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The Productivity Status of Iranian Academic Institutions

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Abstract

Scientific Knowledge is the engine to growth and development, and is also the major solution to the socio-economic issues and problems. Based on the development history, great revolutions were closely linked with transformative breakthroughs in knowledge, which had a far-reaching impact on the rise and fall of a nation and the destiny of a country as well. The countries and nations that were able to seize the opportunity and achieve the socio-economic take-off had taken the lead in fulfilling progress and development. Academic disciplines, especially engineering disciplines, have key role in science and technology and knowledge creation. In this study, the status of engineering disciplines of Iranian state universities of technology is studied with survey method. Based on the analysis of the study, the effectiveness and efficiency of engineering disciplines is not balanced. The efficiency of engineering disciplines of Iranian universities is more than their effectiveness. Thus, the productivity of Iranian of scientific system is low. The entrepreneurship of academic institutes and engineering disciplines is not in suitable level. In Iran, promotion of the academic innovation and entrepreneurship is a key necessity. It is recommended that the effectiveness and efficiency of engineering disciplines are considered more than ever. It must be planned in a systematic approach by utilization of effective actions and initiatives to develop the efficiency and effectiveness of engineering disciplines concurrently. Also, It seems there aren't operational road map and especial and effective program to execute, promote and monitoring the national science and technology policies.

Keywords: Academic entrepreneurship, Productivity, Knowledge Production, Scientific System.

Introduction

Science and technology is the engine and innovation and entrepreneurship is jet engine to sustainable development, and they are also the major solution to the socio-economic growth and progress. Science, technology, innovation and entrepreneurship are connected rings in synergy chain of science, wealth and legitimate power (Mahdi, 2015). Looking back at the development history, most great revolution was closely linked with transformative breakthroughs in Science and technology, which had a far-reaching impact on the rise and fall of a nation and the destiny of a country as well (Yongxing, 2010).

Contemporary modern societies are formed based on successful technologies, most of them have been established based on scientific discoveries (Best, 1990). Technology is considered the product of new development of human civilization, determining of essential element in economical and political exchanges in the communities. It is expression of advancement level and empowerment and a superior parameter of a society (Webster, 1991). The main goal of research and scientific production of technical-engineering disciplines is creation of wealth and power through the production of knowledge of technology development (Pestre, 2000). As expected, knowledge resulted from technical-engineering activities is technology and its power due to the development of technology (Davari, 2000).

Developments in the last two centuries in industrialized countries are due to attention to the production and application of science and technology more than other things. Various relatively fixed ranking of the first seven science productive countries in the world during recent years in one hand, and similar position of them in number of filed patents in other hand, show positive relationship between knowledge and technology production (Salamon, 2000). Technology production as infrastructure of social and economical development has important place in today's world. Present time is era of knowledge-based societies, economies and institutions. Promotion of national development and international position of countries in the competition depends on production and application of knowledge (Delanty 2001). From another perspective, production of science has not the certain and determined level. To achieve its competitive advantages and benefits, the minimum value of science, called the critical mass, is required to produce respected quality within quantity. Also, there is a narrow range of use of knowledge and empowerment. This spectrum includes two head end: 1 - production and supplementation of knowledge with the maximum possible pressure and using the mass production of knowledge for use in different areas (Science Push). 2- Knowledge production based on demand of market and different areas of social and economic (Technology-Market Pull) (Rush et al., 1995; Meyer, 2000).

By considering to given level of development and participation rate in global science production in the developing communities (e.g., Iran), the combination of modes 1 and 2 has better performance (Mahdi, 2008). It is due to lack of necessary institutions for normal potential and pressure for the mass production of science and knowledge, or if so, they have not been given adequate levels of development and maturation in order to create proper potential and pressure. Hence, complete stop for create a demand for expected scientific output or expect for creating required pressure of mass production of science, may hit the efficient institutions and science consumer and science production and also to postpone their relative development. In any case, the reality shows achievement of national sustainable development, a level of knowledge production is needed which is far above from the current level of scientific production in Iran. The fact is that there is somewhat different between the growth in science and technology system at the level of academic and research institutes and what there is in the society level and the impact and implications of science and technology in the economy and wealth of the country. This difference and gap between science and society is a

