Preparing 5.0 Engineering Students for an Unpredictable Post-COVID World

Rouvrais Siegfried
Lab-STICC, UMR CNRS 6285
IMT Atlantique
Brest, France
https://orcid.org/0000-0003-2801-3498

Gerwel Proches Cecile
University of KwaZulu-Natal
Durban, South Africa
gerwel@ukzn.ac.za

Audunsson Haraldur
Department of Engineering
Reykjavik University
Reykjavik, Iceland
https://orcid.org/0000-0002-7730-346X

Chelin Nathalie
IMT Atlantique
Brest, France
nathalie.chelin@imt-atlantique.fr

Liem Inggriani
Institut Teknologi DEL
NBO Bebras, Indonesia
inge@informatika.org

Tudela Villalonga Lluis
Fundació Universitat Empresa de les
Illes Balears, Spain
lluis.tudela@fueib.org

***Abstract*—In 2020, Higher Education and industry across the globe were immersed in extreme, unpredictable environments. Given the devastating impacts and disruptions observed since the appearance of COVID-19, the question to ask Higher Education is how it can better prepare students who are capable of being agile and proactive, and who demonstrate effective decision-making capabilities in complex situations. This paper therefore seeks to explore how educational engineering programs can better prepare 5.0 engineering students for their future workplace. It draws on the authors' involvement in two European Union projects, to provide insights and recommendations, which suggest that the focus be on: revisiting the curriculum; developing transversal skills and V-shape Engineer workspaces; work-based learning; graduate employability; and strengthening ties between academia and industry. We are also increasingly moving towards a 5.0 era where the emphasis is on developing human-centred IT soft-skills. This paper presents educational engineering-program leaders and managers, with suggestions for how to be responsible and proactive in ensuring that 5.0 engineering students have not only a qualification, but the requisite skills to make a more meaningful impact in their future workplace.**

Keywords — engineering education, COVID-19, transversal skills, industry relations, workplace.

I. Introduction

In the job market, specific and extraordinary demands are anticipated. Cedefop's skills forecast in 2018 already highlighted that in Europe, work environments in the near future are expected to feature more autonomy, less routine, more use of Information and Communications Technology, reduced physical effort and increased social and intellectual tasks [1]. The European labour market is challenged by changes in the demographic composition of the labour force and by increasing work complexity and processes.

Most countries across the globe have been severely affected by COVID-19, with most workplaces in 2020 also experiencing the effects. Educational and professional practice in 2020 has been clearly characterized by high levels of Volatility, Uncertainty, Complexity, and Ambiguity (VUCA) [2]. Such impacts are predicted to continue beyond 2020, in light of the severe consequences wrought by the COVID-19 pandemic in several sectors.

The future of work, along with graduate students' employability and careers, needs to be re-examined for the post-COVID era. A recent analysis carried out by *Société des Ingénieurs et Scientifiques de France* (www.iesf.fr) on competence assessment, illustrates that "the academic knowledge and the professional competence of French Alumni, holders of an Engineer's degree, are of utmost importance in the present days, in order to actively contribute to the challenges of the post-COVID-19 era, tomorrow and thereafter" [3]. Engineers and scientists will have to actively contribute to new societal challenges. The younger generation of students and new graduates need to be adequately prepared for a range of possible world crises (e.g. economic, natural disasters, terrorism, biological warfare, pandemic, climate, etc.).

This paper explores how Higher Engineering Education (HEE) program leaders and managers can best prepare 5.0 engineering students for future changes in workplaces and a post-COVID-19 VUCA world. It is critical that HEE program leaders and curriculum designers learn from the 2020 pandemic in order to proactively adapt and realign educational offerings and services, to ensure that new transversal and versatile 5.0 skills are developed and reinforced in engineering students. Engineering graduates, who are to be workplace ready, should be able to effectively deal with complex issues and make decisions instantly in professional situations characterised by higher levels of risks, uncertainty, and complexity.

