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21st CENTURY ENGINEERING EDUCATION CHALLENGES

DESAFÍOS EN LA ENSEÑANZA DE INGENIERÍA EN EL SIGLO XXI

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Abstract: Engineering programs have a crucial role to play in the successful formation of future engineers, according to the 21st century society needs. Through a systematic literature review, dialogue with academia, industry and governmental stakeholders fundamental topics that engineering programs must constantly monitor to adapt their curricula, teaching methods, student admission and retention processes, were identified. Within these topics are: the rapid changes in the labor market, technological advances and the growing need for diversity and inclusion. To deal with these challenges, engineering teaching must be more adaptable, receptive and integrative, and focus on the development of the most demanded competences in the labor market, a more practical learning and based on projects, interdisciplinary approaches, interpersonal competencies and ethical and social elements.

Keywords: Education, engineering, 21st century Educación, ingeniería, siglo XXI

Resumen: Los programas de ingeniería tienen un papel crucial que desempeñar para que la formación de los futuros ingenieros sea exitosa y se adapten a las necesidades de la sociedad del siglo XXI. A través de la revisión bibliográfica, el diálogo con actores de la academia, la industria y entes gubernamentales se identificaron unos tópicos fundamentales que los programas de ingeniería deben constantemente monitorear para adaptar sus currículos, métodos de enseñanza, procesos de admisión y retención de estudiantes. Dentro estos tópicos se destacan: los rápidos cambios en el mercado laboral, avances tecnológicos en educación y la creciente necesidad de diversidad e inclusión. Para hacer frente a estos retos, la enseñanza de la ingeniería debe ser más adaptable, receptiva e integradora, y centrarse en el desarrollo de las competencias más demandadas en el mercado laboral, un aprendizaje más práctico y basado en proyectos, enfoques interdisciplinarios, competencias interpersonales y elementos éticos y sociales.

Palabras claves: Educación, ingeniería, siglo XXI.

1. INTRODUCTION

Engineering has had a tremendous impact on the history of society. From the development of transportation, communications, and energy sources to the use of technology to enhance the human experience, engineering has been fundamental in shaping the modern world (Lucena, 2003; Picon, 2004; Steffen et al., 2011; Stephanopoulos & Reklaitis, 2011). In the early days of civilization, engineers developed systems to facilitate transportation, such as building roads and inventing the wheel, enabling more efficient movement of goods. Engineers developed physicochemical processes and materials that have contributed to numerous technological advancements in fields as diverse as medicine, computing, aerospace, telecommunications, transportation, agriculture, textiles, and plastics, among others.

The first tools created by humans were made of stone, but ancient engineers mastered the fundamentals of working with metals, giving rise to the Bronze and Iron Ages, which radically transformed the tools and equipment used in agriculture, construction, and, unfortunately, even warfare. Tools made of bronze and iron, in addition to being much stronger and more durable than those made of stone, were also easier to mold, leading to the creation of more advanced and specialized tools.

The greater global abundance of iron ore compared to copper and tin, combined with the discovery of the effects on material strength achieved by adding a small amount of carbon during iron metallurgical processes, marked the beginning of steel usage. The iron industry also underwent significant changes with the smelting of iron ore using coke instead of charcoal; coke was cheaper than charcoal and also produced higher-quality steel. Later, engineering advancements such as the steam engine and the railway revolutionized the way goods and people moved across the world (BISSELL & BENNETT, 1997; Cardoso & Chanin, 2022; Friedel, 1986; Picon, 2004).

Technology also facilitated communication. From the invention of the telegraph in the 19th century to the development of the Internet in the 20th century, engineers have applied their knowledge and expertise to create new ways of sending and receiving information. This has enabled people to stay connected regardless of geographical distance.

The development of energy sources has also been influenced by engineering. From the use of coal to power steam engines, to the invention of the light bulb, and the adoption of renewable energy sources such as wind and solar, engineers have continuously worked to create new and improved ways of generating energy (Hammond, 2004; Kaminski et al., 2008; Owusu & Asumadu-Sarkodie, 2016).

To continue this great contribution of engineering to society, engineering programs must train students to be competent in addressing the challenges that contemporary society requires solving. Future generations of engineers will face challenges that previous generations did not encounter, and engineering education programs must acknowledge and adapt to these changes.

