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Promoting Technological Entrepreneurship through Sustainable Engineering Education

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Abstract

The main purpose of this paper is to identify appropriate solutions considered essential for the implementation of an authentic sustainable engineering education for the students in engineering. This is completed with the aim to increase the adaptation of the graduates in engineering to a competitive and dynamic economy, characterized by the attributes of sustainable development and the current society needs and has in view Romania's situation. The paper introduces new solutions for the promotion of technological entrepreneurship and also presents the original inventory of qualities needed for a student in engineering to become an authentic technopreneur. The findings of this paper have the potential to help graduates in engineering to be able to develop their innovative side, being better "equipped" to become technological entrepreneurs or intrapreneurs.

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Keywords: technological entrepreneurship; sustainable engineering education.

1. Introduction

The most important driver of technological development is innovation which is connected with the quality of human capital. Education of human resources is the foundation of innovation, and engineering programs are responsible with talent development in all technological fields. By educating and stimulating human resources, by providing them with valuable knowledge in technological fields, a nation may develop an increased innovation

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capability, especially in technological areas. That is why engineering education from Romania should transform and adapt itself to the requests of the present, where technological entrepreneurship is perceived as an important source of development and prosperity [1, 2]. This transformation has the potential to lead to the formation of new generations of entrepreneurial engineers, internationally considered as a main society demand [3], whom may constitute the foundation for a sustainable economic growth of Romania.

A new educational approach is needed which will potentially increase the desire and knowledge of graduates to build new innovative enterprises and the newly created businesses to produce significant value added, improvement of life and, at the same time, new technical products/processes. But the fulfillment of these facts entails a deep knowledge that must be acquired both in technical and entrepreneurial engineering, leading to the creation of an authentic technopreneur. Therefore, engineering education must be tailored from sustainable point of view and enriched with key issues in order to give the labor market the originality, competitiveness and morality Romania presently needs.

2. Methodology

The methodology employed aims to transform the teaching act in engineering in such a way that will allow the development of creativity, innovation in technological area and also the enhancement of accountability of graduates. The methodology consists in several steps:

- exploration of the current situation in innovation in Romania
- gain insight into the possibility that a student will acquire technological entrepreneurship qualities by the completion of an *inventory of qualities* required for an increased innovation potential in technology
- identification of solutions for engineering education on a triangular approach involving education stakeholders - students, faculty, industry.

3. Exploration of the current status of innovation in Romania

The strategy Europe 2020 sets as main goal the smart sustainable growth [4] and this is to be achieved by national and European measures to help the people of European Union (EU-28) to become more competitive and better coping with a world in change [5]. Unfortunately, Romania scores last from the EU-28 in terms of innovation capability, ranking 55th out of 143 economies, as regards the composite global innovation index, having an overall score of 38 (100 is the best) [6]. By analyzing more into detail the situation from the knowledge point of view, this situation is even worse for Romania, as it:

- ranks 69th for “human capital and research”
- ranks 66th for “knowledge and technology output – knowledge creation”
- ranks 67th for “creative outputs”
- ranks 85th for “innovation linkages” and the research collaboration between universities and industry.

Moreover, the situation is worrying if regarded from a larger perspective in time. Over the interval 2002-2012, Romania conserved its last position within the EU-28, occupying the 28th position for key innovation indicators, as revealed by table 1 [7-9]. Despite a strong increase of about 467% over the studied interval of ten years in terms of patent applications to the European Patent Office (EPO), Romania still represents only about 2% from the EU-28 average for that indicator.

These facts demonstrate that Romania is a modest innovator, having innovation results well behind the EU-28 average and the country did not recuperate the great disparity from other member states, despite many declarations, policies, studies and targeted conferences on the subject. Consequently, several issues are to be addressed and the starting point is represented by education. Taking into consideration the importance of innovation in technology, the

engineering education from Romania was considered as the main argument on the road to a desired technological development and several solutions were suggested in the next section.

Table 1. Evolution of key innovation indicators for Romania over 2002-2012 interval.

Indicator & geographic location\time	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	% increase
Patent applications to the EPO (applications/million inhabitants)												
Romania (place 28th)	0.49	0.75	1.06	1.34	0.95	1.51	1.57	1.52	1.69	2.48	2.78	467.35
EU-28 (average)	105.22	107.78	112.32	115.27	117.17	116.9	113.17	112.08	111.42	109.63	108.55	3.16
Research and development expenditure (% of gross domestic product)												
Romania (place 28th)	0.38	0.38	0.38	0.41	0.45	0.50	0.57	0.46	0.45	0.49	0.48	26.32
EU-28 (average)	1.81	1.80	1.76	1.76	1.78	1.80	1.85	1.94	1.93	1.97	2.01	11.05
Human resources in science and technology (% of active population)												
Romania (place 28th)	20.80	20.50	21.20	22.00	22.80	23.00	23.80	24.10	24.40	25.80	25.70	23.56
EU-28 (average)	35.00	35.90	37.00	37.80	38.60	39.00	39.60	40.10	40.50	42.40	42.90	22.57

Sources: compiled and calculated by the author from [7-9].