II. Study Background and Approach

New curriculum guidelines were recently proposed, e.g. for Industry 4.0 [4], as well as numerous recommendations to University management that have to anticipate changes and make choices on how to adapt [5].

The paper draws on two Erasmus projects (DAhoy and EASTEM) to address the main question under investigation, namely, identifying ways in which HEEs can ensure that engineering students are appropriately trained to meet future challenges in the workplace. DAhoy is a strategic partnership focused on developing the decision-making skills of engineering and Science, Technology, Engineering and Mathematics (STEM) students. DAhoy is founded on an understanding of academia and industry's perceptions and expectations of students, and is fully aligned with the strategic VUCA challenges to accelerate pedagogical innovations and revise their educational systems with transversal skills. The second project, EASTEM, is a capacity-building project within South-East Asia, facilitating a competency approach and University Business Industry

This work was supported by the European Erasmus+ program under grants 2017-1-FR01-KA203-037301 and 2018-1-SE-EPPKA2-CBHE-JP.

978-1-7281-9756-2/20/$31.00 ©2020 IEEE

Collaboration models (UBICs) within STEM education programs in Europe and eastern Asia.

Both projects have sought to transform Engineering students into technological-change-leaders and decision makers, specifically for a VUCA world. Student-centred learning approaches are employed.

EASTEM enhanced STEM students' employability in an unpredictable future by facilitating the exploration of multiple realities, in different cultural settings and contexts, at an international level. The broader context also highlighted how important it is that students, while still at HEEs, spend time in industry to be exposed the working world. Another important aspect to consider is that HEEs and other institutions should take responsibility in developing the entrepreneurial skills of students and where possibly, assist with small start-ups / incubators. The rationale is that students are not only developed to be mere employees who will be working for a boss or company. It is important to also bear in mind that a shift was made in some institutions to be entrepreneurial universities, whereby academics help students in this respect, rather than only be pure research universities.

A major outcome of DAhoy is that seven decision-making skills were identified as transversal skills (formerly known as transferable skills) and introduced to facilitate VUCA training. Key outcomes from the project include defined and evaluated innovative teaching and learning (T&L) activities to be integrated in educational frameworks at a systemic level; quality assurance and recommendations. DAhoy's European partnerships resulted in positive and sustained effects in the participating organisations and their staff and students' transversal skills integration, which is also now evident in other regional, national and European Institutions.

Given their focus on VUCA and career preparation, these two projects – although emanating primarily from a European perspective – provide insights into how HEE managers and program leaders could better prepare 5.0 engineering students for the future workplace and a post-COVID-19 unpredictable world. This enhances academia's capacity to be responsible and proactive in ensuring that 5.0 engineering students have the requisite skills, as well as qualification, to make a more meaningful impact in the workplace.

III. Revisiting Curricula for New Contexts

Through a 3-year design-based research, including qualitative and quantitative iterative analysis, DAhoy conceptualized and analyzed seven decision-making-skills statements [6], shared several constructively aligned T&L courses and investigated their mapping in some national qualification frameworks. Results offer some recommendations for adapting curricula in the short term, to incorporate greater emphasis on transversal skills, including V-shape perspectives.

A. Transversal Skills

New graduates are potential leaders and managers of the future and they should have the necessary skills and competencies to face the current, as well as future VUCA situations. HEE has to ensure that engineering graduates have effective transversal skills to more comfortably face VUCA-like situations while working in the new post-COVID-19 VUCA world and also, along with professionals and graduates, to take advantage of the new landscape of career opportunities for a 5.0 future. Engineers need to develop 5.0 soft skills, such as Information Technology (IT) communication skills (working more online and less face-to-face), adaptation to change, and empathy – some of the 24 generic skills as highlighted in the work of Abdulwahed et al. [7].

