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The history of Engineering Education: learning from the past to design the future

A história da Educação em Engenharia: aprendendo com o passado para projetar o futuro

La historia de la Educación en Ingeniería: aprendiendo del pasado para diseñar el futuro

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Abstract
The objective of this study is to present and analyze the evolution of Engineering Education in the periods of antiquity, medieval, modern and contemporary age. It was also accomplished to analyze in more detail the current contemporary society, its behavior, and its aspirations from a literature review. Through this analysis, some forms of established education in engineering were identified to be more confluent with the aspirations of the current society. It is observed today that formal education in Engineering is out of step with the world. It was concluded that the future of engineering education aims to prepare the student for three main challenges: sustainability, industry 4.0, and employability. To ready the world's future engineering professionals, two perspectives must be considered; what skills students should acquire to better prepare for current challenges, and what new methods and techniques should be used in an education focusing on the student as the protagonist.
Keywords: History of engineering; Engineering education; Society and engineering.

Resumo
O objetivo deste trabalho é apresentar e analisar a evolução da Educação em Engenharia no período da antiguidade, medieval, moderno e contemporâneo. Procurou-se, também, analisar com mais detalhe a sociedade contemporânea atual, o seu comportamento e suas aspirações e a partir de uma revisão da literatura, identificou-se algumas premissas da educação formal em engenharia que seja mais convergente com as aspirações desta sociedade. Observa-se, hoje, que a educação formal em Engenharia está em descompasso com o mundo atual. Concluiu-se que o futuro da educação em engenharia tem o objetivo de preparar o aluno para três desafios principais: sustentabilidade, indústria 4.0 e empregabilidade. Para a formação do profissional em engenharia do futuro, duas perspectivas devem ser consideradas: quais as habilidades que os alunos devem adquirir para melhor prepará-los para os desafios atuais e quais os novos métodos e técnicas a serem utilizadas em uma educação voltada para o protagonismo do aluno.
Palavras-chave: História da engenharia; Ensino de engenharia; Sociedade e engenharia.

Resumen
El objetivo de este trabajo es presentar y analizar la evolución de la Educación en Ingeniería en el período de la antigüedad, medieval, moderno y contemporáneo. También se buscó analizar con más detalle la sociedad contemporánea actual, su comportamiento y sus aspiraciones y, a partir de una revisión bibliográfica, se identificaron algunas premisas de la educación formal en Ingeniería que son más convergentes con las aspiraciones de esta sociedad. Hoy se observa que la educación formal en Ingeniería está desfasada con el mundo actual. Se concluyó que el futuro de la educación en Ingeniería tiene como objetivo preparar al estudiante para tres desafíos principales: sustentabilidad, industria 4.0 y empleabilidad. Para la formación del profesional en Ingeniería del futuro se deben considerar dos perspectivas: qué habilidades deben adquirir los estudiantes para prepararlos mejor para los desafíos actuales, y cuáles son los nuevos métodos y técnicas para utilizar en una educación enfocada en el protagonismo del estudiante.
Palabras clave: Historia de la ingeniería; Enseñanza de la ingeniería; Sociedad e ingeniería.

1. Introduction

Every society that reaches a certain degree of maturity feels the need to practice education. It is the principle through which the human community continually preserves and transfers its habits, customs, skills, values, knowledge, and among others, its physical and spiritual peculiarities. Firstly, education is not an individual belonging, but is essentially linked to the society in which it is inserted (Jaeger, 1995). It is important to emphasize that the development of society, teaching, and education in Engineering is intrinsically related to advances in science and technology (Bazzo, 2006).

According to Bazzo (2006), the degree of dependence that society has on the results of science and technology is such that we cannot separate the advancement of new technologies and the ways of living and thinking from its occupants. Practically everything that is done today has a direct or indirect relationship with scientific and technological advances. Men in past societies were not concerned with academic foundations. They occupied themselves with building armaments, fortifications, roads, bridges, and canals based only on past experiences. It was not from one moment to the next that man began to apply scientific knowledge to construction techniques. For centuries sciences and technologies walked dissociated from each other. For thousands of years, philosophers and thinkers were on one side, with artisans on the other. However, in the course of this trajectory, there was a rapid expansion of scientific knowledge from the 17th century onwards, with the gradual emergence of a specialist in problem solving, the engineer. The formal appearance of this professional resulted from a process of evolution that took place over thousands of years (Bazzo, 2006).

