et al. (2005) argue that professional skills split into three types of skills. Technical skills are those that allow the professional to solve problems. Process skills are related to communication, ability to work in teams and deal with dilemmas. Already the awareness skills involve the analysis of the impact of actions, social-ambiental responsibility and the ability to do lifelong learning. Alves et al. (2016a) consider that process and awareness skills can also be called transversal skills. In this work, the term competence is established considering the different types of skills.

Management Engineering

Management Engineering is related to Production Engineering, Industrial Engineering, Business Engineering or Enterprise Engineering (Lima et al., 2017; Jesus & Costa, 2015; Marin-Garcia & Lloret, 2011; Marin-Garcia et al., 2009; Elrod et al., 2007). Can be noted these terms involve many areas of knowledge and different programs of engineering. Because of that, Custovic (2015) asserts that all engineers should consider the skills of the management engineer. Ram et al. (1999) assert that the competencies, skills and abilities of this engineer is important to all engineers. Mahadevan (2014) note that engineering often takes place across countries, professions, cultures, and organizations. The author raises the need to develop an integrated diversity of competencies in engineering. Analyzing this context, it is entirely consistent that the competencies needed by management engineers should be applied to all engineers.

According to IISE (2019), management engineers must continuously plan, execute, control, and improve integrated systems. It should be noted that systems involve people, materials, information, equipment, and energy. To achieve this goal, professionals must develop a set of competencies aligned to the application of both exact and social sciences.

Boud et al. (2009) and Bayard et al. (2007) argue that professionals must have a wide variety of activities and tasks with increasing complexity. It is crucial to equip management engineers with interdisciplinary knowledge, a vital point for technological change and international competition.

Buch (2016) argues that the management engineer must have holistic view, their practices should be relevant to the kind of problems and challenges provided by problems such as sustainability, global warming, health, and security. These problems are often unique, complex, heterogeneous, ill-defined, and even wicked, and the management engineer is the professional who values the integrative, facilitating, strategic, and holistic view of problems.

Lima et al. (2017) add the professionals should be able to apply their skills to model and operationalize production systems, often with the use of tacit knowledge acquired in the analysis, experimentation of the workflow and with the evaluation of the ergonomic aspects involved.

Marin-Garcia & Lloret (2011), Marin-Garcia et at. (2008) and Salvendy (2001) explain that the professional can handle the planning, modeling, development, deployment, implementation, improvement and evaluation of processes or integrated systems, people, technology and information management. Paying attention to forecasting results and eliminating wasted resources.

Engineering Education and Curriculum Development

The curriculum of any engineering program should reflect the country's legal guidelines and accrediting bodies suggest a program of disciplines needed to shape the professional with market demands. In the case of management engineering, which can also be called as production engineering, industrial engineering, business engineering or enterprise engineering, it is recommended to look at the guidelines listed by the Institute of Industrial & Systems Engineers (IISE).

The Institute of Industrial & Systems Engineers (IISE), which helps to improve complex organizations around the world and across industries. Members of IISE build tools and connections that provide an integrated and systemic perspective for business challenges. It is an international, nonprofit association that aims to develop the industrial and systems engineering.

Moreover, according to Boud et al. (2009), some issues need to be kept in mind when developing a curriculum. It is necessary to establish the necessary competencies to shape the professional, considering both technical and non-technical skills. With that in mind, create appropriate content or subject matter for the development of competencies.

Boud et al. (2009) also say that the professional profile of an engineering graduate must be qualified to act in the global and not regional market scenario, due to the increasing globalization of engineering education. Because of this, it is suggested that competency mapping should not only consider regional opinions.

Riis et al. (2017) suggest that teachers may have to change their attitude and creates new ways of stimulating learning and thus being able to design an innovative curriculum. Alves et al. (2016b) and King (2012) highlight changes in engineering education, such as a better understanding of the human condition; understanding of the process of learning; work in teams with persons from other disciplines; and communicate effectively. It is normal to improve an engineering curriculum from time to time. This statement further supports the need to identify competencies that support curriculum development.