2. IDENTIFICATION OF CHALLENGES

The teaching of engineering plays a significant role in the 21st century. Beyond the classical approach to engineering education, which focuses on the application of mathematics, science, technology, and the analysis and design of complex systems, engineers must be able to think innovatively and provide effective solutions. Through tools such as internal audits and evaluations, accreditation processes, and constant communication with industrial, research, and government institutions, engineering programs must be able to identify the key elements necessary to train professionals who meet the needs of society in the 21st century.

Through the literature review, dialogue with stakeholders from academia, industry, and government, several fundamental and relevant topics were identified for inclusion in engineering programs and curricula. These include: the evolution of the curriculum to meet labor market needs, the use of technology in engineering education, the development of interpersonal skills, the inclusion of underrepresented populations, along with the implementation of efficient student admission and retention processes.

2.1. Labor Market Needs and Curriculum Adaptation

Engineering programs play a crucial role in preparing graduates for future job positions. As technology and industries evolve, the skills and knowledge required to succeed in engineering are constantly changing. Therefore, it is important for engineering programs to periodically review and update their curricula to ensure that graduates are equipped with the skills and knowledge needed to excel in the workforce (Edström & Kolmos, 2014; Grimson, 2002).

The increase in opportunities for project-based practical learning is one-way engineering programs could better prepare graduates for the labor market. Students can apply the principles they learn in class to solve real-world problems through these types of activities, which can also help them develop important skills such as teamwork, problem-solving, and effective communication. Furthermore, project-based learning can be more engaging and stimulating than traditional classroom-based instruction, and it can contribute to a better understanding of the subject matter (Abd-Elwahed & Al-Bahi, 2021; Grimson, 2002; Karim, 2016; Li et al., 2012). Another important aspect of the curriculum in engineering programs is the incorporation of interdisciplinary approaches in the work skills of engineering students. Graduates must be able to collaborate productively with experts from other fields as the field of engineering becomes more interdisciplinary. Therefore, engineering programs should include courses and projects that involve teamwork with students and mentors from other disciplines.

For engineering students to succeed in the future, the engineering curriculum must also include interpersonal skills such as teamwork, leadership, and communication. Employers today place high value on these skills, but not all traditional engineering programs typically include them in their training curricula.

Additionally, engineering programs must prepare graduates for the ethical and social challenges they will face in their future careers, in addition to teaching them technical competencies. Teaching social responsibility, sustainability, and the moral consequences of technological and engineering decisions are part of this process, and therefore, the curriculum should include courses or modules that address ethical issues.

Finally, it is essential that engineering programs adapt to changes in the economy and the labor market. To achieve this, programs must periodically examine the most in-demand knowledge and skills in the labor market and use this information to make informed decisions about the curriculum. Additionally, programs should foster relationships with industry to ensure that graduates are well-prepared for the specific challenges and opportunities of their future job positions.

2.2. Use of technology in engineering education.

Technology is increasingly used in engineering education, and like any teaching tool, its use presents certain advantages and disadvantages. Technology in engineering education can provide students with access to new tools and resources that were previously unavailable. For example, with simulation tools and computer-aided design (CAD) software, students can create and test virtual prototypes of their projects, which in some cases can be a more effective and cost-efficient learning method than creating real models. Additionally, internet tools such as tutorials, simulations, and videos not only provide students with more opportunities to study outside the classroom, but also enhance the asynchronous use of time (Abd-Elwahed & Al-Bahi, 2021; Karim, 2016; Potkonjak et al., 2016).

Technology in engineering education can also make learning more dynamic and engaging. Online classes and videos, for example, can be used as a supplement or in place of conventional classes, allowing students to pause, review material, and study information more easily. Moreover, technology can be used to develop interactive exercises and simulations that enable students to explore difficult concepts in a more engaging and practical way (Abd-Elwahed & Al-Bahi, 2021; Froyd et al., 2012; Ożadowicz, 2020).

However, just as the use of technology in engineering education offers significant benefits, it could also present some challenges. For instance, students who do not have access to the latest technology or lack the skills to use it effectively may be at a disadvantage in the classroom; such situations create barriers in the learning process for students in those conditions.

This is especially true for students from low-income backgrounds, who may not have access to the same technological resources as their peers without financial limitations. To address these challenges, engineering programs must be proactive in equipping students with the necessary technology and knowledge to excel in the classroom. This may involve providing students with access to the latest technology and teaching them how to use it competently.