According to Oliveira (2008), the origin of engineering is intertwined with the very origin of humanity, if analyzed through advances in knowledge and skills. These being practices such as the use of methods and techniques to transform, build, and manufacture tools. The development of stone artifacts is the first recognized technology that took place even before our ancestors were fully human. Basic characteristics developed by these individuals was through the practices taught by those who preceded them, in their own experiences, and their ability to build. However, when considering engineering as knowledge organized and structured on scientific bases, its origin is relatively recent, taking place after the birth of modern science. The application of science in technical actions was responsible for the great evolution of means of transport, communication, of industrial equipment, and consequently, of the manufacturing processes. In this way, Engineering, within the formal context of higher education, only occurred as a result of the industrial revolution (Oliveira, 2008).

Society has undergone several transformations over the years, succeeding the industrial revolution, to the present day. There are several names given to the current historical moment: post-modernity (Bauman, 2001 & Lipovetsky, 2013), liquid modernity (Bauman, 2001 and 2008), and hypermodernity (Lipovetsky & Sebastien, 2011). One of the characteristics of today's society is the fact that it is marked by profound transformations, with technological changes that are increasingly fast and complex, always requiring new knowledge (Mosé, 2013). This makes it necessary during life, whenever possible, to build new skills. Formal education is increasingly out of step with the corporate world. The school is progressively moving away from the language of the student, who masters language spontaneously. Languages such as interactive communication networks, using various resources such as, applications, chats, or platforms, which are a communication often unknown by the teacher. Hence the need to encourage and link non-formal education practices and learning experiences outside the school environment to the school curriculum (Pichetola, 2016).

The objective of this work is to present and analyze the evolution of Engineering and Engineering Education over time, and how society has changed along this path. From this analysis, we will examine the current contemporary society, its behavior, and its aspirations, and from a bibliographic review realize a formal education in engineering that is more convergent with its ambitions.

2. Methodology

The methodology used for the development of this article was bibliographic research. The text has been divided into two major parts: "Engineering Education. Learning from the Past" and "Current Society and the Future of Engineering Education". Initially, books, articles, theses, monographs, magazines, documents presented at symposia and congresses, and internet sites were consulted. The search focused on five areas: society, engineering, engineering education, education, and the future of engineering education. The following platforms were used: Portal Capes, ResearchGate, and Google Scholar. After this initial assessment, it has been developed a narrative review. The first part of the work, “Engineering Education. Learning from the Past”, opted for classic books that describe the History of Science and Technology, the History of Engineering, and the History of Education. Among some book titles chosen to narrate the past, we can mention Engineers: From the Great Pyramids to the Pioneers of Space Travel, The History of Science and Technology, the History of Universities, the History of Education in Antiquity, and History of Education in the Renaissance, between others. As for the second part, “Current Society and the Future of Engineering Education”, the texts chosen followed the following reasoning: to describe contemporary society. Texts by renewed authors in the area were used, such as the thinkers Zygmunt Bauman, Gilles Lipovetsky, and Byung-Chul Han. As for the future of engineering education, a search for articles in the last five years (2018-2022) on this topic was carried out in engineering education journals through the Capes portal. The papers chosen were: Hadgraft & Kolmos (2020), “Emerging learning environments in engineering education” and Sakhapov & Absalyamova (2018), “Fourth industrial revolution and the paradigm change in engineering education”, since they address a comprehensive discussion on this topic.