It is necessary to clarify the entities that work for the development of engineering and organs that credit engineering programs covered in this paper:

- The Accreditation Board for Engineering and Technology (ABET) is a nonprofit, non-governmental organization with the purpose of assuring confidence in university programs in science, technology, engineering and mathematics disciplines. The disciplines are accredited to the associate, bachelor's and master's degree levels. The organization was established in 1932 by seven engineering societies: the American Society of Civil Engineers (ASCE), the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), the American

Society of Mechanical Engineers (ASME), the Institute of Electrical and Electronics Engineers (IEEE), the American Society for Engineering Education (ASEE), the American Institute of Chemical Engineers (AIChE) and the National Council of Examiners for Engineering and Surveying (NCEES). Although most accreditations take place in the United States, they can cover all continents, and a relevant number of articles indexed in the scopus database comment on this organization. Therefore, it is necessary to involve the ABET in this research.

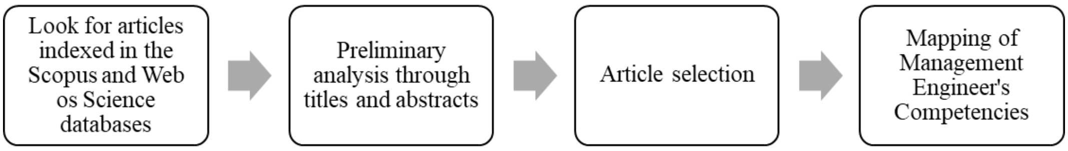
- The International Engineering Alliance (IEA) also is a notforprofit organization, and involves 29 countries. IEA is involved in seven international agreements, and these agreements predict the recognition of engineering educational qualifications and professional competence. The organization seeks to improve engineering education and competence globally with the publication of accords and agreements. They develop a cohesive framework of good practice for graduate attributes and competence profiles. Thus, is interesting to involve IEA in research.
- The National Academy of Engineering (NAE) is a private, independent, nonprofit institution that provides the well-being of the nation by promoting the engineering profession and the development of issues related to engineering. NEA was founded in 1964 and is considered the greatest achievement in the fields related to engineering, this may be one of the reasons for considering NAE in this research.
- The National Board of Accreditation (NBA) is the entity that promotes quality improvement for engineering in India. The proposal is to stimulate the quality of teaching, self-evaluation, and accountability in the higher education system. They promote teaching practices that enable them to produce high-quality professionals, advising and accrediting the programs offered by the institutions. NBA was established by the All India Council for Technical Education (AICTE) in 1994, operated as an autonomous body since 2010, and it was granted a full membership status in the Washington Accord in 2014. This may be a plausible reason to involve the entity in this research.

In addition to the stories made above, such entities were found in the analysis of the articles referenced in this research. Mainly for this reason, only these associations are being considered.

Research Method

The method was divided into four steps: first, there was a search for articles published in journals and congresses indexed in the Scopus and Web of Science databases. Second, a preliminary analysis was made considering the titles and abstracts of each article. Third, the article selection criterion was: if the article describes competencies relating to the management engineer, then select him. Fourth, the management engineer competencies identified in the articles were listed in a chart. Figure 2 illustrates this process.

Figure 2
Research Process



Note. Prepared by the author

Shukla et al. (2019) assert that Scopus and Web of Science databases are one of the widely used databases for researches. Scopus has a broader range of publishing article indexing, and Web of Science concentre high-quality publications.

Thus, the words that were used in the research were skill, competence, business engineer, enterprise engineer, management engineer, industrial engineer, or production engineer and engineering education. The query used in the Scopus database was:

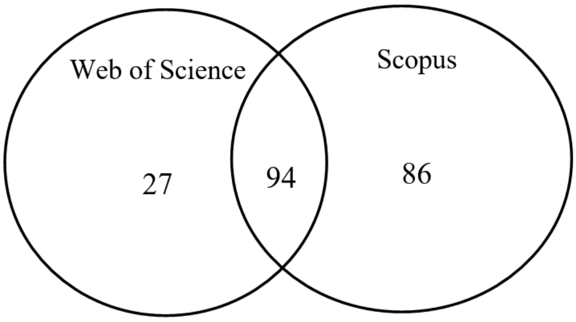
(TITLE-ABS-KEY (skill* OR competenc*) AND TITLE-ABS-KEY ("business engineer*" OR "enterprise engineer*" OR "management engineer*" OR "industrial engineer*" OR "production engineer*") AND TITLE-ABS-KEY ("engineering education"))

