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Design Engineering Capacity Building and Training issues in North African Countries: the case of Algeria

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Abstract: *Africa needs to develop its own indigenous engineering design capacity through engineering education that will meet international standards if we want African enterprises to be competitive and African economies to be self-reliant in this field. The training of engineers becomes a critical issue in training institutions, syllabuses, pedagogical methods, and the relationships between the training sphere and industry. Engineering design training faces the challenge of the massive introduction of new technologies or the 'technologisation' of the D&E function (CAD, rapid prototyping, and 3D printing). In this paper, we examine the design and engineering training system in Algeria. To what extent has it been able to build effective D&E capabilities? How has it been able to meet industry needs, and in particular, how prepared is it to meet the future innovation needs?*

Keywords: Design Engineering- Training- Pedagogy- Capacity building- Algeria
Jel Classification Codes : O5 ; Z19

Résumé : *L'Afrique a besoin de développer sa propre capacité de conception d'ingénierie à travers l'enseignement de l'ingénierie qui respectera les normes internationales si nous voulons que les entreprises africaines soient compétitives et que les économies africaines soient autonomes dans ce domaine. La formation des ingénieurs devient une question critique dans les institutions de formation, les programmes, les méthodes pédagogiques et les relations entre le domaine de la formation et l'industrie. La formation en conception technique relève le défi de l'introduction massive de nouvelles technologies ou de la « technologisation » de la fonction D&E (CAO, prototypage rapide et impression 3D). Dans cet article, nous examinons le système de formation en conception et en ingénierie en Algérie. Dans quelle mesure a-t-il été en mesure de construire des capacités de D&E efficaces? Comment a-t-il pu répondre aux besoins de l'industrie et, en particulier, est-il prêt à répondre aux besoins futurs en matière d'innovation?*

Mots-clés : Ingénierie de conception- Formation- Pédagogie- Renforcement des capacités- Algérie
Codes de classification Jel : O5 ; Z19

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Introduction :

Countries seek to strengthen their human, institutional, and infrastructure capacities by providing a solid base of technically prepared people to effectively improve their economies and quality of life in pursuit of a safer, more stable, and sustainable world.

While a deeply human creative activity, the engineering design process is now hugely facilitated by such technologies. The technologisation of the design process has dramatically changed engineering practice, especially in lowering the cost and the time it takes to produce a prototype, thereby freeing up time and resources for other activities. Also, engineering educators must take a closer look at how engineering students are being prepared to enter the "real world." Current graduates will be called upon to make decisions in a socio-geo-political environment quite different from todays. In their lifetimes, engineering students now attending college can expect to see an increase in world population from 6 to 9 or 10 billion people, major global warming phenomena, and major losses in biological and cultural diversity on Earth.

Whether colleges and universities are doing enough proactively to teach students what they need to know to operate in a future environment is an open question (Orr, 1998). Engineers must complement their technical and analytical capabilities with a broad understanding of so-called "soft" skills that are nontechnical. Experience has shown that the social, environmental, economic, cultural, and ethical aspects of a project are often more important than the technical aspects.

An issue of equal importance is the education of engineers interested in addressing problems specific to developing communities. These include water provisioning and purification, sanitation, power production, shelter, site planning, infrastructure, food production and distribution, and communication, among many others. Such problems are not usually addressed in engineering curricula in many countries in the world including some advanced countries, however. Thus, engineers are not educated to address the needs of the most destitute people on the planet, many of them living in industrialized countries. This is unfortunate because an estimated 20 percent of the world’s population lacks clean water, 40 percent lacks adequate sanitation, and 20 percent lacks adequate housing.

Furthermore, engineers will be critical to addressing the complex problems associated with refugees, displaced populations, and the large-scale movement of populations worldwide resulting from political conflicts, famine, shortages of land, and natural hazards. Some of these problems have been brought back to our awareness since the tragedy of September 11, 2001.