4. Solutions on a triangular students – faculty - industry approach

The first step is an engineering education that should be molded by the actual requirements of sustainability, therefore a sustainable engineering education must be considered. Sustainable engineering education is that education aimed to develop the engineer's personality on technological, economical, social, managerial and moral levels, which leads to positive results for graduates and society, in economic, social and environmental terms.

Moral and ethical development of young professionals is the key for a better and safer modern future world. Therefore, an engineering education that transforms or influences the transformation of a high school graduate into an engineer, with respect for moral values and principles, should be tackled with priority by the engineering education. The present situation is somehow very lax in terms of requirements of originality of papers/projects from the faculty. In a country characterized by poverty, Romania being the poorest country along with Bulgaria from the EU-28 [10], and a very relaxed position in terms of piracy, maybe also due to products' affordability, professors should take the initiative and attempt to change the students' mentality and respect for ethics, originality and intellectual property. For example, software piracy was in Romania in 2014 twice as compared with the EU-28 average, 62% of the computers from Romania running illegal programs [11].

The second step is to develop technological entrepreneurship, as this is an important part of the solution that has the potential to determine technology-based innovation. Therefore, an inventory of qualities needed for a student in engineering to become an authentic technopreneur is constructed by considering all the measures and actions that are to be taken for faculty and students. This inventory of qualities is built with the aim to gain insight into the possibility that a student will acquire technological entrepreneurship qualities required for an increased innovation potential in technology which will pave the way for the identification of the required steps to be taken for the transformation of engineering education. Table 2 contains the main qualities considered for entrepreneurial engineers of all engineering specialties, along with measures and actions taught at faculty and students levels. The enumerated qualities are in certain degrees interdependent, therefore some of the requirements are in some way

overlapped. The measures considered are to be introduced at Bachelor or Master Programs in engineering and suppose changes in curricula, syllabi, manner of teaching and organization of didactic activities for courses belonging to all engineering fields.

Table 2. Top 10 technical and personal qualities of an ideal entrepreneurial engineer – inventory of qualities of a true technopreneur.

Quality	Knowledge implications	Measures for faculty in engineering education	Actions for students in engineering education
Analytical skills	Solve complex problems	Develop engineering curricula with interconnected lectures Adopt an appropriate level of redundancy of disciplines	Use knowledge acquired in different contexts Be pro-active
Rigor	Critical thinking	Inspire students through complex and appropriate curricula Stimulate/reward accuracy Design appropriate questions for evaluation	Improve your knowledge Be exact Be interested in reliable information
Communication skills	Listening, trusting, feed-back, courteous manner of persuasion, understanding culture differences	Design interactive lectures/seminars/debates Design interactive presentations of projects Involve competent professors	Get involved Collaborate Be assertive
Creativity	Curiosity Imagination Desire to learn Appealing for new	Insert projects that stimulate creativity and initiative within engineering curricula Stimulate working in small groups/teams Generate excitement through specific applications	Proceed a hobby Be inquisitive Be unique Be enthusiastic
Logical skills	Clear reasoning Flexibility	Insert approaches from different angles into the syllabi of courses Teach students to think not only to prepare for evaluating tests	Systemize the acquired information Seize opportunities
Technical knowledge	Problem solving (use of scientific knowledge to obtain technical solutions) Adapt to new technology Use of different equipments, tools, software programs Environmental awareness	Consider specific industry internships Design specific technological courses, with appropriate weight into the curricula Present up-to-date information Introduce a course on sustainable development	Study hard Show interest Be perseverant Ask the right questions Pursuit sophistication
Economic knowledge	Insight on world business and basic legislation Understanding the offer, demand and society needs	Introduce a course on managerial economics Implement of a course in European economics	Get informed Pay attention to details Be adaptable
Managerial knowledge	Time and budget constraints Initiative Leadership Quality management Strategic thinking Risk management	Request a strong respect for deadlines for projects/seminar works Implement a 2 semesters course of industrial management Implement a course/chapters/applications about risks Focus on decision making	Plan ahead Embrace risk Make decisions Be pragmatic Cope with challenges Use self-explanation
Reliability	Resourcefulness	Include simulations and specific up-to-date case-studies into the syllabi	Show punctuality