Already in the Web of Science database:

TOPIC: (skill* OR competenc*) AND TOPIC: ("business engineer*" OR "enterprise engineer*" OR "management engineer*" OR "industrial engineer*" OR "production engineer*") AND TOPIC: ("engineering education")

Documents have been filtered by articles only. Removing 15 duplicate records, 94 articles were selected in both databases, according Figure 3.

Figure 3
Database Reports



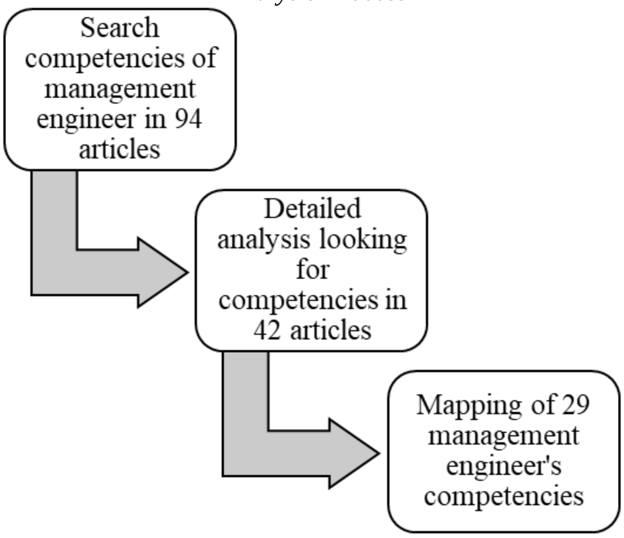
Note. Prepared by the author

It was important to consider some entities that works for the development of engineering and organs that credit engineering programs. Thus, documents regarding specific entities were analyzed in this research. These organizations were: Accreditation Board for Engineering and Technology (ABET), International Engineering Alliance (IEA), Institute of Industrial & Systems Engineers (IISE), National Academy of Engineering (NAE), National Board of Accreditation (NBA) and the CDIO Initiative (document by Crawley).

It was necessary to verify the adherence of the articles with the research question, so the articles selected have undergone a qualitative analysis of their titles and abstracts. The selection criteria were to select the article if it describes competencies relating to the management engineer. Then, the competencies were listed in a chart. These steps can be seen in Figure 4.

Figure 4

Analysis Process



Note. Prepared by the author

For better structuring and data analysis, similar terms were agglutinated into a single column. Twenty-nine competencies for management engineers were identified and listed in a chart, according Table 1.

Findings and discussions

Each competency listed in this paper will be briefly described and related to the day-to-day of management engineer. It is believed that this way the professional will be able to work in the labor market with a better understanding of the competencies required for his exercise.

Communication involves oral communication, writing and presentation in public are competencies that are present in several thematic areas. Even the most technical position, it is necessary for the professional to know how to communicate with peers and people from other sectors. It should be emphasized that this communication must take place both in the oral and in the written form, in many companies the meetings for alignment of the team happen daily and the exchange of emails is constant. Knowing how to communicate is a crucial ability for all professionals. No less important are the presentations in public; many of the techniques of leadership and persuasion require excellent performance in public.

Teamwork requires knowing how to work in teams and have a collaborative profile is useful for all organizations. Many organizations are divided into different sectors, which need to work together for the same purpose. A professional who acts as an integrator and facilitator between areas is vital for both the organization and the person. Moreover, it is notorious that there are companies that work through projects, such projects pass through several sectors; the professional must be able to work together with several entities to achieve a goal.

Problems are present everywhere, knowing how to identify them and solving them is a necessary skill for professionals. One of the reasons for the engineer's existence is precisely to solve problems. From the beginning of graduation, the student is asked to learn how to solve various types of problems, involving mathematics, physics, chemistry, social sciences, and other disciplines. He will see the same within the organization, of course, the themes may be different, but the essence of problem-solving should be part of the management engineer.