The incorporation of technology into engineering education can raise new ethical and social dilemmas. For example, the use of augmented reality and virtual reality in engineering education may raise concerns about how technology influences interpersonal communication and human behavior. The use of technology in engineering education can also raise concerns regarding safety and privacy, as well as the use of student data for research and other purposes (Guntzburger et al., 2017; McGowan, 2013; Sari et al., 2021). Engineering programs must inform students of their rights and the data protection options available, as well as be transparent and honest about how student data is collected and managed.

2.3. Social competences

Recently, productive activities have undergone profound changes as a result of the introduction of information technologies, as well as new working methods, environments, and habitats. To meet these needs, the new generations of engineers must begin to acquire interpersonal skills that focus on fostering a set of attitudes and behaviors that support interaction and a person’s ability to form bonds with those they interact with. These talents are known as "soft skills," among which teamwork, empathy, adaptability, conflict resolution, and effective communication are particularly prominent.
Engineering education should also emphasize the acquisition of these "soft skills," which are crucial in today’s job market. These are highly sought-after skills by employers, yet are sometimes neglected in conventional engineering programs.

Engineering education includes the study of engineering ethics and professional responsibility. This type of education is essential for the responsible practice of engineering (Schipper & Stappen, 2018; Shahabadkar et al., 2015). Technical skills such as arithmetic, science, and engineering concepts have traditionally been at the core of engineering education, but in today’s job market, employers are increasingly looking for engineers with "soft skills" such as teamwork, leadership, and communication. In order to prepare students for future challenges, engineering education must give significant attention to the development of these competencies in its curricula (Direito et al., 2012; Rao, 2014; Schipper & Stappen, 2018). One crucial soft skill for engineers is leadership. Project and team leadership is a characteristic frequently requested from engineers, so students should be given the opportunity to develop their leadership skills through class projects and internships that include opportunities to lead teams, manage budgets, and make decisions.

Communication is a key interpersonal competence for engineers, who in their daily work will likely need to interact with communities, clients, colleagues, and more. This implies including activities in the training processes that require students to write, present, and develop both technical and non-technical material clearly and concisely, allowing for effective communication with trained personnel and the general public (Coşkun et al., 2019; Shahabadkar et al., 2015; Sydorenko, 2020; Vo et al., 2017), therefore, engineering education should include courses and exercises focused on communication skills.

Teamwork is another essential interpersonal competence for engineers. In the field of engineering, teamwork is a common practice, so being able to work effectively with others is crucial for success. This can be achieved by working on group projects, participating in team-building activities, and learning about effective teamwork strategies (Direito et al., 2012; Shahabadkar et al., 2015; Vo et al., 2017).

Furthermore, engineering education should include opportunities for students to acquire critical thinking, problem-solving, and creativity skills. Opportunities to work on innovative projects where they can recognize and address real-world problems and propose original solutions are examples of this. Engineering teaching programs should make a determined effort to provide students with the opportunity to acquire these soft skills (Ahmed et al., 2012; Shahabadkar et al., 2015; Sydorenko, 2020; Vo et al., 2017).

2.4. Diversity of the student population

The creation of a diverse population in engineering education has proven to be a challenging task. Engineering remains a male-dominated field, and despite efforts to recruit and retain a diverse student body, underrepresented populations such as women, minorities, people with disabilities, and those who, due to their socioeconomic conditions, experienced low-quality primary and secondary education, are still prevalent. This lack of diversity not only affects the underrepresented populations but also has broader implications for society (Salazar-Fernandez et al., 2019; Waizmann et al., 2020; Williams et al., 2016).

Since underrepresented populations are less likely to see themselves reflected in the profession, they may be less motivated to pursue a career in engineering. This lack of representation also creates a vicious cycle, which can be difficult to break.

The absence of support and guidance for these populations is another factor contributing to the lack of diversity in engineering education, which is why the constant interaction of engineering programs with primary and secondary education schools is essential. The involvement of engineering programs in introductory science and technology courses, science fairs, laboratory visits, and other activities in coordination with schools can help engage and interest more students in studying engineering. These types of initiatives can contribute to reducing the barriers for underrepresented populations, who may not have access to the same types of support networks, connections, and resources as other populations, thus helping them overcome obstacles to enter and succeed in the field of engineering. (Salazar-Fernandez et al., 2019; Secundo et al., 2012; Williams et al., 2016).

In addition, the lack of diversity in engineering education can have significant repercussions for the discipline and society at large. This lack of diversity can foster biased conditions in the practice of the profession, which are not compatible with the diverse community it serves. This may lead to solutions that are not inclusive and do not take into account the needs and perspectives of other groups. Furthermore, it is less likely that the population benefiting from engineering solutions will adopt and employ them when they are not inclusive.