The engineer’s role is critical to the relief work provided by host governments and humanitarian organizations. According to the World Health Organization (WHO), 1.8 billion people (30 percent of the world’s population) currently live-in conflict zones, in transition, or permanent instability situations.

Engineers of the future must be trained to make intelligent decisions that protect and enhance earth's quality of life rather than endangering it. They must also make decisions in a professional environment where they will have to interact with people from both technical and nontechnical disciplines. Preparing engineers to become facilitators of sustainable development, appropriate technology, and social and economic changes is one of the greatest challenges faced by the engineering profession today.

Engineering design in Africa should take advantage of these technologies by integrating the competency building program in using the technologies as part of the engineering education curriculum. To achieve this much-needed turnaround, revamping or, as the case may be developing engineering education and engineering design education in particular, is an indispensable departure point.

Ensuring that a single African International Engineering Education program is followed cannot be addressed without reorienting engineering design education towards a vigorous competency building program (South Africa DST Minister, 2006). Finally D&E training needs to enhance creative skills and innovation capabilities as the world is moving fastly in a world economy where competition is mostly driven by innovation.

To what extent has the training programme been able to build effective D&E capabilities? How has it been able to meet industry needs, and in particular, how prepared is it to meet the future innovation needs? These are some of the questions our paper will address.

Methodology:

A survey was conducted in both polytechnic high schools in Algiers and in Oran.
In Algiers, the *Ecole National Polytechnique* (ENP) is one of the oldest high schools established under colonial rules. In Oran, the *Ecole Nationale Polytechnique* of Oran (ENPO) was established in 2012 out of the former Ecole Nationale Supérieure de l'Enseignement Technique (ENSET). A sample of 38 students was selected from ENPO from various cohorts. A limited number of teachers were interviewed in both schools.
The article is structured as follows: After a literature review about in a first section, we examine briefly the structure of training in Design & Engineering (D&E) in Algeria in a second section. The third section analyses the results of the survey conducted on a sample in the two Engineering schools. The last section concludes.

1. Literature review

In the global economy, engineers play an important role in the overall economic development of countries. The aim of engineering capacity building is to develop a sufficient pool of well-educated engineering graduates who are accredited in countries to achieve the required technical capacity that helps to participate effectively in the global economy. Foreign direct investment, international trade, engineer mobility, and workflow will result in countries with talent in cost-effective.

The question now arises whether it is possible to satisfy the needs of a growing population exponentially while preserving the carrying capacity of our ecosystems and biological and cultural diversity. As we enter the twenty-first century, we must embark on a worldwide transition to a more holistic engineering (Amadei, 2004). This will require: (1) a major paradigm shift from control of nature to participation with nature; (2) an awareness of ecosystems, ecosystems services, and the preservation and restoration of natural capital; and (3) a new mindset of the mutual enhancement of nature and humans that embraces the principles of sustainable development, renewable resources management, appropriate technology, natural capitalism (Hawken et al., 1999), biomimicry (Benyus, 1997), biosoma (Bugliarello, 2000), and systems thinking (Meadows, 1997).

In addition, engineering educators must take a closer look at how engineering students are being prepared to enter the "real world." Current graduates will be called upon to make decisions in a socio-geo-political environment quite different from todays. In their lifetimes, engineering students now attending college can expect to see an increase in world population from 6 to 9 or 10 billion people, major global warming phenomena, and major losses in biological and cultural diversity on Earth.

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Furthermore, engineers will be critical to addressing the complex problems associated with refugees, displaced populations, and the large-scale movement of populations worldwide resulting from political conflicts, famine, shortages of land, and natural hazards. Some of these problems have been brought back to our awareness since the tragedy of September 11, 2011. The engineer's role is critical to the relief work provided by host governments and humanitarian organizations.