	Dependability	Stimulate entrepreneurial awareness	Show commitment
	Respect for deadlines		Be a good citizen
Integrity	Correctness	Introduce strong principles in the curricula and syllabi of all engineering programs	Demonstrate respect for other people's work
	Ethics	Implement a course/chapters on intellectual property	Show a moral attitude
	Respect for others	Consider severe punitive measures for cheating	Be honest
	Socially responsible		

Tertiary education for engineers in Romania is mainly organized around formal, mainly disconnected lectures coupled with laboratories/seminars. This has to be changed and new curricula must be designed for all engineering specialties [5], which imply the re-evaluation of the relevance of some courses, introduction/elimination/modification of a number of courses, the investigation of the adequacy of the conventional disciplines, a better connection among disciplines, and a more focus on practical aspects of education. This is to be achieved also by a change in the professors' mentalities and by involving them into the academic education based on merits and competence. Some of the professors from technical universities from Romania need a serious introspection, as they are less involved into the academic research, surpassed by the present-day knowledge, unwilling to update the content of the courses, resistant to change, and unconscious of the new learning environment. This may lead to an engineering education that is not adapted to the European and world business and technological environments, characterized by a very lax evaluation of students, all these leading to a decrease in the quality of engineering education offered by Romania.

Engineering education which encapsulates entrepreneurship must be supported by new curricula where the theory must be properly balanced with practice, where working in small teams is to be combined with leadership [12]. In such a way, the students in engineering will be able to generate valuable business ides, to develop a strong confidence in their own forces, to get an insightful understanding of society needs, and to turn ideas into valuable action. Increasing the entrepreneurial awareness of students in engineering means that some important measures and actions are to be taken both for faculty, but also for students, as presented by table 2. Other specific measures must include all or at least some of the followings:

- development of new courses on entrepreneurial engineering
- development modules/chapters involving specific technological entrepreneurship
- dedicated programs for Master degree in entrepreneurial engineering
- summer schools in entrepreneurial engineering
- implementation of dedicated centers for entrepreneurship within the technical universities
- competitions for best business ideas and their endorsement by university-industry collaboration
- development of academic spin-offs for results obtained from the research performed within university by teams of professors and students
- involvement of industry, by inviting experts, consultants, and managers to be part of the teaching process.

The question that may arise is whether there is enough room left for technical education. The courses incorporating the acquiring of knowledge in economics, management or communication may be mandatory, optional or elective depending on the requirements of the specific engineering program. Technical education must extend outside the university walls and this is to be achieved by the industry real involvement, besides specialty technological courses. Industry participation is seen as essential for the development of applied technical knowledge of students in engineering and therefore authentic industry internships that go beyond the formal practical stages should be considered. Moreover, the industry-university collaboration based on research and cluster building where the technical university is to be involved, are considered essential for the attainment of the success of entrepreneurial engineering.

The findings of this paper have the potential to help graduates in engineering to be able to develop their innovative side, being better "equipped" to become technological entrepreneurs or intrapreneurs. Besides technical

and economic knowledge of the students in engineering, very important for generating valuable innovative ideas, the considered measures may also lead to an increased responsibly of students and the respect for principles and moral values, this having the potential to create a safer, more rational and more just society. The findings of this paper will contribute to the solving of several problems on distinct levels, all having the potential to conduct to an authentic sustainable development of Romania:

- economic: increase of welfare and competitiveness
- social: increase of employment, especially in specialized technological employment
- environmental: creation of new business in the area of engineering/reengineering of the infrastructure with the aim to adapt it to the current and future environmental requirements
- educational: increase of the quality of engineering programs and knowledge transfer
- technological: creation of new/better technical solutions in the existing and emerging technologies.

5. Conclusions

Engineering education has the responsibility to develop programs that will lead to a better, safer and moral modern future world. Knowledge, creativity and innovation in technology are the main requirements for this future world and the creation of entrepreneurial engineers - technopreneurs, with valuable technological ideas, is an important aspect of the technological development. The paper introduces new solutions for the promotion of technological entrepreneurship and also presents the original inventory of qualities needed for a student in engineering to become an authentic technopreneur. Moreover, the application of the principles of sustainable engineering education, tackled together with the solutions introduced by this paper have the potential to conduct to a safer, more rational and more just society. Sustainable engineering education is introduced by this paper and is based on the author's beliefs on engineering education from Romania.

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