good sign for studying and analysis of science production of scientific disciplines, particularly technical-engineering disciplines. Due to this problem, major scientific revolutions, the national innovation system, industry-government-university triple helix model and systems approach and the productivity (efficiency + effectiveness) of technical-engineering disciplines of the Iranian universities of technology has been analyzed based on normative model of science and technology system, such as the modes of knowledge production (Mahdi, 2008; Etzkowitz, 2001; Viale & Ghiglione, 1998).
In the study, based on normative model of science and technology system, the status of engineering disciplines has analyzed by survey method. To analyze the status of engineering disciplines of Iranian universities of technology has been used cybernetics model of science and technology system. In conclusion, appropriate suggestions and proposals are presented for policy-making and management of national engineering disciplines.

Literature Review

Generally, Evaluation is examining or making judgments, and policy evaluation could be understood as part of the historical process of development of tools and information systems for public management as a decision support system (Mahdi, 2015). Evaluation of science and technology policies includes activities and practices that usually looks back at the past performance of policies and they are part of the science and technology policies cycle as is traditionally described (study, design, implementation, monitoring, evaluation, review). science and technology policy evaluation consists in a process of knowledge and information production by actors embedded in research, national science and technology policy, policy-making systems, knowledge and information refers to different issues such as the associations between problems and solutions, or the properties and effects of policies. But, evaluation of science and technology policies is not the only type of information or knowledge input about past experience in the policy process. Advice could come to the decision and policy process through very different channels and providers. Evaluation must produce information and knowledge, in addition the availability of information and the process of evaluation provides legitimation, it offers transparency and fair play between the players in the science and technology system, and it creates a shared space of interpretation for the negotiation between conflicting interest involved in the increase complex game of science and technology policy (Menendez, 1996). Thus, it is highly important to evaluate the science and technology developments and policies in countries continuously. In this article, the literature and conceptual framework of the study has presented based on documental review with the following details (Mahdi & Pourgol, 2011).

Great Scientific Revolutions: During last two centuries, two major scientific revolutions have occurred with significant impact on the educational institutions (Etzkowitz, 2001). The first revolution occurred in the late 19th century that universities accepted the mission of research addition to its educational mission. The second revolution occurred in the late of 20th century which during it universities in addition to educational and research missions accepted the technological innovation and scientific entrepreneurship mission. Morin (2009) believes that nowadays science is established in the heart of society, and science while expanding its influence on society, accepts the bureaucratic and technical determination of work industrial organization. Therefore it is very difficult to understand the reactions and interactions between science and society (Morin, 2009).

Knowledge Production Modes: Knowledge production has been four major transformation modes. Mode 0: In this mode, knowledge production in general had been done by philosophers and physicians. Today, because of created rules and the frequency demand and need for scientific knowledge, knowledge production to this mode, due to the impossibility to meet needs and its partial viewing and simultaneously interdisciplinary of scientific research, contribute a little in the knowledge production. Mode 1: The sociology of science has been two distinct views, in terms of concepts and interpretation of scientific practices in the 20th century. Before the publication of Gibbons thought (Gibbons, 1994), Merton's view (Merton, 1973) had been main stream of sociology of science. Merton style knows the science as independent activity and science institutions as independent from other social institutions. Normative structure of science institutions is status of independent activities of scientists and is behaviour criteria in this institution. Whenever this structure has adapted with the normative structure of society and political and economic institutions, scientific activities grow by suitable conditions and if the inconsistency, the scientific development falls on the risk. In this mode, knowledge is produced within individual disciplines in universities and other academic institutions. Important promotion of first style is curiosity and the search for new knowledge because of knowledge nature. Mode 2: Mode 2 (Gibbons' mode) emphasizes on the scientific activities associated with the economic and political institutions. This mode knows that Merton pattern (mode 1) belongs to academic science which instead with post-academic science now (Gibbons 1994). This Style knows scientific activities undergo to a fundamental transformation. So on science is open for social institution influence and with growing information society more open form of knowledge is visible. Gibbons named this style of knowledge production style in front of known traditional style of science production (Ghaneirad, 2004). In style two, methods of research and knowledge production is produced mainly in areas in various industry organizations, universities and etc under the direct influence of the economic and social needs. Mode 3: This mode of knowledge production has been proposed by Etzkowitz and others (Etzkowitz & Leydesdorff, 2000) within the framework of university-industry-government triple helix model. In this mode, university has third function and mission to supply the needs of knowledge-based society (Etzkowitz, 2003). This mission is technological innovation and economic development. Academic system pays to knowledge-based entrepreneurship and economic activity by knowledge production (Sije et al, 2005).