To overcome these obstacles, engineering education must be more proactive in attracting and retaining a diverse student body. This involves creating partnerships with organizations that support minority communities, offering scholarships and other forms of financial aid, and establishing mentorship and support programs for underrepresented students (Martin et al., 2013; Maton et al., 2012; Secundo et al., 2012). In addition to increasing representation in the profession, attracting a diverse student body is crucial because it fosters a more dynamic and creative learning environment by bringing new perspectives and ideas into the classroom.

2.5. Strategies to increase student retention

The implementation of an effective methodology to determine student retention is a very important tool because it provides universities with a measurable metric to quantify and understand why students do not complete their studies. Moreover, by understanding the causes of low retention, appropriate solutions can be designed and implemented. Low retention rates indicate that students are facing difficulties in their educational process (Hall et al., 2015; Judson et al., 2015).

Retention rates can be improved through the creation of an inclusive culture that recognizes and addresses the difficulties faced by students in their education, as well as by groups of underrepresented students, minorities, and those with disabilities. Developing an inclusive culture within the program is crucial to attract new students and retain them in the programs. Engineering training programs must be proactive in socializing their procedures and efforts to create a diverse and inclusive community. (Constantinides & Zinck Stagno, 2011; Diekman et al., 2015; Moakler Jr. & Kim, 2014).

3. CONCLUSIONS

Engineering programs play a crucial role in ensuring that the education of future engineers is successful and meets the needs of society. Engineering education in the 21st century faces a number of challenges, such as rapid changes in the job market, technological advancements, and the growing need for diversity and inclusion. To address these challenges, engineering education must be more adaptable, responsive, and inclusive, focusing on the development of the most in-demand skills in the job market.

In this way, engineering programs should incorporate more hands-on, project-based learning, interdisciplinary approaches, interpersonal skills, and ethical and social elements into the curriculum. The use of technology in engineering education provides students with access to new tools and resources, enabling more dynamic and engaging ways to carry out the learning process. The development of "soft skills," such as creativity, teamwork, critical thinking, and leadership, which are crucial for success in the engineering profession, must also be effectively integrated into the training process.

Moreover, engineering education should strive to be more inclusive and proactive in attracting and retaining a diverse student body. To have a diverse and inclusive student body, engineering programs must implement proactive admission and retention initiatives. This can be achieved by forming alliances with organizations that support underrepresented groups, offering financial assistance in the form of scholarships and other types of aid, and fostering an inclusive culture within the program.

REFERENCES

Abd-Elwahed, M. S., & Al-Bahi, A. M. (2021). Sustainability awareness in engineering curriculum through a proposed teaching and assessment framework. *International Journal of Technology and Design Education*, *31*(3), 633–651. https://doi.org/10.1007/s10798-020-09567-0

Ahmed, F., Capretz, L. F., & Campbell, P. (2012). Evaluating the Demand for Soft Skills in Software Development. *IT Professional*, *14*(1), 44–49. https://doi.org/10.1109/MITP.2012.7

BISSELL, C., & BENNETT, S. (1997). The Role of the History of Technology in the Engineering Curriculum. *European Journal of Engineering Education*, *22*(3), 267–275. https://doi.org/10.1080/03043799708923459

Cardoso, M., & Chanin, R. M. (2022). The history of Engineering Education: learning from the past to design the future . *Research, Society and Development*, *11*(11 SE-), e364111133606. https://doi.org/10.33448/rsd-v11i11.33606

Constantinides, E., & Zinck Stagno, M. C. (2011). Potential of the social media as instruments of higher education marketing: a segmentation study. *Journal of Marketing for Higher Education*, *21*(1), 7–24. https://doi.org/10.1080/08841241.2011.573593

Coşkun, S., Kayıkcı, Y., & Gençay, E. (2019). Adapting Engineering Education to Industry 4.0 Vision. In *Technologies* (Vol. 7, Issue 1). https://doi.org/10.3390/technologies7010010

Diekman, A. B., Weisgram, E. S., & Belanger, A. L. (2015). New Routes to Recruiting and Retaining Women in STEM: Policy Implications of a Communal Goal Congruity Perspective. *Social Issues and Policy Review*, *9*(1), 52–88. https://doi.org/https://doi.org/10.1111/sipr.12010

