Mining engineering education in developing countries: the case of Iran

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ABSTRACT In the last few decades, many developing countries have tried to expand and improve upon higher education, which is acknowledged to be the leading factor for development. In this respect, developing countries have significantly increased the number of tertiary institutions and their students. These rapid expansions, along with all the benefits, have drawbacks as well. An example is the status of mining engineering education in Iran. Presently, the number of active mining engineering departments in Iran (27) is more than the sum of similar departments in Canada, Australia, the United Kingdom, and South Africa (23 altogether). Also, the number of annual mining graduates in Iran (645) is more than the cumulative graduates of the United States, Canada, the United Kingdom, and Australia (613). The expansion of mining engineering education in Iran has coincided with the closing or merging of similar departments, as well as a decline in the number of interested students in the industrialized world. The present study shows that the need for development and the excessive number of high school graduates, resulting from high population growth in the early 1980s, are the two primary factors influencing the significant expansion of mining engineering education in Iran.

KEYWORDS Mining engineering, Education, Iran

INTRODUCTION

Technical and empirical studies show that output growth in developing countries depends largely on the availability of workers with relevant and quality skills (Lim, 1999). They also show that technical progress is becoming a more important determinant of output growth as economic growth proceeds. Universities can be an important supplier of such skills through the courses offered and an important source of technical progress through their research.

The results of numerous studies carried out by national and international organizations (e.g. UNESCO 1997, 1998) point to higher education as a prerequisite for sustainable development. Each university program should have defined objectives and a system for evaluating its success, which in part reflects the readiness of students for their future involvement in industry. The quality of higher education can be controlled through the internal control of academic programs, government regulations, market mechanisms, and accreditation. On the other hand, the quality of a higher education institution is determined by its resources (human and material), learning and teaching processes, and the quality of its products (graduates, research, and service; Tadjudin, 2001).

Since the revolution of 1979, Iran has been developing a centralized higher education system. Independent organizations, similar to the US Accreditation Board for Engineering (ABET, 1998, 2001) and the Canadian Engineering Accreditation Board (CEAB, 2001), have not been active in Iran. Almost every aspect of education, ranging from accreditation of programs to decisions about the number of students, as well as evaluation of universities offering mining, has been planned and supervised by the government.

In recent years, different areas of reform have been suggested, providing incentives for public institutions to diversify sources of funding, redefining the role of government in higher education, and introducing policies unequivocally designed to give priority to quality and equity objectives. During this time, there has been excessive expansion of higher education institutes and a significant increase in the number of mining engineering students and graduates.

For the past few decades, state-operated mines and agencies in Iran have been the main source of jobs for mining engineering graduates. Based on the objectives of the Third Five-Year Cultural and Socio-Economic Development Plan initiated in 2000, the trend towards privatization of the Iranian mining industry has been accelerated. In 1999, of the 2436 operating mines, 2027 mines were run by the private sector, excluding sand and gravel, decorative stones, and rubble stone mines (SCI, 2000). So far, most of the private mines are relatively small in size, with no fulltime mining engineers in charge.

This paper presents the results of research carried out for the Ministry of Industries and Mines of Iran during 1999-2000. Statistics derived from more than 150 questionnaires completed by mining students and professors of different universities reveal some of the major pitfalls of mining engineering education in Iran. During the course of this study, mining education has also been studied in ten selected countries (the United States, Canada, Australia, the United

Kingdom, South Africa, Finland, Bulgaria, Chile, India, and Pakistan) and the results have been used to evaluate the state of mining engineering education in Iran (Memarian, 1999).

As part of present research, a database for mining, metallurgy, and material education in Iran was prepared for the Ministry of Industry and Mines of Iran (Memarian, 2000). This database stores a wide variety of information such as details about accredited degree programs, universities and other higher education institutes offering mining and material education, as well as statistics on their academic members and graduates. This database has been used by the Ministry of Industries and Mines of Iran since mid-2001.

HIGHER EDUCATON

Higher education in Iran is free of charge and the government is generally the only source of funds for universities, although a few private universities charge tuition fees. Since the revolution of 1979, Iran has been developing a centralized higher education system, in which the university programs are designed and accredited by the Ministry of Science, Research and Technology (MSRT). The Board of Planning for higher education programs of different disciplines normally consists of university professors, as well as representatives from the mining industry and the ministry. New regulations that have been introduced recently are going to give some autonomy to more established universities, which would enable them to modify (diversify) the present programs (MSRT, 2000).

Soon after the revolution of 1979, all the universities and other higher educational institutes in Iran were closed for more than two years during the Cultural Revolution. In 1982, the first post revolution private higher education institution, Islamic Azad University (IAU), opened in Tehran and shortly spread its activities to almost all other cities in Iran. Since 1983 and the reopening of universities, many new state-ruled higher education institutes have been opened and, consequently, the number of students and graduates have been increasing significantly. The number of Iranian students (175,675 in 1979) has increased more than 80 times in about 20 years. In the 2000-2001 academic year, a total of 1,573,322 students were registered in Iranian higher education institutes (Table 1). More than half of the students attend IAU University. About 21% of these students registered for the Associate Diploma degree, 71% for the Bachelor's degree, and about 8% for Master's and PhD programs.