3. Engineering Education. Learning from the Past

The Ancient Age, or Antiquity, took place between the mid-4000s B.C. until 476 A.D. The Ancient Age is characterized by several civilizations, divided into two of significance. The eastern civilization, in which the peoples who had the greatest impact on society and engineering were the Mesopotamians, Egyptians, and Persians. And in western civilization, the highlights were for the Greeks and Romans. Despite differences in technology or society, all civilizations seem to have emerged politically from similar roots. Most had a stratified society, which classified individuals based on their socio-economic conditions. Even before antiquity, with the agricultural revolution (around 10,000 B.C.), we have the beginning of a sedentary life. Later, Mesopotamian society is born based on the collective ownership of land, which requires moral development, through the construction of rules and punishments, including a hierarchy of values and powers, thus creating a pyramidal power structure (a kind of social pyramid) (Mosé 2013). However, it was in the Egyptian civilization that the great constructions began through slave labor. Imhotep, an Egyptian polymath who served Djoser, pharaoh of the third dynasty, is considered the first engineer in history. He was behind the construction of Egypt's first pyramid (between 2630 B.C. and 2611 B.C.), with the scale of his accomplishments leading to being worshiped as a god. The pyramids are perhaps the most visible engineering work of the ancient world. Their construction, requiring thousands of cubic meters of stone, was an impressive achievement (Hart-Davis, 2012). And from those great constructions, important creations were born, such as mathematical formulas and engineering techniques. In Western civilization, which occurred at a later fundamental period in the development of humanity, Greek society had a democratic vocation. Communication, a verbal instrument in which rhetoric was used, created a society accustomed to arguing and philosophizing. In this period the Greeks began to dedicate themselves specially to thought and were responsible for the first argumentative model we have, reason. Furthermore, the history of Greek education substantially coincides with that of literature. Iliad – a Greek epic poem that narrates the events of the last year of the Trojan War, is considered the oldest literary work in Western literature (The Iliad is attributed to Homer, who is believed to have lived around the 8th century BC). If the Egyptians gave us the pyramid as a model of power and political management, then Greece gave us a pyramid, but in the domain of concept, of the management of thought.

In antiquity, a successful ruler of a domain and/or village aspired to rule a larger region, effectively becoming a king, whatever be the ruler's name. By a similar process, kings sought to extend their rule over a larger region, encompassing ethnically different people, resulting in the formation of empires. An empire lasted for a while and then disintegrated under pressure from outside, or as a result of mismanagement, often from both. This pattern generally influences the type of technology to be employed, and how the society could be structured in a given civilization. Thus, civilized people were divided into classes, while society was organized by the state, and labor was specialized in different trades. From this formed structure, and from a unified control, they developed construction projects such as: pyramids, temples, canals, roads, and so on. Furthermore, the process of forming kingdoms and empires usually involved wars. It was like this in the construction of the Macedonian empire, between the years of 359 B.C. and 323 B.C. and the Roman Empire 27 B.C. and 475 A.D. Therefore, military engineering was often at the forefront of change. For example, the use of war chariots preceded by hundreds of years trolleys being used to transport goods (Bunch & Hellemans, 2004).

Known as the “Age of Faith”, the medieval period corresponds to the consolidation of Christianity throughout Europe. The Middle Ages is the period of general history that begins in the 5th century, just after the fall of the Western Roman Empire. It ends in the 15th century, with the conquest of Constantinople by the Turkish-Ottoman Empire. The church became the main propagator of the legitimation of society and managed to shape the customs of individuals such as: sexuality, family life, dress, leisure, and others, based on their intentions. Medieval society was hierarchical, with very restricted social mobility. Before the 15th century, the use of books was still restricted. People in power were not particularly interested in the masses being literate, and economic needs did not call for an educated workforce. Universities emerged during this period for a very restricted group of people, with the main ones being Bologna in 1158, Paris in 1200, Cambridge in 1209, Padua in 1222, Naples in 1224, and Toulouse in 1229 (Charles & Verger, 2011). Knowledge was isolated from the common man and was explicitly configured as the power of the few. The intellectual, the teacher, was proud of his status as a master, which was at the top of the pyramid. In this time, the Exact Sciences, which could be located among the quadrivium species were relegated to marginal courses, sometimes optional. With regard to techniques in the development of studies and mechanical and architectural works, these were unworthy of doctors, as they never had the right of citizenship in medieval universities. The architects and the first engineers, who appeared in the 14th century, were trained outside of them (Charles & Verger, 2011; Marrou, 2017 and Nunes, 2018).