National Innovation Systems and Triple Helix Model of Government, University, Industry: According to the national innovation system theory, universities, industry and government have certain specified boundaries. Technological innovation is specific function of industry, while science development and education is specific function of universities. Policy-making and motivation of innovation is also specific function of governments (Nelson 1993). Innovation was emerged due to interactions between industry and university in R&D market (Entezari, 2005). Incidence of new developments in knowledge production and the emergence of style 2 (Gibbons, 1994) and the second academic revolution (Etzkowitz, 2001) and the emergence of knowledge-based economy and society have been disrupted the boundaries between university, industry and government. Due to overlapping of university, industry and government missions, the new multi-ethnic organizations were born (Etzkowitz & Leydesdorff, 2000) or must come to live. Main mission of these organizations is facilitating relations of university, industry and government in the framework of the university-industry-government triple helix model (Etzkowitz & Leydesdorff, 2000), excellence national system of innovation and national economic development. Also, Today, university, industry and government retaining their independence in the domains of development of technology expand their area of activities resulting in overlap of the missions between them. Industry and research are so intertwined that does not seen one day that have not been conflicts between the interests of researchers and commercial interests. Many researchers or research disciplines are controlled by industrial companies that follow the benefit through patent (Bourdieu, 2007).

Systems Approach to Knowledge Production. A system is set of components and elements including input, process and output set up to achieve a certain goal (Senn, 1989 and Bazargan, 2002). System elements must be in contact and exposure to external environment wherein after a process of changes on inputs and performing the necessary transforms, will lead to the desired output. Science and technology system can be defined as a sub-system of the cultural, economic and social and innovation systems. Or it may be spite to a variety of other sub-systems such as engineering disciplines system, services system, scientific research and science production system. It is important that the science and technology system must has efficient input and processes, useful and appropriate and effective and reliable products and outputs in order to continue desirable life (Dias, 1998). Also, science and technology system must solve problems of society.

Cybernetics model of science and technology system: Based on cybernetics model system, science and technology system (UNESCO, 1990) should be managed in three areas of ability, efficiency and effectiveness of fully proportional and concurrent planning, control and protection. Elements of science and technology of cybernetics model cited from UNESCO (1990) is shown in Figure 2. In the developed countries, the ability to scientific promotion and research ability of institutions in the form of policies, financial resources, human resources, infrastructures, facilities and equipments, lead to increase strength and ability of the scientific-technical outputs. This Situation is not governed in developing countries (Krishna et al., 1998). It is important to determine the scientific system efficiency and measuring its effectiveness. Based on the theory of national innovation systems, in addition to increasing potential and power of scientific systems, the information flow intensity of science system (efficiency) and its innovation flow intensity (effectiveness) must be upgraded. Also, determination of efficiency and the effectiveness of the scientific system are fully adapted with differentiation functions and system integration. Differentiation and integration functions determine the limit of freedom, independence and ethics and social responsibility of the scientific system (Ghaneirad, 2004). To analyze situation of engineering disciplines of Iranian universities of technology, cybernetics model of science and technology system has been used (Figure 1) (Mahdi, 2008; Mahdi & Pourgol, 2011).