Engineering education needs to be changed (or even reinvented) to address the challenges associated with these global problems. There is still a large disconnect between what is expected of young engineers in engineering firms, the magnitude of the problems in our global economy. As an example, in United States, the Accreditation Board for Engineering and Technology (ABET) is recognized in the United States as the sole agency responsible for accreditation of educational programs leading to degrees in engineering1. Most engineering studies do not meet ABET 2000 engineering criteria (Criteria 3 and 4, for instance).

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Preparing engineers to become facilitators of sustainable development, appropriate technology, and social and economic changes is one of the greatest challenges faced by the engineering profession today. Meeting that challenge may provide a unique opportunity to renew the U.S. engineering profession's leadership as we enter the twenty-first century.

The need for an indigenous scientific and technical ability ensures that international aid funds are used effectively and efficiently for long-term operation and maintenance and to develop the capacity to implement future projects, with people who are particularly educated and willing to participate in emerging entrepreneurship efforts that meet local needs (Jones, R. C., 2002). Hence, engineering capacity is seen as an effective way to develop technical engineering skills.

Currently, important technologies are related to fields of science or applied engineering. As mentioned in many of the contributions, design and engineering activities are among the most important systems of science, technology, and innovation in advanced industrial economies, which has led to the emergence of a wide gap between developed economies and less developed countries in terms of expansion capabilities (Djeflat, 2017).

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[1] https://user.eng.umd.edu/~zhang/414_97/abet.html

The study of Abdulwahed & Hasna (2017) revealed new perspectives on developing engineering skills. The highest developmental effects of design engineering capacity were observed in the following procedures: Work experience - Teamwork - Creative thinking - Decision Making - Problem Solving - Professionalism - Analytical thinking - Systems thinking - Leadership and ICT skills. It is a vehicle for developing the full range of soft competencies essential to developing a knowledge-based economy.

Design engineering is team-based and is an open, collaborative approach under constraints, involves the engagement of multiple interpersonal, cognitive and managerial skills or competencies such as teamwork, communications, decision making, problem-solving problems, etc. where they need to have a wide range of interpersonal skills (Abdulwahed & Hasna, 2017).

Countries must have the scientific, technological, and engineering capacities necessary to provide solutions to sustainable development challenges, including strengthening the capacities to conduct scientific research, scientific education at all levels, effective training in engineering and universities, and quality research centers.

The ability to engineering with science and technology is essential to find appropriate solutions. The creation of scientific networks and the facilitation of access to scientific information are of great importance in building strong scientific research bases integrated into international scientific communities (UNESCO). The use of information and communication technologies is increasingly important.

2. Structure of training in Design & Engineering (D&E) in Algeria

In Algeria, engineers' training was aimed at the constitution of a technical body capable of taking charge of industrial installations following the economic system chosen by the country of an import-substtution model driven by the industrial engine (De Bernis, 1971). Initially, it was provided in three types of institutions: technological institutes related to the industrial sector, foreign schools and universities, and the Algerian university. Historically, the higher education system in Algeria is based on the former French model of the four faculties (medicine, science, law and economics, and humanities) (Touati, 2013). And it is this academic configuration that is found within the company among the alumni.

But, with the decline of training abroad and following political decisions to close technological institutes, engineering training has been completely entrusted to the university. The first consequence of this change was his disconnection from the industrial sector, thus finding itself deprived of the financial support of industry and access to companies for work placements.

The university, grappling with insufficient resources, a quality of its teachers who are often unaware of the reality of the industry, a pedagogy dominated by theoretical content where little room is given to practical work, delivered generalist training with little orientation. Towards the specific needs of the sector it is supposed to meet.

These conditions have contributed to impoverish training and to affect its quality, a concern that we find in the words of engineers, especially the youngest who report shortcomings in their preparation to face the world of work, which they situate in the lack of practical internships, in unsuitable teaching methods and in the quality of teachers. They also evoke difficulties in mastering the language of instruction, French, which they attribute to their fully Arabized primary and secondary education, which has forced them, at the university level, to a double challenge: to learn language and discipline. An exploratory study on a sample of engineering students from the Department of Manufacturing and Engineering Sciences at

Tlemcen University showed that students are motivated to learn English. However, their attitude towards this course is described as unfavourable at first (Messaoudi & Hamzaoui-Lachachi, 2017).