In Iran, admission to post-secondary institutions is through a nation-wide entrance examination and only a small portion of the huge number of applicants can pass this barrier. Although all Iranian universities work at full capacity, demands for post-secondary education far exceeds supply. In 2000, a total of 178,596 new students were admitted into Iranian universities and other tertiary institutes of the public sector. Also in 2000, the number of newly accepted female students exceeded the number of males for the first time. Since the mid-1990s, almost 50,000 Iranian post-secondary students were studying abroad, of which about 4,000 were sponsored scholarship students. Most of the later group that have returned to Iran are now teaching at universities and other higher education institutes.

The academic year in Iran consists of two terms and a summer session. Each term is 17 weeks and the summer session is six weeks. Each theoretical credit is 17 hours of class, each practical or lab credit is 34 hours, and each training or workshop credit is 51 hours.

ENGINEERING EDUCATION

The establishment of Tehran University in 1934 marks the birth of modern engineering education in Iran. The Engineering Faculty of Tehran University commenced its activity by registering 40 students in four departments of civil, mining, mechanical, and electrical engineering. A good part of the early academic staff of the engineering faculty were professors hired from European countries. For a few decades, Tehran University remained the only higher education institution in Iran offering engineering programs.

The number of universities offering engineering courses, as well as the diversity of accredited programs, has been extensively increased during the past two decades. Presently, more than 20% of Iranian students are studying engineering. The number of graduates from engineering programs in Iran in 2000 was about 52,000 (Table 1).

The four levels of tertiary engineering education offered in Iran include a two-year Associate Diploma (ASc.), a four-year Bachelor of Science (B.Sc.), a two-year Master of Science (M.Sc.), and a three- to four-year PhD. The courses in the A..Sc. and B.Sc. programs are divided into four groups, namely general, basic science, basic engineering, and specialized

Table 1. Iran's higher education statistics in 2000-2001 (MSRT, 2001; ISC, 2001)

	Field of Study	Higher Institutions	A.A./ A.S.	B.A./ B.S.	M.A/ M.S.	PD	PhD	Total	
Students	All fields	Public	142,030	512,161	32,287	39726	10,869	737,073	1,573,322
		IAU*	189,362	600,307	34,205	12,375		836,249	
	Technical and engineering	Public	69,166	74,450	9,323	–	1,251	154,190	352,742
		IAU	69,475	124,793	4,123	161		198,552	
Graduates	All fields	Public	40,563	69,330	6,866	4,110	1,749	122,618	263,,275
		IAU	31,007	102,288	6,335	1,027		140,657	
	Technical and engineering	Public	18,790	10,502	1,914	–	68	31,274	51,931
		IAU	7,186	13,004	467	0		20,657	

* Privately owned university

engineering (Table 2). The general courses, and to some extent the basic science courses, are almost similar for all engineering programs.

MINING ENGINEERING EDUCATION

During this study, different aspects of mining education were considered, namely institutes offering mining courses, accredited programs, academic members of mining departments, and students and graduates. These issues are briefly discussed below.

MINING DEPARTMENTS

For almost four decades, Tehran University was the only institute offering mining engineering education. In the mid-1970s, two other universities (Amir kabir Tech. and Esfahan Tech.) started to offer similar programs. The number of higher education institutes active in mining engineering education has increased significantly in the past two decades (Fig. 1). Presently, 17 state-ruled universities offer mining programs. The private IAU university, which commenced mining education in 1985, also offers mining in 12 of its branches that are spread all over Iran (Fig. 1). In 2001, mining education was available in almost half of the 28 provinces in Iran. Under a new program released by MSRT, specialized centres (poles) with extra research funds have been established for different disciplines.

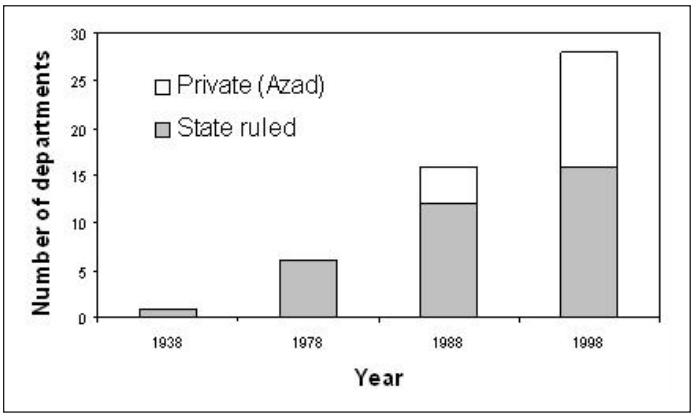

Fig. 1. The expansion of Iranian tertiary institutes in mining engineering education.