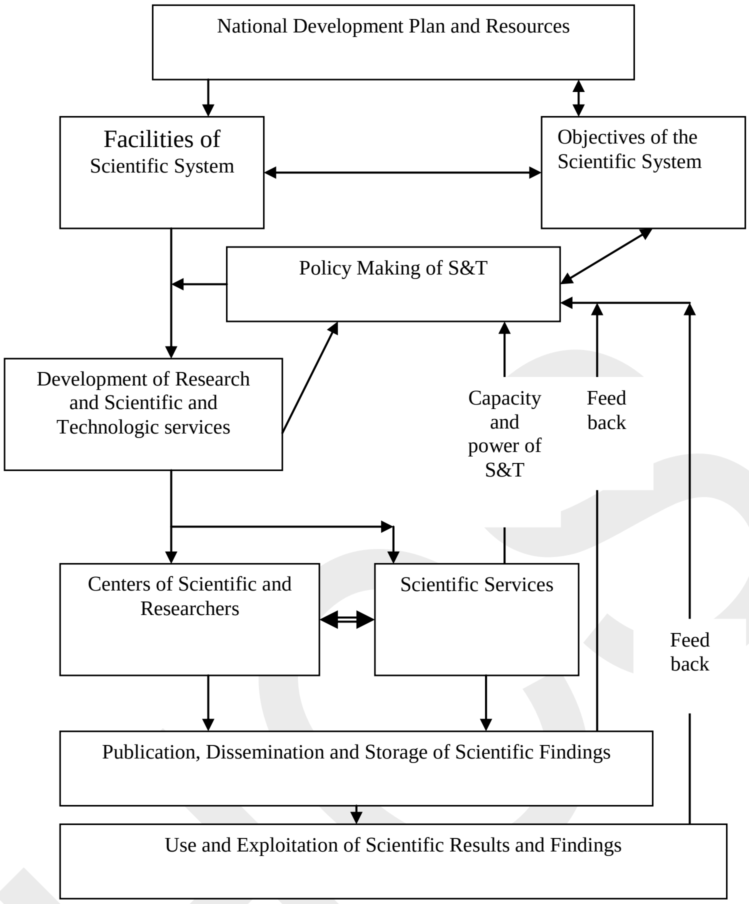

Fig 1. Cybernetics model of science and technology system (Mahdi & Pourgol, 2011)

Methodology

The aim of this study is to evaluate the status of engineering disciplines of Iranian state universities of technology. The study has been done by survey method. In this paper, the engineering disciplines are those disciplines of research and technology that the results of their work are in the field of industrial design, engineering design, construction and manufacturing, industrial equipment and the similar (Yaghoubi et al., 2006). Thus, engineering disciplines include engineering disciplines of universities, research disciplines, applied-science-based engineering research institutes (i.e. physics, chemistry and mathematics), research firms, incubators and scientific and research parks and towns, and research and development institutes. So, the purpose of the engineering disciplines is those activities and fields of scientific research and scientific activities classified in a general in the field of engineering and technology. The main areas of engineering disciplines including universities, technical-engineering disciplines and institutes, units of research and firms in research parks and scientific-research town under administration of the ministry of Science, Research and Technology has been covered.

The statistical samples have been selected with scientific principles of sampling by cluster, stratified, randomized, comparison methods and determination of sample size criteria, 95% confidence and 10% of the maximum permissible error. Based on sample size calculation formula for qualitative variables ($n = z^2.p.q / d^2$), the final sample size is 85 (Cohen and

Manion, 1992; Sarmad et al., 2001). N is the population of statistical society, n is sample size, z is standard normal distribution variable (with 95% confidence interval), d is maximum tolerated error, p is the probability of incorrectness of the population opinion about the status of research system. In the study, based on normative model of science and technology system, the status of engineering disciplines is analyzed according to the knowledge production modes, great scientific revolutions, national innovation system, and the triple helix model of government-university-industry. The status of engineering disciplines has been analyzed quantitatively based on the research statistical data collection and sampling analysis. Evaluation of view of statistical samples has been done based on Likert questionnaires in three scale range (weak equivalent to 1, moderate equivalent to 2, and good equivalent to 3). Questions and statements of preliminary questionnaire have been developed based on results of studies documents, theoretical principles of previous studies and meta-analysis. In the paper, conceptual framework of the research has been analyzed based on documental review. The status of the national engineering disciplines has been reviewed based on cybernetic model (Mahdi & Pourgol, 2011).

Analyses and Results

Based on research method, the status of engineering disciplines of public universities of technology is summarized and analyzed in three areas of the capability, efficiency and effectiveness based on the views of statistic population using single-sample t-test with test value equal to 2 (moderate) and the significance level 0.050 in Table 1. Ten faculty members in engineering disciplines, four researcher in engineering disciplines, four chief officers of science and technology development institutes and five graduated student participated for standardization and providing validity of research questions and statements (preliminary questionnaire). To test reliability of the questionnaire, 12 test samples by 12 members of the study population have been assessed and completed. Assessment of questionnaire by using Cronbach's alpha coefficient in SPSS software shows high degree of reliability of 0.85. Thus, the validity and reliability of questionnaire diagnosed good and reliable standard, and assessed as valid tool for obtaining the views of statistical population.