They also stated that English-speaking professionals are in greater demand in the labour market because companies require a certain English mastery, an essential condition to be recruited.

Nonetheless, Engineering scholls seem to benefit from specific treatment according to Sahali et al. (2020). Although Algeria has reformed its higher education system within the framework of theBologna Process (Law on the Orientation of Higher Education of the 17 August 1998 and its enforce-ment by the Executive Decree of 23 August 2003), the engineering schools have remained outsidethese reforms, being considered as protected spaces, destined to train the elite (Gardelle et al., 2017).

3. Case studies

3.1. Case study 1. The National School of Polytechnique in Oran

The *Ecole Nationale Polytechnique* of Oran (ENPO) was established in 2012 out of the former Ecole Nationale Supérieure de l’Enseignement Technique (ENSET). This latter was created in 1970, the School's main mission was to train teachers in technical secondary education and exact sciences on behalf of the Ministry of National Education. Since the start of the 2012-2013 academic year, a new statute has replaced the previous one, officially validating the transformation of ENSET in Oran into a National Polytechnique School of Oran, in accordance with executive decree No. 12-376 of 29 October 2012. The National Polytechnic School of Oran resulting from the transformation process will have the mission of ensuring higher education, scientific research and technological development through the training of engineers in the various specialties of science and technology. As a transitional measure, the National Polytechnic of Oran will continue to provide training for trainers for the benefit of the national education sector until the completion of the training cycles initiated. (Benziane, 2016).

Since the start of the 2012-2013 academic year, ENP d´Oran provides engineering training in the following 05 specialties: Electronics and embedded systems; Automatic; Electrical engineering; Mechanical production; Diagnosis, maintenance and rehabilitation of structures. Since the start of the 2014-2015 academic year, a 6th specialty has been accredited by the MESRS and relates to water desalination. Currently, the School provides engineering training in 10 specialties. The Oran ENP has a cumulative workforce of more than 500 enrolled in the engineering cycle in the ten specialties provided.

The investigation among the sample of 38 students shows the dominance of males in gender variable with 27 respondents and only 11 women. Most respondents are aged between 20 and 25 years.

Table 1: Structure of the sample

	Number	%
In electronics	11	29
Civil engineering,	10	26
Electrical engineering	9	16
Mechanical engineering	6	15
Electronics and embedded systems	3	08
In automatic,	3	08

Source: Authors

Per specialty, we note 11 respondents' specialists in electronics, 10 in civil engineering, 9 in electrical engineering, 6 in mechanical engineering, 3 in electronics and embedded systems, 3 in automatic, 1 in process engineering, and 1 in manufacturing. 25 of the respondents are in their 4th year, 9 are in the 3rd year, and only three are in the training cycle.

a. Education Context

For the axis cycle of education statistics show that only one student did his secondary education in private schools, the rest are all from public school. 89.47% of respondents consider that they have good teachers of mathematics and science while, 24% of respondents only consider that they have well-equipped laboratories. The rest refers primarily to the lack of material in these laboratories in general and modern equipment. Other respondents mentioned the lack of budget to manage these laboratories. Most respondents had very good grades (16-20) in the Bachelor exam of Mathematics (87%) and Physics (17%). As against in Geology and Biology statistics show a high concentration of grades between 12 and 16. The engineering career choice is often motivated by two factors: attractiveness to engineering sciences and getting a good job. However, we note eight respondents (23%) selected the "other" reasons for choosing this career.

b. Engineering design

Statistics respondents show great interest in engineering design studies with 45% with high and very high interest, 21% with average interest, and the rest (34%) with low interest. The overall performance in the subject of engineering design is more or less average, with 14 responses (37%) for "average" score, 7 (18.5%) for "high " score and 7 (18.5%) for " low" score. For the other modalities we note an average score response for adequacy of learning materials, appropriate teaching methods, teacher quality, availability of equipped laboratories and relevance to employment and future employment interests.