Lifelong learning is related to knowledge always evolving, and it is necessary to be updated from time to time. More than this, knowing that self-guided learning is an extremely relevant skill for the professional. Since many technological innovations do not yet have a formal course, it is necessary for the professional to seek that knowledge and draw their conclusions. This competence is related to change management, which happens in an increasingly fast way within organizations.

Nowadays, projects are part of every organization. Whether or not the companies need professionals focused on working on projects. Many demands are temporary, have a singular nature and are exposed to a limited amount of resources. The management engineer must know how to manage such resources to complete the project in the term, within the estimated value and meeting the need and expectation of the stakeholders. Risk monitoring and control is an essential part of the work of the professional who is dealing with projects, as well as the preparation of action plans.

The application of exact and social sciences should be part of the characteristics of every engineer. The concepts and foundations of the sciences are presented as early as the first periods of the course and are tried and applied in the following periods. Many applications are used daily by organizations. If the application is not made in full, at least one parallel can be made to solve the problem. The problem-solving ability has a great relationship to that of the application of sciences since many of the problems presented in the earlier periods of the course involve just the mathematical, physical, and chemical contents.

Critical thinking, data interpretation, and decision making are skills that are related and impact more than one area within the same company. The information generated by the extraction of the data can be dangerous. A critical analysis should always be done to support decision making. The management engineer will often be involved in the monitoring and control of processes and operations, and it will be indispensable to know how to analyze, interpret the data, and indicate or decide.

Professional ethics, and social-environmental responsibility are attributes that must be considered in every attitude of the management engineer. Analyzing the reasons that cause, alter, or guide the way the human being acts are sources of production of functional, correct, and reliable work. These points should be considered both concerning peers and in the provision of a product or service.

Look for technological innovation is important because the world is always changing, and evolutions are constant. Being aware of the innovations that are emerging is a vital utility skill for the development of the professional. There is a relationship with self-learning because it is necessary to learn autonomously many times.

Any action should consider its economic, environmental, and social impacts, and the ideal scenario is to meet each of these points together. When proposing a new management system, the management engineer will inevitably be generating some impact. Knowing how to look at and considering the various points of impact is an essential skill for the management engineer. Organizational processes are subject to risks that can positively or negatively affect the development of a given product. Action plans here are treated as contingency or mitigation plans if an event occurs.

Integrated systems vision is one of the essential competencies of the management engineer. The departments and sectors within an organization are usually interconnected; the professional must be able to see these interconnections using them to meet the team's goals. Having this vision helps in building a network that will support the professional in achieving the goals.

Leadership is a skill that has a stable relationship with emotional intelligence. It is the ability of the professional to do the right thing and get others to do the right thing. The use of persuasion techniques can significantly assist in the development of leadership competence, as well as self-knowledge, self-control, motivation, empathy, and social dexterity.

Creative ability can be used in day-to-day tasks and activities, it can also help a lot in solving problems. Not necessarily creativity is linked to radical innovation, to produce something that has never been done before, may be related to incremental innovation, where improvement steps are given from time to time.

Resilience and flexibility are linked to an adaptative profile and change management. Organizational projects, teams, and decisions change, and the professional who knows how to handle it well is ahead of many others.

Adverse scenarios than predicted before are happening faster and faster, and management engineers need to follow this carefully and have an adaptive power.

Mastery foreign languages helps in the development of a range of skills, such as oral and written communication, work in multidisciplinary teams, and the search for continuous learning and self-learning. The professional often needs this domain both inside and outside the organization. The development of this competence can add professionally and personally.

Professionals who have self-confidence, self-esteem and motivation are desirable for organizations. Usually, the management engineer with this profile has a positive personality and is willing to take a certain level of risk.

The entrepreneurial profile can appear in professionals inside and outside the organization. When within the organization, it is related to the professional looking for new organizational goals. Outside the organization is the one who starts a business.

Commitment, maturity and perseverance are desirable for hiring management engineering professionals. These terms are also related to the ownership feeling that the professional has. The organization needs employees who embrace and persist in problem-solving and goal achievement.