In the transition from the Middle Ages to the Modern Age, around 1450, Johannes Gensfleisch Gutenberg, a German blacksmith and publisher, revolutionized with the invention of the press. Implementing metallic movable types for graphic composition, he mechanized the process, making it possible to print many copies of the same text quickly. Thus, completely changing the history of reading, the circulation of ideas, and therefore, education on a worldwide scale. This fact was an important milestone for the dissemination of science and technology, as it injected new dynamism into intellectual progress. From then on, knowledge began to circulate with greater speed, as it could be reproduced more easily. Until that time knowledge only circulated verbally or through manuscripts, which were rare and difficult to reproduce.

The Modern Age followed the Middle Ages and preceded the Contemporary Age. Chronologically, the Modern Age began with the conquest of Constantinople by the Ottomans in 1453 and ended with the storming of the Bastille in 1789. After Gutenberg's invention, the literary industry practically set in motion the social revolutions that provoked profound changes in the world, even having repercussions. Printing influenced scientism, the evolution of technology, and reinforced rationalist, progressive, and mechanistic convictions, culminating in the industrial revolution. Leonardo da Vinci and the other artist-engineers of the Renaissance united an interest in the reflective and erudite theoretical-philosophical knowledge of humanist scholars, such as Pico della Mirandola, with the practical-technical interests of artisans. They were able to bring these worlds together, not only by of their own talents and personal skills, but also because they were able to benefit from the opportunities offered by clients, such as the Medici family, who were willing and able to pay for their services. And, from the 16th and 17th centuries onwards, knowledge began to appear more consistently and gave momentum to the birth of modern science. Galileo Galilei (1564-1642), Johannes Kepler (1571-1630), Nicolaus Copernicus (1473-1543), René Descartes (1596-1650), Isaac Newton (1643-1727), and Charles Augustin Coulomb (1736-1806) are among those responsible for the systematization of this new phase of humanity. The physicist Galileo was responsible for the official birth of scientific experimentalism. Then began the replacement of the long, formal, logical arguments of dialectics by the observation of the facts themselves. Galileo was an excellent researcher, who theorized and experimented, corroborating the Cartesian method. He studied weightlifting problems, invented the thermometer, investigated the laws of gravitation and oscillation, and the flexural strength of beams (Bazzo, 2006)

From then on, the application of scientific knowledge becomes part of the practice of this new engineering. Before, artifacts were built based on aesthetic and operational determinants, always taking as a reference the previous experience of the builder. Now a theoretical project, based on scientific concepts, formally studied theories, and methodologically controlled laboratory experiments, precedes construction. This brought about systematized knowledge of nature, for example: the structure of matter, electromagnetic phenomena, the chemical composition of materials, the laws of mechanics, energy transfer, and mathematical modeling of physical phenomena.

For the foundation of scientific knowledge to become part of engineering, books and schools are needed. The first book that organized what there was of engineering knowledge at that point was “La science des ingenieurs dans conduite des travaux de fortification et d”architecture civile. Dedié au roy.”, published in 1729 by Bernard Forest de Belidor (1698-1761). This book dealt with the forces that act on arches, the pressure of the ground, and the construction of retaining walls, among others. Another important book for many other crafts, not just engineering, was the influential Encyclopedie, co-edited by Denis Diderot and mathematician Jean Le Rond d'Alembert. It published in the 1750s and 1760s and included various crafts and technical arts presented as forms of knowledge on an equal footing with traditional academic disciplines (Hård & Jamison, 2005). Concerning schools, École Nationale des Ponts et Chausseés, founded in 1747 in France, was the first institution dedicated to training in engineering that was organized with characteristics that most resemble those of the current day. It was considered the first school for the formal education of engineering in the world, that produced professionals with the title of engineer (Oliveira, 2008). The name “civil engineer” would have been used for the first time in 1768 by the English engineer John Smeaton, who was one of the discoverers of Portland cement – who named himself that way to distinguish himself from military engineers. In 1783 the École des Mines was founded in Paris. At that time, mining operations required the application of the most advanced construction and mechanical techniques available. In 1795, the École Polytechnique was founded on the initiative of Gaspard Monge (1746-1818) and Antoine François Fourcroy (1755-1809). This school’s course lasted three years, whose high-level teachers (Monge, Lagrange, Fresnel, Prony, Fourrier, Poisson, and Gay Lussac, including others) taught basic engineering subjects, whereafter the students were sent to other specialized schools, such as Ponts et Chausseés and École de Mines” (Oliveira, 2008).