Direito, I., Pereira, A., & Duarte, A. M. de O. (2012). Engineering Undergraduates' Perceptions of Soft Skills: Relations with Self-Efficacy and Learning Styles. *Procedia - Social and Behavioral Sciences*, *55*, 843–851. https://doi.org/https://doi.org/10.1016/j.sbspro.2012.09.571

Edström, K., & Kolmos, A. (2014). PBL and CDIO: complementary models for engineering education development. *European Journal of Engineering Education*, *39*(5), 539–555. https://doi.org/10.1080/03043797.2014.895703

Friedel, R. (1986). Engineering in the 20th Century. *Technology and Culture*, *27*(4), 669–673. https://doi.org/10.2307/3105321

Froyd, J. E., Wankat, P. C., & Smith, K. A. (2012). Five Major Shifts in 100 Years of Engineering Education. *Proceedings of the IEEE*, *100*(Special Centennial Issue), 1344–1360. https://doi.org/10.1109/JPROC.2012.2190167

Grimson, J. (2002). Re-engineering the curriculum for the 21st century. *European Journal of Engineering Education*, *27*(1), 31–37. https://doi.org/10.1080/03043790110100803

Guntzburger, Y., Pauchant, T. C., & Tanguy, P. A. (2017). Ethical Risk Management Education in Engineering: A Systematic Review. *Science and Engineering Ethics*, *23*(2), 323–350. https://doi.org/10.1007/s11948-016-9777-y

Hall, C. W., Kauffmann, P. J., Wuensch, K. L., Swart, W. E., DeUrquidi, K. A., Griffin, O. H., & Duncan, C. S. (2015). Aptitude and Personality Traits in Retention of Engineering Students. *Journal of Engineering Education*, *104*(2), 167–188. https://doi.org/https://doi.org/10.1002/jee.20072

Hammond, G. P. (2004). Engineering sustainability: thermodynamics, energy systems, and the environment. *International Journal of Energy Research*, *28*(7), 613–639. https://doi.org/https://doi.org/10.1002/er.988

Judson, E., Ernzen, J., Chen, Y.-C., Krause, S., Middleton, J., & Culbertson, R. (2015). What is the effect of establishing programs that address sense of belonging on undergraduate engineering retention? *2015 IEEE Frontiers in Education Conference (FIE)*, 1–8. https://doi.org/10.1109/FIE.2015.7344202

Kaminski, W., Marszalek, J., & Ciolkowska, A. (2008). Renewable energy source—Dehydrated ethanol. *Chemical Engineering Journal*, *135*(1), 95–102. https://doi.org/https://doi.org/10.1016/j.cej.2007.03.017

Karim, M. S. A. (2016). Entrepreneurship Education in an Engineering Curriculum. *Procedia Economics and Finance*, *35*, 379–387. https://doi.org/https://doi.org/10.1016/S2212-5671(16)00047-2

Li, K. F., Zielinski, A., & Gebali, F. (2012). Capstone team design projects in engineering curriculum: Content and management. *Proceedings of IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE) 2012*, T1C-1-T1C-6. https://doi.org/10.1109/TALE.2012.6360372

Lucena, J. C. (2003). Flexible Engineers: History, Challenges, and Opportunities for Engineering Education. *Bulletin of Science, Technology & Society*, *23*(6), 419–435. https://doi.org/10.1177/0270467603259875

Martin, J. P., Simmons, D. R., & Yu, S. L. (2013). The Role of Social Capital in the Experiences of Hispanic Women Engineering Majors. *Journal of Engineering Education*, *102*(2), 227–243. https://doi.org/https://doi.org/10.1002/jee.20010

Maton, K. I., Pollard, S. A., McDougall Weise, T. V, & Hrabowski, F. A. (2012). Meyerhoff Scholars Program: A Strengths-Based, Institution-Wide Approach to Increasing Diversity in Science, Technology, Engineering, and Mathematics. *Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine*, *79*(5), 610–623. https://doi.org/https://doi.org/10.1002/msj.21341

McGowan, A. H. (2013). Teaching Science and Ethics to Undergraduates: A Multidisciplinary Approach. *Science and Engineering Ethics*, *19*(2), 535–543. https://doi.org/10.1007/s11948-011-9338-3

Moakler Jr., M. W., & Kim, M. M. (2014). College Major Choice in STEM: Revisiting Confidence and Demographic Factors. *The Career Development Quarterly*, *62*(2), 128–142. https://doi.org/https://doi.org/10.1002/j.2161-0045.2014.00075.x