There is no doubt that any engineer should be able to design and conduct experiments. Experiments may be within industry or academia and are usually done before taking action or developing a product or service.

The ability to negotiate is vital, especially for professionals in leadership positions. Often a person is unable to achieve all the company's goals and needs to negotiate with others to reach consensus. Sometimes it is necessary to negotiate with external entities, as in works where more than one company participates in the same endeavor. The same is seen when the purchasing department reaches an agreement with the supplier.

Proactivity, initiative and dynamism are skills related to the professional who actively acts. The subordinate can and should resolve some issues without a formal request from the boss.

Resourcefulness and agility are related to the ability to solve problems and achieve goals quickly and efficiently. Of course, this involves several factors, but the professional must also have this agile profile.

Task prioritization and organized thinking is important for management engineers' professionals. They learn at the undergraduate level some tools that enhance management in any organization. The professional who knows how to apply these tools is one step ahead of others.

Evaluation systems are turning to results orientation. Instead of focusing on the amount of service performed, attention should be paid to the quality of these services. Looking at the professional profile, this is no different.

Lean thinking is related to being objective in speech and actions. Professionals with this personality tend to eliminate waste in their tasks, meetings, and in the organization. Table 1 lists these competencies relating references and the number of citations (N).

Table 1

Competencies for Management Engineers

Competence	References	ABET (2018)	IEA (2013)	NAE (2004)	NBA (2012)	N
Communication	Jangali & Gaitonde (2019), ABET (2018), Kulkarni et al. (2017), Lima et al. (2017), Manzoor et al. (2017), Alves et al. (2016a), Podges & Kommers (2016), Custovic (2015), Nepomuceno & Costa (2014), IEA (2013), Abdulwahed (2012), King (2012), NBA (2012), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), Shuman, Besterfield-Sacre & McGourty (2005), Hofstein & Lunetta (2004), Abd-El-Khalick et al. (2004), NAE (2004), Crawley (2001), Pimmel (2001), Hart et al. (2000), Payne & Radcliffe (1999) and Benefield et al. (1997)	X	X	X	X	25
Teamwork	Jangali & Gaitonde (2019), ABET (2018), Gaspar, Régio & Morgado (2017), Kulkarni et al. (2017), Lima et al. (2017), Podges & Kommers (2016), Alves et al. (2016a), Custovic (2015), IEA (2013), Abdulwahed (2012), King (2012), NBA (2012), Marin-Garcia & Lloret (2011), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), Shuman, Besterfield-Sacre & McGourty (2005), Crawley (2001), Pimmel (2001) and Payne & Radcliffe (1999)	X	X		X	20

Competence	References	ABET (2018)	IEA (2013)	NAE (2004)	NBA (2012)	N
Problem-solving	Jangali & Gaitonde (2019), ABET (2018), Kulkarni et al. (2017), Lima et al. (2017), Manzoor et al. (2017), Podges & Kommers (2016), Custovic (2015), IEA (2013), Abdulwahed (2012), NBA (2012), Marin-Garcia & Lloret (2011), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), Hofstein & Lunetta (2004), Abd-El-Khalick et al. (2004), Crawley (2001) and Hart et al. (2000)	X	X		X	18
Lifelong learning	Jangali & Gaitonde (2019), ABET (2018), Kulkarni et al. (2017), Lima et al. (2017), Nepomuceno & Costa (2014), IEA (2013), Abdulwahed (2012), NBA (2012), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), Shuman, Besterfield-Sacre & McGourty (2005), Hofstein & Lunetta (2004), Abd-El-Khalick et al. (2004), NAE (2004), Crawley (2001) and Hart et al. (2000)	X	X	X	X	17
Project management	Jangali & Gaitonde (2019), Kulkarni et al. (2017), Lima et al. (2017), Custovic (2015), IEA (2013), Abdulwahed (2012), King (2012), NBA (2012), Marin-Garcia & Lloret (2011), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), NAE (2004), Crawley (2001), Pimmel (2001), Payne & Radcliffe (1999) and Benefield et al. (1997)		X	X	X	17