As an illustration of the need for transversal skills, the COVID-19 crisis of 2020 has demonstrated that it is now critical to have effective judgment and decision-making capabilities. In 2005, the European Qualification Framework [8] indicated the importance of students at Bachelor level 6, being able to:

"[take] responsibility for decision-making in unpredictable work or study contexts" and, at Master level 7, to "manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams".

In 2015, the European Network for Accreditation of Engineering Education, which sets program outcomes for engineering education accreditation in the EU, prioritized decision-making and judgement abilities among its ten outcomes [9]. In Europe it is expected that the learning process should enable Masters' degree graduates to demonstrate the:

- ability to manage complex technical or professional activities or projects that can require new strategic approaches, taking responsibility for decision-making;
- ability to integrate knowledge and handle complexity, to formulate judgements with incomplete or limited information, that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgement.

The needs of the economy have changed in 2020 as a result of COVID-19, with new workforce requirements and revised economic-growth strategies. Graduate attributes and core learning outcomes need to change so that they include transversal skills, such as decision-making, as conceptualized and analysed by DAhoy.

Now, soon after the initial COVID-19 crisis, HEE programs should be realigned without waiting until the periodic quality evaluation processes or revised engineering program outcomes are formalized in qualification frameworks. The conventional periodic review and evaluation of engineering programs, often at four or five-year intervals (as with the US ABET or with CTI in France) [10], may need to be examined in light of 2020's exceptional changing context and needs.

B. V-shape 5.0 Engineers

In 2018, Robin Karvo, Human Resources Consultant at Nokia France, indicated that, "today's business world is changing more quickly than ever before: rapidly evolving markets, regulations, and technologies make it hard to see very far into the future" [11]. Before the crisis, technological universities were mainly focused on producing a 2020 STEM graduate, with 'T-shape' skills [12]. T-shaped scientists [13] are those who have good depth of knowledge and skill in one

discipline, and a reasonable breadth of knowledge and skill across multiple disciplines, e.g. management, so have transferable skills for judgement and decision-making (T-shaped were an evolution of 'I-shaped' graduates, who have developed good depth of knowledge and skill in a single discipline only).

As the VUCA context is now prevalent in most sectors, engineering graduates should ideally be more 'V-shaped' [14], a quality reinforced as a result of a versatility-oriented curriculum. V-shaped individuals grow in knowledge and skill, and also in spiral fashion, both horizontally and vertically. A V-shaped graduate is neither a specialist nor a generalist [15]. V-shaped graduates have balanced knowledge and skills and can learn a new domain of skills easily; this is why in software engineering programs, ACM-IEEE curricula recommendations include additional requirements about domain-specific knowledge [15]. More and more, it is evident that an engineer 5.0 era prevails [14], with human-centred IT soft-skills, and empathy requirements being at the forefront of the skills required. Society 5.0 encompasses a combination of cyberspace and physical space and is "a human-centred society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space" [16].

For the post COVID-19 period in HEEs, transversal skills are required, and this context provides an opportunity for HEEs to revise program outcomes and aim for V-shaped perspectives for their graduates. V-shaped individuals are the kind of people needed post-COVID-19, with a focus on careers and competency development, both across and up, to grow tomorrow's workforce. STEM graduates will need to implement decisions, knowledge and skills in order to be able to actively contribute to the post-COVID-19 era, to replicate the success of spontaneous and ongoing mission-driven engagement. This engineer needs to embody the traits of a leader: decisive, bold yet humble, courageous, resilient, open to change and continuous learning, and able to be adaptable in various contexts.

C. *Flexible Curricula in the Digital Era*

The 2020 crisis is changing the nature of work, of workers, and of workplaces. Professional workplaces and communication technologies will need to change business practices, and companies will also need to adapt their approaches and processes [4]. The value of online learning platforms and video-conferencing procedures were reinforced all around the world in 2020, as they were for the HEE sector with the sudden, rapid shift to remote education. The new generation of STEM students (digital native) is open to distance education, e.g. Massive Open Online Courses and Small Private Online Courses. Most STEM students, especially engineering students, are already aware of 'learning to learn' in 2020 and are fairly independent.