Owusu, P. A., & Asumadu-Sarkodie, S. (2016). A review of renewable energy sources, sustainability issues and climate change mitigation. *Cogent Engineering*, *3*(1), 1167990. https://doi.org/10.1080/23311916.2016.1167990

Ożadowicz, A. (2020). Modified Blended Learning in Engineering Higher Education during the COVID-19 Lockdown—Building Automation Courses Case Study. In *Education Sciences* (Vol. 10, Issue 10). https://doi.org/10.3390/educsci10100292

Picon, A. (2004). Engineers and engineering history: problems and perspectives. *History and Technology*, *20*(4), 421–436. https://doi.org/10.1080/0734151042000304367

Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrović, V. M., & Jovanović, K. (2016). Virtual laboratories for education in science, technology, and engineering: A review. *Computers & Education*, *95*, 309–327. https://doi.org/https://doi.org/10.1016/j.compedu.2016.02.002

Rao, M. S. (2014). Enhancing employability in engineering and management students through soft skills. *Industrial and Commercial Training*, *46*(1), 42–48. https://doi.org/10.1108/ICT-04-2013-0023

Salazar-Fernandez, J. P., Sepúlveda, M., & Munoz-Gama, J. (2019). Influence of Student Diversity on Educational Trajectories in Engineering High-Failure Rate Courses that Lead to Late Dropout. *2019 IEEE Global Engineering Education Conference (EDUCON)*, 607–616. https://doi.org/10.1109/EDUCON.2019.8725143

Sari, R. C., Warsono, S., Ratmono, D., Zuhrohtun, Z., & Hermawan, H. D. (2021). The effectiveness of teaching virtual reality-based business ethics: is it really suitable for all learning styles? *Interactive Technology and Smart Education*, *ahead-of-p*(ahead-of-print). https://doi.org/10.1108/ITSE-05-2021-0084

Schipper, M., & Stappen, E. van der. (2018). Motivation and attitude of computer engineering students toward soft skills. *2018*

IEEE Global Engineering Education Conference (EDUCON), 217–222. https://doi.org/10.1109/EDUCON.2018.8363231

Secundo, G., Elia, G., Margherita, A., & Passiante, G. (2012). Student diversity in engineering education: Insights to build a glocal program. *Proceedings of the 2012 IEEE Global Engineering Education Conference (EDUCON)*, 1–8. https://doi.org/10.1109/EDUCON.2012.6201143

Shahabadkar, P. K., Vispute, P. S., & Nandurkar, K. N. (2015). *Soft Skills Training Through Cooperative Learning: A Case Study BT - Proceedings of the International Conference on Transformations in Engineering Education* (R. Natarajan (ed.); p. 573). Springer India.

Steffen, W., Grinevald, J., Crutzen, P., & McNeill, J. (2011). The Anthropocene: conceptual and historical perspectives. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *369*(1938), 842–867. https://doi.org/10.1098/rsta.2010.0327

Stephanopoulos, G., & Reklaitis, G. V. (2011). Process systems engineering: From Solvay to modern bio- and nanotechnology.: A history of development, successes and prospects for the future. *Chemical Engineering Science*, *66*(19), 4272–4306. https://doi.org/https://doi.org/10.1016/j.ces.2011.05.049

Sydorenko, V. (2020). Soft skills as an educational trend and a necessary development component for a vocational lifelong education teacher. *Fundamental and Applied Researches in Practice of Leading Scientific Schools*, *38*(2 SE-Articles). https://doi.org/https://doi.org/10.33531/farplss.2020.2.23

Vo, H.-P., Berglund, A., & Daniels, M. (2017). A Perspective from Vietnamese Students on Teaching of Soft Skills. *2017 International Conference on Learning and Teaching in Computing and Engineering (LaTICE)*, 23–24. https://doi.org/10.1109/LaTiCE.2017.11

Waizmann, B., Schuhbauer, H., & Brockmann, P. (2020). Smart Technology to Improve Cultural and Gender Diversity in Engineering Education. *2020 IEEE Global Engineering Education Conference (EDUCON)*, 61–65. https://doi.org/10.1109/EDUCON45650.2020.9125350

Williams, S. A., Lutz, B., Hampton, C., Matusovich, H. M., & Lee, W. C. (2016). Exploring student motivation towards diversity education in engineering. *2016 IEEE Frontiers in Education Conference (FIE)*, 1–5. https://doi.org/10.1109/FIE.2016.7757565