To analyze the data, single sample t-test with 95% confidence ($\alpha = 0.05$) and the second test value (average score of options) are used. For data analysis, the average statistical community perspectives (m) have been compared with an average Likert scale questionnaire (μ) using t-test with 95% confidence. In fact equality of perspectives mean of statistical with average Likert scale questionnaire is examined (Cohen and Manion, 1992).

Table 1. Status of productivity

Variable	Average	S. D.	t	Sig level	Results
Efficiency (EFFIC)	2.19	0.83	1.72	0.100	No significant difference with the t value (moderate)
Effectiveness (EFFEC)	1.70	0.64	-6.42	0.000	Significant difference with the t value (low)
Productivity (Efficiency + Effectiveness)	1.90	0.73	-4.5	0.000	Significant difference with the t value (low)

Average views about the efficiency of engineering disciplines for research and production of knowledge hasn't significant difference with test value (EFFIC = 2.19). In other word, statistical population believes with 95% confidence that efficiency of engineering disciplines is moderate.
Average views about the effectiveness of engineering disciplines for research and production of knowledge has significant difference with the test value (EFFEC = 1.70). In other word, statistical population believes with 95% confidence that the effectiveness of engineering disciplines is lower than average. Thus, in engineering disciplines, the information flow intensity is stronger than the innovation flow intensity. The trend must be managed. Therefore, the productivity (= efficiency + effectiveness) of engineering disciplines for research and production of knowledge has significant difference with the test value and is low.

Discussion

According to t-test, from the views of statistical population, it concluded that the potential of engineering disciplines is higher than moderate (t value), efficiency of disciplines is equal with moderate (t value) and effectiveness of disciplines is lower than moderate. Thus, it is assessed that potential of the technical-engineering disciplines is higher than their efficiency and their potential and efficiency is higher than the effectiveness of these disciplines. The status of engineering disciplines is same direction with the results of Mahdi and Pourgol’s study (2011).
Development of science and technology, innovation and entrepreneurship are necessary for development. Also, because of several such as dry climate, water crisis, young people and very much graduates of universities, Iran need to development of science and technology seriously. On the other hand, Iran is captive in chronic barriers of lack of development that to exit from this cycle is very hard and Time consuming. In science and technology field, Iran faces with serious challenges such as jobless of graduates (its rate is more than general jobless rate, about 18,5 percent), the higher education and research budgets (per year financial power of government is declining), the small share of Iran from international higher education, the weakness of international relations of Iran’s science and technology system with world even with Islamic world, also the quality of higher education of Iran. Iran’s higher education has low power to help national development, development and to support decisions of the supreme policy-makers and planners. In practice, Iranian specialists haven’t consensus about some science and technology policies. The reasons of this disagreement are different. Also, based on the evaluation, aggregate of Iranian capabilities (economic, politic, social, technological) aren’t in size of level of the science and technology policy-makers’ ideals and goals. The policies are evaluated in level of very high and somewhat abstract. In other words, in these policies there are an army from very good words and concepts that are difficult and even sometimes impossible to fulfill in practices. It is suggested that in next versions be balanced between idealism and realism by the science and technology policy-makers.
There are hard centralization-oriented on science and technology and to spread higher education in Iran. The major and axial policy has been focused on new and high technologies such as bio, nanotech, aerospace, nuclear, defensive technologies, stem cells and they like. The policy has gained suitable results, but main critique is that it is strongly centralization-oriented and the government responsibility was been heavy. The private sector and business have a little share to finance research and technology development (Mahdi et al, 2009; Mahdi, 2015). Totally, the government intervention in science and technology, specially the higher education, is high and in most cases this issue is antonym with the normal and balanced development of science and technology, innovation and entrepreneurship. It is suggested that be increase the role and share of private sector and business in science and technology system.

One of the key solutions is to strengthen industry-university relations based on triple helix model of university-industry- government (Etzkowitz & Leydesdorff, 2000). The foreign relations of Iran isn't so that to provide context to fulfill the policies easily and low costly. The policies have been seen endogenous and founded to domestic capabilities. It is suggested that be spread international relations of Iran with countries. Otherwise, the fulfillment of science and technology policies will be difficult. For example, Islamic countries (Islamic world) aren't so united and coordinated with Iran. Thus, a section of Iranian science and technology policies that have been designed based on relations and capabilities of Islamic countries have little chance of achieving.