In our sample, 57.89% are ready to encourage other students to undertake the same studies considering that engineering is a good area and works very well in Algerian schools. While the rest of the students (42%) are demotivated because of the deficient level of education and inferior teaching methods. They consider that most teachers are not competent and there are not enough laboratories equipped, which takes them to think of following an engineering education at foreign schools. Twenty-two of respondents states that the evaluation of engineering design study is base d on a reworking of existing designs. Only nine (24%) respondents talk about creating a real new design. Furthermore, 84% of engineering students in our sample had practical training courses during their curses' while 44% of them used knowledge acquired in training courses in engineering design labs in their research project.

Only one-third of our sample of respondents are against encouraging other students to study engineering design, advancing arguments such as lack of qualified teachers, lack of adequate equipment for practical application, not future for graduates, etc. After graduation, 10% of our sample (4 respondents) believes in further foreign schools studies. We note multiple choices for almost 30% of respondents for each of the three following ways: pursuing higher education in engineering design, creating their employment, and joining existing companies. Finally, very few students are interested in consulting.

3.2. Case study 2: The Ecole Nationale Polytechnique of Algiers

The Ecole Nationale Polytechnique started life as the Institut Industriel d'Algérie in 1925 and haschanged names several times since then. With the Decree of 25 June 1963, it became the Ecole Natio-nale Polytechnique which aimed to'train the technological elite which shall take charge of the econ-omic development of Algeria' (Benguerna, 2004, 11). The Ecole Nationale Polytechnique of Algiers is one of the country's oldest technical schools inherited from the French colonial system. It has thirteen disciplines: Automation, Electronics, Electrotechnics, Electrical engineering Chemical engineering, Civil engineering, Environmental engineering, Mechanical engineering, Mineral engineering, Materials engineering, Hydraulics, Quality Hygiene, Security, Environmental engineering, Environment & Management of industrial risks (QHSE-GRI), Management Innovation management, and industrial Management and innovation management. The first cycle of the engineering diploma includes three years.

A total of 938 students are registered (see table 2).

Table n°2: Number of students in the engineering cycle in ENP Algiers

Cycle	Number of students	%
1st year	331	35%
2nd year	294	31%
3rd year	313	34%
Total	938	100%

Source: field work

They have developed DE in almost every specialty. All the subjects of the training program are considered essential for the training in design engineering. However, they were unable to define in precise terms what is the content of DE. The curricula are reviewed internally every three years, both at the school level by a committee. The curriculum is reviewed externally for accreditation every three years by the Ministry of higher education. The Ministry has a division in charge of higher studies monitoring and evaluation which also evaluate the programs' implementation. The curriculum appears to be reasonably flexible to incorporate new and evolving engineering design technologies. This incorporation is usually made by the lecturers in their own subject.

a. Human resources developing Engineering design capacity

Regarding, staff profile for Engineering and design training, PhD and doctorate holders appear to be the dominant group (57%) while Master’s degree or Magister holders represent 43%. The school has had a very active policy of recruitment of Ph.D. and French doctorate holders. It has been also very active in pushing its postgraduate students to complete their doctoral studies.

Consequently, the school does not experience any shortage of engineering design staff. It has developed its succession plan for the engineering design staff. The final project, recently adopted had not been implemented at the time of writing.

b. Student profile for Engineering design

The total number of undergraduate students is 938, as seen earlier. This gives staff to Undergraduate student ratio of 1 to 6. The number of post-graduate students reached 525 in 2014 representing36% of the total which is fairly impressive if we compare it to the universities' ratios.