The Contemporary Age is a chronological division of history, comprising the period between the beginning of the French Revolution, with the fall of the Bastille, to present day. Society, engineering, and education in contemporary engineering have been living in this period of great transformation, following the three successive industrial revolutions. The first industrial revolution (1780-1850) was characterized by the mechanization of production in industry, with the use of water and steam engines as a source of energy. The second revolution (1850-1945) was based on the organization of work and the use of electrical energy to promote mass production. The third (1845-present day) was based on the integration of electronic components and information technology in industry for the automation of production tasks. Today, as a direct outcome of the advances of the third revolution, we are witnessing the incorporation of intelligent industrial systems developed by the integration of several advanced technologies (Artificial Intelligence, Internet of Things, Big Data, robotics, and others) favoring the advent of the fourth revolution; industrial.

All industrial revolutions have dramatically changed the content of work, labor relations, demand for different specialties and professions, and brought a new approach to the education system. From the industrial revolution comes capitalism, which required the segmentation of work through an assembly line, stratifying the work between those who cut, who sew, and who sell, etc. In the society of the first industrial age, production was segmented and sectored, but power still remained centralized in the pyramidal format. Education was still characterized by a form of teaching that was not formal and accessible only to a privileged few.

The second industrial revolution provided the rapid development of high technology industries such as: automobiles, chemicals, aviation, and energy. This increased the demand for science and engineering, and in turn, increased their prestige. Many countries have created personal training and education systems for the industry. Factories (employers) were actively involved in the educational process, creating labor training centers and sending the most talented young workers to higher schools. Education in the second revolution emerged in response to society's need to democratize education and train as many people as possible. This gave rise to mass education with advanced and formal teaching methods focused on educational institutions (schools, colleges, universities). Formal education was conceived with the idea of reflecting the factory environment in the school environment. Desks lined up, blackboard in front, professor standing up giving a speech, with students sitting and listening. Fixed schedules, pre-defined tasks, a series of isolated subjects that are made up of uniforms, sirens, tests and segmented evaluations, and promotions. Then diplomas, labor specialization, and technical courses. During the third industrial revolution, information and communication technologies (ICTE) are increasingly being integrated into education. New models of open and online education (Massive Online Open Courses, or MOOC, Corporate Online Open Course, or COOC, and Small Private Online Courses, or SPOC), completely changed the way we learn and teach. This made education accessible to the general public without restrictions of space, time, and place, providing the facilities for the next educational revolution, in Table 1. Hadgraft and Kolmos (2020) and Sakhapov and Absalyamova (2018), "Education 4.0 will somehow complement the phenomenon of incl. digital use in our daily lives where human and machines are aligned to extract the solvent and of course discover new theories about innovation". The Education 4.0 paradigm could be defined contingent on two emerging trends, based on innovations and general changes in education and pedagogy, and on the integration of technologies introduced by Industry 4.0 in education.

Table 1. Changing technological cycles and educational paradigms during industrial Revolution.

Periods/Centuries	Revolution	Industrial changes	Educational changes
XVIII – IXX	First Industrial Revolution	Invention of the steam engine, transition from manual to industrial work	Emergence of specialized work, establishment of professional schools and development of universities
IXX – Beginning of **XX**	Second Industrial Revolution	Transition to electricity, development of: transport, communications and high-tech industries.	Development of a training system for industry, standardization of education and growth in the prestige of engineering education.
Second half of **XX** – Beginning of **XXI**	Third Industrial Revolution	Transition to telecom technologies, production automation, rapid service development	Integration and globalization of education, development of academic mobility, transition to international educational standards, increased training of specialists for service activities
Beginning of **XXI**	Fourth Industrial Revolution	The Internet of Things, integration of "cyber-physical systems", or CPS, in production processes, neuronet.	Individualization and virtualization of education, design strengthening and multidisciplinary nature of engineering education, the development of interactive educational resources.

Source: Sakhapov and Absalyamova (2018).

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4. Current Society and the Future of Engineering Education

An analysis of current contemporary society is necessary before approaching the future of engineering education.