Iran is in key stage to make structures and institutions for science and technology and innovation. Thus, yet the country has long distance with complete and integrated execution of the policies and achieving their consequences. In comparative with general science and technology field, the situation and conditions of innovation and entrepreneurship in Iran is worse (Mahdi, 2015). Indeed, innovation and entrepreneurship of the academic institutions and societies is the bottleneck of development process in Iran.

At present, the great advantage of science and technology system in Iran is arrival of females into this field. Certainly, presence result of females will have positive outcomes to develop science and technology. For sample, in 2015 Iranian females constitute about half (46%) the population of 5 million in higher education. The gender is almost fading from education courses and the science and technology subfields. This evolution can be good sign better than before to develop the science and technology system, innovation and entrepreneurship in Iran. Totally, providing to fulfill major parts of the science and technology policies, the future of Iran is evaluated bright. Of course, in practice fulfilling these policies will be a hard and difficult work (Mahdi, 2015). The entrepreneurship of academic institutes and technical-engineering disciplines isn't in suitable level. Thus, promotion of the academic innovation and entrepreneurship is a necessity.

Conclusion

Since more than 3 decades ago, most of the present science and technology policies have been followed as written or unwritten, explicit or hidden, formal or informal in Iran, but it hasn't accessed clear and tangible results in most dimensions. The engineering disciplines of Iranian public universities have prominent and crucial role in the national system of innovation. Its purposeful and powerful research and knowledge production can be cause to develop the national technology and innovation. In this study, based on the requirements of two major scientific revolutions, modes of knowledge production, national innovation system, triple helix model of government-university-industry and systems approach, efficiency and effectiveness of the Iranian technical-engineering disciplines of public universities have been and analyzed by two methods of documental study and survey research. Based on this analysis, the efficiency and effectiveness of technical-engineering disciplines of universities of technology is not balanced and proportionate with each other. So, the efficiency of technical-engineering disciplines is higher than their effectiveness. Therefore, the effectiveness and efficiency of engineering disciplines must be studied and improved more than before. In addition, policy making, guidelines, planning and resource allocation and management of the scientific system of engineering disciplines must be done with simultaneous consideration to local and global criteria for efficiency and effectiveness of science and technology system.

According to documents of the development 5^{th} plan, national science and technology policies and Iran's 20-year vision, there are proper strategies to generate knowledge in engineering disciplines. But, implementation and execution of these strategies are not well prepared. Here consideration to implementation of their strategies with more efforts and accretions is recommended. Also, the combination of share of private sector, industry and government shows that private sectors and firms have negligible share in comparison with global trends in research and science production. It is recommended that management of scientific system perform further efforts to motivate the contribution of private sector and business firms in research and knowledge production.

Considering the weak relationship industry-university and the position of the engineering disciplines in technology development, it is proposed that serious mechanisms and initiatives must be planned and executed according to domestic engineering capabilities for export of processed materials to provide the research and technology development opportunities for the engineering disciplines. By considering to goals of knowledge production and technology development in the engineering disciplines, it is recommended to perform special support of exportation of the production with high technical knowledge and technologies and consecutively firms are encouraged to using of high technology and research opportunities. Due to inappropriate and low levels of effectiveness of knowledge production in engineering disciplines, it is recommended to double support the commercialization of research and technologies results. It seems in Iran there aren't road map and especial program to execute, promote, monitoring of general science and technology policies. It is necessary the road map and execution plan be soon designed and entrepreneurship in academic institutes, especially in engineering disciplines, must be serious and important considered.

Also, about universities, entrepreneurial university as the new generation university has created from evolution of first and second generations. The function of entrepreneurial university is individually and organizational social-economical entrepreneurship in link to educational and research. The major specifications of entrepreneurial university are target-oriented activities, mission- driven, creating balance among education, research and social services, vary financial resources, helping local and national socioeconomic development and strengthening national innovation system in the entrepreneurial university topics, the major defect is centralization on technical-economical entrepreneurship and neglect from entrepreneurial approach integration and reduction of entrepreneurial university in commercial firm level. It must emphasize on entrepreneurship in socio-economic dimensions and in individually and organizational levels of academic society, academy and its departments to increase the productivity (efficiency + effectiveness) of engineering disciplines for research and production of knowledge.

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