The trend of undergraduate students enrolling in engineering design for the past five years is not communicated. The statistics are held at the ministerial level according to the respondent. Similarly, the trend of postgraduate students enrolling in engineering design for the past five years is not provided.

The school appears to have a very active alumni system, as shown by its website2. It is run by the association of former Polytechnic students (AEP). The association organizes various events every year and a yearly conference in which members are invited. This allows the school to keep a database of those who pursue higher degrees in engineering design, those who create their jobs, those who join existing companies, and those who become consultants.

c. Pedagogical infrastructure

In terms of teaching and pedagogical infrastructure, the school almost all the technics : chalk and board, overhead projector and overhead slides, the most common uses and data projector and computers. Some members are more advanced than other and have more extensive use of ICTE (information and communication technologies for Education), such as online lectures/tutorials. All kinds of library resources seem to be easily accessible to students: Textbooks used in the classroom, Journals and Periodicals, Electronic library resources accessible on the Internet, databases etc. The availability of laboratory/workshop infrastructure for teaching and learning is perceived as excellent. Similarly, the conditions of the equipment in the laboratories are judged good. The adequacy of the classrooms for teaching and learning is also perceived as good.

d. R&D, Industries and IP issues

The school appears to have linkages/networking with R&D institutions. However, respondents were unable to specify what percentage of the linkage is focused on engineering design. Similarly, the school is known for its close links with industry, but it cannot specify what percentage of the linkage is focused on engineering design. The school has Intellectual Property Rights Policy (IPRP). It has been able to fill a patent application. Nonetheless, it has not been granted any patent or license.

[2] https://www.linkedin.com/edu/school?id=12062

It has not been able to specify how it motivates staff & students to engage in engineering design projects. In the past few years, Developing countries, including Algeria, have experienced massive amounts of cheap goods from the five major emerging national economies: Brazil, Russia, India, China, and South Africa. (BRICS). However, this seems to have no relevance to engineering education and the quality of Algeria's engineering training.

The status of developing indigenous technology and pursuing technology transfer is not well perceived. On the whole, there is high level of skepticism regarding technology transfer from foreign firms. Indigenous knowledge does not seem to promote engineering design, and there are no precise ideas on how to support both indigenous knowledge and technology transfer for engineering design. Finally, engineering design projects/products are promoted through trade fairs and exhibitions essentially.

Concluding remarks :

This article aims to analyze the Design Engineering Capacity Building and Training issues in North African Countries: Algeria's case by surveying two Polytechnique schools in two different cities in Algeria: Algiers and Oran.

We can conclude that there is a growing gap between training of D&E specialists in Polytechnic schools and in universities. Moreover, migration graduates' rate from these leading educational institution is extremely high: for example, between 60% and 100% of graduates of the National Polytechnic School of Algiers move to foreign countries immediately after they graduation, depending on the year and the specialty (Gardelle et al., 2016). In this respect, teachers consider that they are training engineers for the benefit of foreign countries, especially in Europe, and not for the benefit of Algerian companies (Sahali et al., 2020).

Faced with the demands of the new economic context and the transition to a market economy, the university has shown little reactivity, both in terms of scientific content, teaching methods and openness to management sciences and foreign language learning. This inability to adapt to the changes taking place in society has further deteriorated training and has made it less relevant to the economic sector it was intended to feed.

For companies, the constraints are increasingly burdensome, forcing them to make up for the shortcomings of the education system by setting up a costly integration process (Touati, 2013). The more postgraduate programs (Masters and Doctorates) Higher Education Institutions offer, the more likely they are to reach out to the industry (Saad et al., 2020).

The study shows that a high proportion of engineering graduates, both men or women, entered the public service and that as such, they act as civil servants among others: it would still be necessary to examine in these administrations which are their specific tasks or if the diploma is only a means of access to a category in a bureaucratic hierarchy (Grelon, 2004).

Education systems must be changed in Algeria so that they make people creative, employable and enable them to transform their creativity into innovative marketable products and services.