This new generation is therefore fertile ground for this VUCA-like environment of learning, but the monitoring of the learning process remains a concern for all. In 2020, society is in the midst of a cultural change, and is experiencing a transition towards a new generation of universities where technology-enhanced learning is becoming the norm, including diversity of learning paths.

Nevertheless, as highlighted by Kamp [5], it is far easier to educate students for our past than for their future. The chaotic VUCA situation is not a predictable linear extension of the present. Long-term forecasts of discrete scenarios lead to billowing plumes of uncertainty. University leaders and HEE program managers need to revise their curricula to better prepare their students for an uncertain future. For the post-COVID-19 period, traditional recognition of learning and competence development will have to be revisited.

D. *Workspaces*

In 2020, the risk of virus transmission, resulting in COVID-19 infections, was greatest in places where large numbers of individuals congregate, such as universities. While it became apparent at the outset of the COVID-19 crisis that ensuring continuity of study and work was made possible by enabling rapid external engagements, which relied in turn on supportive workspaces, managing the crisis required that the ideal workspace was balanced by mitigating the risk of unsafe crowding in university environments.

Workspaces in universities need to be rethought, due to constraints pertaining to physical proximity. Innovative solutions to confined spaces, through the design of more space-driven intersection and student-working meeting places with industry were required for Vocational Education and Training education. Lots of campuses in 2020 were closed, semesters abroad have been cancelled, internships have been interrupted, and the European Schengen area will probably remain closed for a while until COVID-19 is perceived to be more manageable.

Multiple and diverse impacts will be observed in the long run as a result of the COVID-19 period. On the one hand, HEEIs will have to consider various factors, such as international status, quality and certification, teachers' confidence, students' confidence, and financial reserves. On the other hand, students are more concerned with employability, quality of education and training, having a well-recognized diploma and social connection with peers.

IV. Preparing Engineers for the Workplace

EASTEM, with 13 technological universities, conceptualized eight UBICs via literature reviews and semi-structured interviews [17]. Its analysis lay the foundation for a structured relationship model for STEM universities to be expanded later by shared good practices among partners thanks to a 3-days collaborative international and virtual meeting in October 2020, including industrial stakeholders. Requirements and maturity levels in UBIC models differ greatly between countries and institutions and are part of the international diversity of culture, educational and industry history, and national economic growth. One objective is that STEM programs will be more sustainable once partner institutions are better equipped to interact with corporate partners in the development of their STEM-university education. The results could echo strategic plans and policies of HEE and, in the short term, suggest some recommendations to reinforce cooperation with industry and companies.

A. *Work-based Learning Tensions and Recognition of Learning*

In 2020, professional work activities integrated into the engineering curricula were under pressure, mostly in countries where internships and apprenticeship models are in place for engineering education [18]. As a result of COVID-19, many interns had to immediately leave their companies

as some organizations were forced to close in some countries or sectors.

For the post-COVID-19 period, recognition of student learning and competence development in companies will have to be revisited. Student engagements devised to practically assist society could perhaps include grading of portfolios of experiences, a process which may be applicable also as a means for universities to recognize accomplishments by informal dynamic learners, as well as their prior learning processes for VET.

B. Graduate Employability and Professional Needs

Graduate employment and employability analysis protocols in HEE will need to change. The recruitment market, nationally and internationally, will not be the same as before COVID-19. There is for example already change in how industry is being relocated in Europe, with some countries bring more adaptable than others. However, some sectors, currently under skills pressure, will offer growth opportunities, such as IT and telecommunications, some Industry 4.0 pillars, health, science and biomedical Research and Development, logistics and supply chains, or start-ups.