Competence	References	ABET (2018)	IEA (2013)	NAE (2004)	NBA (2012)	N
Application of exact sciences	Jangali & Gaitonde (2019), Kulkarni et al. (2017), IEA (2013), Abdulwahed (2012), NBA (2012), Marin-Garcia & Lloret (2011), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), Hofstein & Lunetta (2004), Abd-El-Khalick et al. (2004), Crawley (2001), Hart et al. (2000), Benefield et al. (1997) and Augustine & Vest (1994)		X		X	15
Application of social sciences	Jangali & Gaitonde (2019), Kulkarni et al. (2017), IEA (2013), Abdulwahed (2012), NBA (2012), Marin-Garcia & Lloret (2011), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), Hofstein & Lunetta (2004), Abd-El-Khalick et al. (2004), Crawley (2001), Hart et al. (2000), Benefield et al. (1997) and Augustine & Vest (1994)		X		X	15
Data interpretation	Jangali & Gaitonde (2019), ABET (2018), Kulkarni et al. (2017), Lima et al. (2017), Manzoor et al. (2017), Nepomuceno & Costa (2014), IEA (2013), Abdulwahed (2012), NBA (2012), Marin-Garcia & Lloret (2011), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), NAE (2004) and Crawley (2001)	X	X	X	X	14
Decision-making	Jangali & Gaitonde (2019), ABET (2018), Kulkarni et al. (2017), Lima et al. (2017), Manzoor et al. (2017), Nepomuceno & Costa (2014), IEA (2013), Abdulwahed (2012), NBA (2012), Marin-Garcia & Lloret (2011), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), NAE (2004) and Crawley (2001)	X	X	X	X	14

Competence	References	ABET (2018)	IEA (2013)	NAE (2004)	NBA (2012)	N
Professional ethics	Jangali & Gaitonde (2019), ABET (2018), Kulkarni et al. (2017), Lima et al. (2017), IEA (2013), Abdulwahed (2012), King (2012), NBA (2012), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), Shuman, Besterfield-Sacre & McGourty (2005), NAE (2004) and Crawley (2001)	X	X	X	X	14
Social-environmental responsibility	Jangali & Gaitonde (2019), ABET (2018), Kulkarni et al. (2017), Lima et al. (2017), IEA (2013), Abdulwahed (2012), King (2012), NBA (2012), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), Shuman, Besterfield-Sacre & McGourty (2005), NAE (2004) and Crawley (2001)	X	X	X	X	14
Look for technological innovation	Jangali & Gaitonde (2019), ABET (2018), Kulkarni et al. (2017), Alves et al. (2016a), Nepomuceno & Costa (2014), IEA (2013), Abdulwahed (2012), King (2012), NBA (2012), Marin-Garcia & Lloret (2011), Marin-Garcia et al. (2009), Shuman, Besterfield-Sacre & McGourty (2005) and Payne & Radcliffe (1999)	X	X		X	13
Impact analysis	ABET (2018), Lima et al. (2017), IEA (2013), King (2012), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia & Lloret (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), Payne & Radcliffe (1999) and Augustine & Vest (1994)	X	X			10
Integrated systems vision	Jangali & Gaitonde (2019), Kulkarni et al. (2017), Lima et al. (2017), Custovic (2015), Abdulwahed (2012), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007) and Crawley (2001)					8