An effort must also be made in pedagogy to promote the qualification of Engineers with an emphasis made on the means made available to favor the qualitative aspects before the quantitative questions.

References :

Abdulwahed, M., & Hasna, M. O. (2017). The role of engineering design in technological and 21st-century competencies capacity building: Comparative case study in the Middle East, Asia, and Europe. Sustainability, 9(4), 520.

Amadei, B. (2004). Engineering in the developing world, Engineering and Foreign Policy Volume 34 Issue 2.

Benguerna, M. (2004). La non émergence de la profession d'ingénieur en Algérie : modèles de formation et trajectoires socioprofessionnelles. Les Cahiers du CREAD66/67: 119–138.

Benyus, J.M. (1997). Biomimicry: Innovation Inspired by Nature. New York: Quill, William Morrow.

Benziane, A. (2016). Projet de transformation de l'ENSET d'Oran en ENP d'Oran comme prélude à un projet d'établissement, ouvrage collectif édité par le RIFEFF sous la direction de Thierry Karsenti, Montréal . Canada.

Berry, T. (1988). The Dream of the Earth. San Francisco: Sierra Club Books.

Bugliarello, G. (2000). Biosoma: the synthesis of biology, machines and society. Bulletin of Science, Technology and Society 20 (6): 452-464.

Destanne de Bernis, G. (1971). Les industries industrialisantes et les options algériennes. In: Tiers-Monde. 1971, tome 12 n°47. Le tiers monde en l'an 2000. pp. 545-563. doi : 10.3406/tiers.1971.1802

Djeflat, A. (2017). Design and Engineering Capacity Building for a Sustainable Development of African Economies: The Case of Algeria. In Managing Knowledge and Innovation for Business Sustainability in Africa (pp. 137-151). Palgrave Macmillan, Cham.

Gardelle L., Emmanuel Cardona G., Benguerna,M. Bolat, A & Naran, B. (2017). The spread of European models of engineering education: the challenges faced in emerging countries, European Journal of Engineering Education, DOI:10.1080/03043797.2016.1241983

Grelon, A. (2004). Les ingénieurs au Maghreb : un bilan d'avenir. In Gobe, É. (Ed.), L'ingénieur moderne au Maghreb (xixe-xxe siècles). Institut de recherche sur le Maghreb contemporain. doi : 10.4000/books.irmc.1549

Hawken, P., Lovins, A. & Lovins, L.H. (1999). Natural Capitalism. Boston: Little, Brown and Company.

Jones, R. C. (2002). Engineering capacity building in developing countries. In regional conference on innovation systems and innovative clusters in Africa (p. 88).

Meadows, D. (1997). Places to Intervene in a System. Whole Earth 91(Winter): 78-84.

Messaoudi, N., & Hamzaoui- Elachachi, H. (2017). An Analysis of Algerian Manufacturing and Engineering Master's Students' Needs. Arab World English Journal, 8 (4). DOI: https://dx.doi.org/10.24093/awej/vol8no4.18

Orr, D. (1998). Transformation or Irrelevance: The Challenge of Academic Planning for Environmental Education in the 21st Century. In Academic Planning in College and University Environmental Programs: Proceedings of the 1998 Sanibel Symposium, P.B. pp. 17-35

Saad, M., Guermat, C., & Boutifour, Z. (2020). The interaction between academia and industry and its impact on national innovation capacity: The case of Algeria. Industry and Higher Education, 0950422220931418.

Sahali R., Gardelle, L. & Benguerna, M. (2020): Innovation training in Algerian engineering schools: aiming to serve companies, European Journal of Engineering Education, DOI: 10.1080/03043797.2020.1730307

Touati O., (2013). La formation des ingénieurs : transformations et conséquences sur l'entreprise, Insaniyat 60-61 | pp. 251-264. https://doi.org/10.4000/insaniyat.14230

UNESCO. https://en.unesco.org/themes/building-capacity-science-and-engineering