For the post-COVID-19 period, the employment indicators will have to be revised alongside territorial, regional and national priorities. Institutions will need to organize and implement new actions and adapt processes to the VUCA situation.

Students always need to be exposed more quickly to new career perspectives, so that they can navigate their career path with less anxiety in the short term. For the post COVID-19 period, universities, along with industry, should provide more support to their students by setting personal, national and regional goals in preparation for their future careers. Students should reinforce their capabilities to analyze and judge the situation for career decision-making, in order to organize and implement actions to better prepare for the end of their studies in readiness for their first job [19]. Moreover, they may need to re-orient themselves in their chosen career path and personally take on that responsibility, for themselves and for the broader society. It is time to identify and motivate new role models, e.g. as future entrepreneurs, via high-potential recruitment programs.

C. Strengthen Ties between Academia and Industry

Engagement with industry has always been a crucial requirement for technological universities to support economic development since the 1st Industrial Revolution [20]. During the COVID-19 crisis, some university-industry engagement experiences around the world have shown the capacity of HEEI, and their students, to engage rapidly and flexibly. Ongoing collaboration will be critical to ensuring the recovery phases of both HEE and the economy. The magnitude of the 2020 economic crisis, at national and global levels, will require that HEE institutions rise above systemic passive inertia and reactively engage in the constant work of creating new forms of collaboration, models and processes.

Cooperation between academia and industry will be critical for both parties during and after COVID-19. Academia can improve its curriculum and knowledge delivery whilst industry takes advantage of subjects developed by academia. Some universities have been slow to acknowledge the academia-industry divide. Reimers and Schleicher [21] proposed a checklist in their Organisation for Economic Co-operation and Development (OECD) report, aimed at supporting education decision-making to develop and implement effective educational responses to the COVID-19 global pandemic. The first task is to establish a task force or steering committee that will have the responsibility to develop and implement an educational response. It must be ensured that, where possible, those in the task force represent different constituents, including representatives of industry when relevant.

Support structures are essential for enabling rapid external engagement; transdisciplinary, multi-sector strategies are necessary when seeking to solve complex problems that threaten global public health and safety [22]. Other tasks include exploring partnerships with the private sector and the community in securing the necessary resources to provide devices and connectivity. These issues are largely in the hands of HEEs. We need to have shared strategies with governments (national and regional), industry and business sectors, universities and their students. Students, as future professionals, need to assist in the short term with economic recovery, in order to have a more resilient future.

V. Discussion and Recommendations

The 2020 crisis has demonstrated just how fragile many systems actually are. Strategic leadership is required to create crisis-recovery groups, incorporating both analysts and skilled VUCA decision makers, to prepare for any future crises that may echo in STEM and engineering education. It is important to put plans (short, medium and long-term) in place but HEEs leaders will need to be responsive-ready and agile, should another crisis appear.

HEEs structures, processes and policies need to be revisited on a regular basis, and the institutional culture has to be conducive to embracing change, rather than characterized by extreme bureaucracy and hierarchy, and the upholding of traditions. This is particularly relevant as the world struggles to pick up the pieces after being battered by the pandemic. It is important for HEEs transitioning to the new normal to be able to integrate social and societal aspects, even natural fundamentals and values which are far too neglected, and to encompass the concrete experiences learned from each crisis, to ensure development as reflective practitioners [23].

This analysis may guide university leaders and managers to enhance and accelerate university-industry engagement alongside a V-shaped and more flexible curriculum. It is, however, important to avoid a mismatch in expectations [24]. Collaboration between these two sectors needs to be reinforced [8] but it is likely that there will be inhibiting factors which will remain – “Industry and academia have different cultures, different values, different needs and different expectations (Morell 2014: 2) [25]… the biggest barrier that may exist is the failure to recognize that each sector has different needs” (Morell 2014: 3) [25].