Actual society

Various names have been given to the current historical moment: post-modernity (Bauman, 2001 and Lipovetsky, 2013), liquid modernity (Bauman, 2001 and 2008), and hypermodernity (Lipovetsky & Sebastien, 2011), among others. For Bauman (2001), there are two characteristics that make the current moment a modernity distinct from the preceding or the first moment of modernity, those being: 1) the decline of the old illusion that there is an ideal of society and State to be achieved; and 2) individualism.

One of the characteristics of society in this current historical moment is the fact that it is marked by profound transformations. In today's society, rules and values no longer have the same rigidity, which makes them decentralized. They are not based on hierarchies as in the past, presenting a more horizontal architecture in a network format, in which all relationships and connections are equal (Mosé, 2013 and Pischetola, 2016). Making its inhabitants individualized, singularized, and capable of constituting their lives from themselves, or rather, entrepreneurs of themselves. Thus, having different ways of working, establishing relationships, and constituting their families. This often generates insecurity and anguish of not doing the right thing, or of not producing everything that could be produced. Today, the person explores himself, always demanding a better performance, thinking that he is achieving this, and often this can generate some psychic disturbances (Han, 2017)

The future of engineering education

We can group the challenges of engineering education in the coming decades into three large groups, which Hadgraft and Kolmos (2020) called, sustainability, fourth industrial revolution, and employability. The question is how engineering institutions are responding now, and how they should respond in the near future to these demands. These three challenges will be described below:

Sustainability

The Sustainable Development Goals (SDGs) are the United Nations' universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity. The 17 Sustainable Development Goals (SDGs) (poverty eradication, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent employment and economic growth, industry, innovation and infrastructure, reducing inequalities, sustainable cities and communities, responsible consumption and production, combating climate change, life under water, life on land, peace, justice and strong institutions and partnerships for the goals) were born at the Conference of United Nations on sustainable development in Rio de Janeiro in 2012. Prospective engineering students should be able to understand the needs for technological solutions, within a context in which sustainable solutions are established.

Fourth Industrial Revolution:

This includes the challenge of training professionals who can work with the technologies involved in Industry 4.0, also called the Fourth Industrial Revolution. Encompassing a broad system of advanced technologies such as artificial intelligence (AI), robotics, internet of things (IoT) and cloud computing, advanced materials, multidimensional printing, bio, nano and neuro-technologies, and virtual and augmented reality (Hadgraft & Kolmos, 2020), that are changing production forms and business models around the world.

Employability:

The third challenge, employability, and innovation skills, including entrepreneurship and design thinking, have been on the agenda for some years now, but have not yet been implemented in many engineering programs. The gap between engineering education and work readiness still exists and closing this gap is a challenge. The integration of theory and practice through a focus on employability, through collaboration with the industry, using internships, partnership projects, and learning labs, are partial solutions to this challenge (Hadgraft & Kolmos, 2020). The increasing use of various forms of problem/project-based learning is another mechanism to meet this demand, which we will discuss later.

The training of professionals in engineering:

For the training of the engineering professional of the future, two perspectives must be considered; what skills should students acquire during higher education, and what new methods and techniques should be used in a student-oriented education. These we will present below:

Today, access to information by students is very easy and abundant, mainly due to the advent of the internet and modern electronic devices. Therefore, the teacher needs to assume other more significant functions than that of a mere conveyor of knowledge. This becomes a great challenge for teachers, especially when there is a predominance of lectures restricted to the physical environment of classrooms. This does not mean that, in the face of this new scenario, the moments in the classroom have lost their function and value. On the contrary, many professional skills continue to be very well developed in this way. For example, considering abstract or complex subjects through a teacher-mediated discussion. What has changed is the way in which the teacher is led to look at the teaching-learning processes and the different pedagogical practices in current times. Engineering courses are changing, and should change even more, towards a teaching-learning model with greater emphasis on student initiative to search and apply solutions in solving engineering problems, Santos et al. (2021) and Almeida & Santos (2020), replacing the education processes of old. Historically, the teacher has always been seen as a figure who holds knowledge, with the main function of passing this knowledge on to students. This vision is better understood when one looks back at earlier times, in which the dissemination of information was precarious and restricted to a few books, which were concentrated in monastic academies and libraries. In this way, it was up to the teacher to access this information and transmit it to the students. It is important to emphasize that today the teacher must be prepared to work with the student's ability and must use and apply new technologies in the learning process of these students (Jamison, Kolmos & Holgaard, 2014).