Competence	References	ABET (2018)	IEA (2013)	NAE (2004)	NBA (2012)	N
Critical thinking	ABET (2018), IEA (2013), King (2012), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), Savage, Chen & Vanasupa (2007), Payne & Radcliffe (1999) and Augustine & Vest (1994)	X	X			8
Leadership	ABET (2018), Lima et al. (2017), Custovic (2015), Abdulwahed (2012), Marin-Garcia & Lloret (2011), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009) and NAE (2004)	X		X		8
Creativity	Kulkarni et al. (2017), Lima et al. (2017), Abdulwahed (2012), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009), NAE (2004) and Crawley (2001)			X		7
Resilience and flexibility	Lima et al. (2017), Custovic (2015), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Savage, Chen & Vanasupa (2007), NAE (2004) and Augustine & Vest (1994)			X		6
Mastery of foreign languages	Gaspar, Régio & Morgado (2017), Lima et al. (2017), Marin-Garcia & Lloret (2011), Santandreu-Mascarell, Canós-Darós & Pons-Morera (2011), Marin-Garcia et al. (2009) and Crawley (2001)					6
Self-confidence, self-esteem and motivation	Lima et al. (2017), Nepomuceno & Costa (2014), Hofstein & Lunetta (2004), Abd-El-Khalick et al. (2004) and Hart et al. (2000)					5
Entrepreneur profile	Lima et al. (2017), Alves et al. (2016a), Nepomuceno & Costa (2014) and Abdulwahed (2012)					4
Commitment, maturity and perseverance	Lima et al. (2017), Manzoor et al. (2017), Savage, Chen & Vanasupa (2007) and Crawley (2001)					4
Conduction of experiments	ABET (2018), Marin-Garcia & Lloret (2011) and Crawley (2001)	X				3

Competence	References	ABET (2018)	IEA (2013)	NAE (2004)	NBA (2012)	N
Negotiation	Lima et al. (2017) and Nepomuceno & Costa (2014)					2
Proactivity, initiative and dynamism	NAE (2004) and Crawley (2001)			X		2
Resourcefulness and agility	Savage, Chen & Vanasupa (2007) and NAE (2004)			X		2
Task prioritization	Marin-Garcia & Lloret (2011)					1
Results orientation	Lima et al. (2017)					1
Lean thinking	Marin-Garcia & Lloret (2011)					1
		13	14	12	12	

Note. Prepared by the author

As can be seen from Table 1, 9 competencies cited in the academic literature not being addressed by entities that work for the development of engineering and the organs of credit engineering programs. These competencies are integrated systems vision, mastery of foreign languages, self-confidence, self-esteem and motivation, entrepreneur profile, commitment, maturity and perseverance, negotiation, task prioritization, results orientation, and lean thinking.

The three types of skills, mentioned in the literature review above by Page & Stanley (2014) and Shuman et al. (2005) are technical skills, process skills, and awareness skills. It is possible to note an emphasis on awareness skills. This suggests that this type of professional should have an understanding of the impact of global and social factors, and knowledge of contemporary issues that can impact other areas.

Humanity has been facing complex, integrated and large-scale problems, such as sustainable development, poverty eradication, potable water, basic sanitation, among others. These challenges demand professionals with an emphasis on awareness skills.

More than ever, educational institutions and universities should not focus on developing only technical skills in their students. The world expects more from our engineers, they must have interdisciplinary and socio-emotional actions to innovate and solve complex problems.

Conclusions

Twenty-nine competencies necessary for the management engineer were identified in the academic literature. They were: communication; teamwork; problem-solving; lifelong learning; project management; application of exact sciences; application of social sciences; data interpretation; decision-making; professional ethics; social-environmental responsibility; look for technological innovation; impact analysis; integrated systems vision; critical thinking; leadership; creativity; resilience and flexibility; mastery of foreign languages; self-confidence, self-esteem and motivation; entrepreneur profile; commitment, maturity and perseverance; conduction of experiments; negotiation; proactivity, initiative and dynamism; resourcefulness and agility; task prioritization; results orientation; lean thinking.

Note that IEA cites these competencies, with a rate of approximately 48% (14 mentions of a total of 29 competencies) of the competencies identified in the academic literature. ABET quotes approximately 45% (13 mentions out of 29 competencies). NAE and NBA rate approximately 41% (12 mentions out of 29 competencies).

The results indicate 9 competencies cited in the academic literature not being addressed by entities that work for the development of engineering and organs of credit engineering programs. These competencies are integrated systems vision, mastery of foreign languages, self-confidence, self-esteem and motivation, entrepreneur profile, commitment, maturity and perseverance, negotiation, task prioritization, results orientation, and lean thinking.

It is possible to observe an emphasis on awareness skills. This suggests that this type of professional should have an understanding of the impact of global and social factors, and knowledge of contemporary issues that can impact other areas.

The results are valuable as they ensure that the professional profile of a management engineering graduate represents the global and not regional competencies. They can support works about the development of the professional career of management engineers.

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