In 2020, the future is uncertain, and we have no clear directions as to how societies, economies, and the very way of life will be impacted. We also find ourselves in the midst of a human-centred society 5.0, which involves integrating cyberspace and physical spaces. Despite not having any certainties, HEE have a moral responsibility to ensure that graduates are not ill equipped for a VUCA future with a 5.0

perspective. It is thus imperative that, without further delay, students are taught how to meaningfully contribute to a human-centred society that balances economic advancement with collaboration, nature and the resolution of social and societal problems.

VI. Conclusion

This paper sought to explore how HEE managers and educational program leaders can best prepare 5.0 engineering students for the workplace and a post-COVID VUCA world. Through analysis conducted in two EU projects, the first with four European universities and the second with thirteen technological universities, the authors recommend that HEE leaders focus on: revisiting the curriculum, emphasising transversal skills and V-shape Engineers' workspaces, work-based learning, graduate employability, and strengthening collaborations between academia and industry. To reinforce the adoption of transversal skills, a framework originating from DAhoy highlighted six Reference Models intended to guide university leaders in implementing the learning environment for decision-making skills in VUCA situations. The eight UBICs emanating from EASTEM form a foundation on which to foster collaborations with Industry, including several shared good practices per UBIC.

With a society 5.0 vision in their curricula, HEE must now be ready to adapt themselves into learning spaces for V-shaped students, to prepare their students to become flexible lifelong students, capable of facing VUCA post-COVID once they enter the workforce. The engineer 5.0 era involves a human-centred society which takes into account both the economic and the social, with human-centred IT soft-skills and empathy requirements being at the core. There is a clear shift towards realizing just how important traits and characteristics are, and not only technological know-how. Engineering educational leaders should lead the way in shaping Engineering graduates to thrive in VUCA situations.

Acknowledgment

The authors would like to acknowledge their colleagues from DAhoy and EASTEM projects. The European Commission's support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein, as for the author's respective institutions.

References

[1] Cedefop, "Skills forecast trends and challenges to 2030," European Centre for the Development of Vocational Training, Retrieved from https://www.cedefop.europa.eu/, 2020.

[2] N. Bennett and J. Lemoine, "What VUCA Really Means for You," Harv. Bus. Rev., vol. 92(1/2), 27, 2014.

[3] M. Ventre, "COVID-19: IESF Press release," Ingénieurs et Scientifiques de France (IESF), 8 April 2020. Retrieved from https://www.iesf.fr/offres/doc_inline_src/752/1-CommuniquePresident-IESF-Covid19.pdf, 2020.

[4] PwC, "Skills for Industry Curriculum Guidelines 4.0: Future-proof education and training for manufacturing in Europe," EASME Dpt. A - COSME, H2020 SME and EMF. Final Report, January 2020.

[5] A. Kamp, "Navigating the landscape of higher engineering education: Coping with decades of accelerating change ahead," Delft University of Technology Edition. 4TU. Centre for Engineering Education. Delft, Netherlands, April 2020.

[6] S. Rouvrais, S. Gaultier Le Bris, and M. Stewart, Engineering Students Ready for a VUCA World? A Design-based Research on Decisionship. In Proceedings of the 14th International CDIO Conference, pages 872–881, KIT, Kanazawa, Japan, June-July 2018.

[7] M. Abdulwahed, W.Balid, M. O. Hasna, and S. Pokharel, "Skills of Engineers in Knowledge Based Economies: A Comprehensive Literature Review, and Model Development," In Proc. of the 2013 IEEE International Conference on Teaching, Assessment and Learning for Engineering, 759-765. Bali, Indonesia, August 2013.

[8] European Commission, "*Descriptors defining levels in the European Qualifications Framework (EQF). Learning Opportunities and Qualifications in Europe,"* Retrieved 19 April 2020 from https://ec.europa.eu/ploteus/en/content/descriptors-page, 2005.

[9] ENAEE, "The EUR-ACE Framework Standards and Guidelines (EAFSG)," The European Network for Accreditation of Engineering Education, 2017.