5. Conclusion

The development of stone artifacts is the first recognized technology, and the pyramids are perhaps the most visible engineering work of the ancient world. It was from these great constructions, that important creations were born, such as mathematical formulas and engineering techniques. Education is essentially linked to the society in which it is inserted. In antiquity, society was structured and organized by the state, whose aspiration of the ruler was the formation of empires and the control of their people. Men were not concerned with theoretical foundations; they occupied themselves with building defenses, roads, bridges, and canals, based only on past experiences. For centuries, sciences and technologies walked disconnected from each other. Over many thousands of years, philosophers and thinkers were on one side and artisans on the other. However, during this course, there was a rapid expansion of scientific knowledge from the 17th century onwards, with the gradual emergence of a specialist in problem solving, giving birth to the engineering profession. Over time, both engineering education and society have changed greatly, with a reciprocity in terms of influence between society and engineering taking place. Technological changes influence the behavior of society, and in turn inspires the development of new knowledge. It is observed today that formal education in Engineering is out of step with the current world. It was found that

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there are three major challenges for engineering education in the coming decades, namely: sustainability, fourth industrial revolution, and employability.

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References

Almeida, N. P. & Santos, K. G. (2020). Chemical engineering laboratory teaching using Project-based learning approach: Gas adsorption using banana peel. Research, *Society and Development.* 9 (3).

Bauman, Z. (2001). *Modernidade líquida.* Ed. jorge zahar.

Bauman, Z. (2008). *A sociedade individualizada: Vidas contadas e histórias vividas*. Ed. jorge zahar.

Bazzo, W. A. (2006). *Introdução à Engenharia: Conceitos, ferramentas e comportamento.* Ed. Santa Catarina.

Bunch, B. & Hellemans, A. (2004). *The History of science and technology*. Ed. Houghton Mifflin Company.

Charles, C. & Verger, J. (2011). *História das universidades*. Ed. Unesp.

Hadgraft R.G. & Kolmos A. (2020). Emerging learning environments in engineering education. *Australasian Journal of Engineering Education* 25(1), 3-16.

Han, B. (2017). *Sociedade do cansaço*. Ed. Vozes.

Hård M. & Jamison A. (2005). *Hubris and hybrids: A cultural history of technology and science/*Mikael Hård & Andrew Jamison. Ed. Routledge.

Hart-Davis, A. (2012). *Engineers: From the great pyramids to the pioneers of space travel*. Ed. DK

Jaeger, W. (1995). *Paidea a Formação do Homem Grego*. Ed. Martins Fontes.

Jamison, A., Kolmos, A. & Holgaard, J. E. (2014). Hybrid learning: An integrative approach to Engineering Education. *Journal of Engineering Education,* 103 (2). 253–273.

Lipovetsky, G. & Sebastien, C. (2011). *Os Tempos hipermodernos*. Ed. Edições 70.

Lipovetsky, G. (2013). *A Era do vazio: Ensaios sobre o individualismo contemporâneo.* Ed. Edições 70.

Marrou, H. I. (2017). *História da educação na antiguidade.* Ed. Kirion.

Mosé, V. (2013). *A Escola e os desafios contemporâneos*. Ed. Civilização Brasileira.

Nunes, R. A. C. (2018). *História da educação no renascimento*. Ed. Kirion.

Oliveira, V. F. (2008). *Crescimento, evolução e* o futuro dos cursos de engenharia. *Revista de Ensino de Engenharia*, 24 (2).

Pischetola, M. (2016). *Inclusão digital e educação: A nova cultura da Sala de aula*. Petrópolis: Ed. Vozes.

Sakhapov, R., & Absalyamova, S. (2018). *Fourth industrial revolution and the paradigm change in engineering education*. In MATEC Web of Conferences. 245 (12003).

Santos, F. R., Oliveira, I. M., Santos, L. C., Leal, R. E. G. & Cardoso, M. (2021). Pedagogical strategies for chemical engineering course: Skills development through projet-based learning (PBL). *Research, Society and Development.* 10 (7).