[10] CTI, "Conséquences Episode Coronavirus". Communique by French 'Commission des Titres d'Ingénieur', 26 March, Retrieved from https://www.cti-commission.fr/consequences-episode-coronavirus-2, 2020.

[11] R. Karvo, "Career Decision Making", Retrieved from https://youtu.be/LC0GRvD9ALg, 2018.

[12] I. Liem, Y. Asnar, S. Akbar, A. Mulyanto, and Y. Widyani, Y. Reshaping software engineering education towards 2020 engineers. In 27th Conference on Software Engineering Education and Training (CSEE&T), 171-174. IEEE Klagenfurt, 23-25 April 2014.

[13] D. L. Johnston, "Scientists Become Managers-The "T"-Shaped Man," IEEE Eng. Manag. Rev., vol. 6(3), pp. 67–68, 1978.

[14] B. Hinton, "V Shaped Engineers: The evolution of T-shaped," Blog post of May 4, Retrieved at http://hintonbr.wordpress.com, 2016

[15] A. Koohang, L. Riley, T. Smith, and K. Floyd, "Design of an Information Technology Undergraduate Program to Produce IT Versatilists," J. Inf. Technol. Educ., vol. 9(1): pp. 99-113, 2010.

[16] Japanese Cabinet Office, "Society 5.0," Japanese Council for Science, Technology and Innovation, Science and Technology Policy. Retrieved from https://www8.cao.go.jp/cstp/english/society5_0/index.html, 2020.

[17] S. Rouvrais, G. Jacovetti, P. Chantawannakul, N. Suree, and S. Bangchokdee. University-Industry collaboration themes in STEM higher education: An Euro-ASEAN perspective. In Proceedings of the 16th International CDIO Conference, hosted online by Chalmers University of Technology, Gothenburg, Sweden, 9-11 June 2020.

[18] S. Rouvrais, B. Remaud, and M. Saveuze, "Work-based Learning Models in French Engineering Curricula: Insight from the French experience", Eur. J. Eng. Educ., Special Issue, vol. 45(1), pp. 89-102, 2018.

[19] C. Gerwel Proches, N. Chelin, and S. Rouvrais, « Think first job! Preferences and expectations of engineering students in a French Grande Ecole," Eur. J. Eng. Educ., vol. 43(2), pp. 309-325, 2018.

[20] B. Kloot and S. Rouvrais, "The South African Engineering Education Model with a European Perspective: History, Analogies, Transformations, and Challenges," Eur. J. Eng. Educ., vol. 42(2), pp. 188-202, 2017.

[21] F. M. Reimers and A. Schleicher, "A framework to guide an education response to the COVID-19 Pandemic of 2020," Published under the responsibility of the Secretary General of the OECD, April 2020.

[22] K. H. Jacobsen, A. A. Aguirre, C. L. Bailey, A. V. Baranova, A. T. Crooks, A. Croitoru, P. L. Delamater, J. Gupta, K. Kehn-Hall, A. Narayanan, and M. Pierobon, "Lessons from the Ebola outbreak: action items for emerging infectious disease preparedness and response," EcoHealth, vol. 13(1), pp. 200-212, 2016.

[23] D. A. Schön and V. DeSanctis, V., "The Reflective Practitioner: How Professionals Think in Action", J. Cont. High. Educ., vol. 34(3), pp. 29-30, 1986.

[24] A. C. Bickley and D. H. Nash, "Building a Long Term Strategic University-Industry Partnership". In Proceedings of the 2018 University-Industry Interaction Conference: Challenges and Solutions for Fostering Entrepreneurial Universities and Collaborative Innovation. Pp. 146–154. London, UK, 20-22 June 2018.

[25] L. Morell, "Scaffold to Build and Sustain Industry-University Partnerships," J. Eng. Educ. Trans., vol. 27(4), pp. 2349-2473, 2014.