STUDY PROGRAMS

Prior to the revolution, each university had the authority to develop its own programs, although one or two other existing mining departments followed the Tehran University curriculum. Since the reopening of universities in 1983 and the introduction of the centralized higher education system, the Mining Committee of the Board of Planning of the Ministry of Science, Research and Technology (MSRT) has accredited 22 programs, of which 12, 3, 6, and 1 are A.Sc., B.Sc., M.Sc., and PhD programs, respectively (Table 1).

The two main accredited BSc. level mining engineering programs in Iran are exploration and extraction. A total of about 2900 hours have been allocated to direct education in 64 courses (138 credits) of these programs, of which 70% are theoretical lecture hours and the rest are practical and lab work (Table 2). B.Sc. students must also pass two sessions (300 hours each) of summer practice in the mining industry.

Table 2. Relative activities of the BSc. mining engineering in Iranian universities

Knowledge Area	Number of Courses	Hours of Education		% of Activities
		Theoretical	Practical	
General (humanity, etc.)	10	306	68	13
Basic science (math, physics, etc.)	13	476	136	21
Foundation engineering (static, dynamic, etc.)	20	678	323	35
Specialized engineering (excavation, ventilation)	17	459	306	26
Electives	3	102	34	5
Project	1			
Total	64	2,021	867	100

Exploration, extraction, mineral processing, rock mechanics, petroleum exploration and exploitation are the six accredited masters programs of mining engineering. Mining education at the PhD level has recently begun in Iran. Presently, the mining engineering curriculum in Iran is significantly influenced by similar programs in Canada, the United States, the United Kingdom, and Australia. Comparing the mining programs in Iran with what is presently offered in these countries reveals a close similarity between them (Memarian, 1999).

ACADEMIC MEMBERS

The first teacher of mining engineering in Iran was professor Kock from Austria, who was hired in 1934. Soon, Iranians who had graduated from European universities (mostly from France and Germany) joined the newly established department. In 1999, about 100 faculty members were teaching in 13 mining engineering departments of the public sector. Of these, 4% are professors, 6% are associate professors, 40% assistant professors, and the rest are instructors (Memarian, 1999). The new generation of academic members of mining engineering departments are mostly graduates of PhD programs in Canada, Australia, the United Kingdom, and the United States.

GRADUATES

The first four mining engineers in Iran graduated from Tehran University in 1938. In 40 years of mining

Table 3. Specifications of mining engineering programs (MSRT, 2000)

	A.Sc.	B.Sc.	M.Sc.	PhD
Accredited programs	12	3	6	1
Number of courses	28-97	40-64	12-14	8-10
Number of credits	68-72	130-140	32	44-51
In school educational activities (hours/program)	1,600-5,747	2,134-2,980	391-527	357-408
% of practical activities	43-52	36-41	0-7	0

education prior to the Islamic Revolution, a total of 454 mining engineers were trained in Iran and all were graduates of Tehran University (Fig. 2). In less than two decades after the revolution, the number of graduates increased to 5,377 (Fig. 2). Presently, about 700 mining engineers graduate annually in Iran, of which 63% are from 17 state-ruled universities and the rest are the graduates of IAU University. About half of those institutes active in mining education have started offering mining programs in recent years and, hence, had little output up to 2000. The graduates of these departments will soon impose another jump on the already ascending curve of mining graduates (Fig. 2). Only one woman received a mining engineering degree prior to 1979. Since the mid-1990s and since a total removal of the ban on girls studying mining, the number of female graduates in mining engineering is growing rapidly.

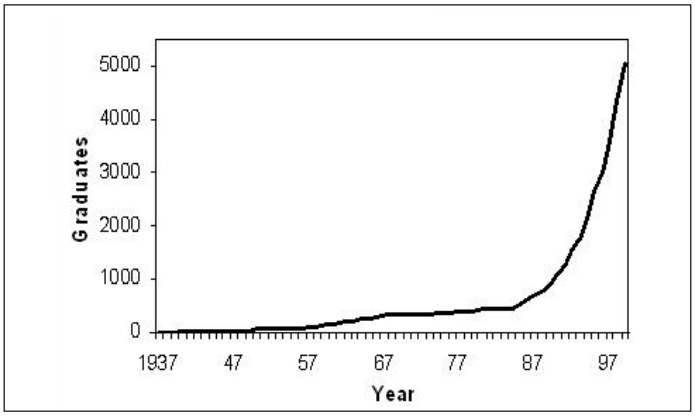

Fig. 2. Cumulative diagram of the number of graduates since the establishment of mining engineering education in Iran.

GLOBAL TRENDS

In the past two decades, higher education in Iran has been experiencing a significant expansion, similar to what some other countries have found in the past. For example, in the 1960s, the government of Australia realized that mental capital was the key to future economic success, so they expanded the student population at universities immensely (Lynch, 1998). Comparisons of the state of mining education in Iran with selected countries from different continents reveal some interesting points.

In North America, 25 universities offer mining engineering programs. In the the United States, 16 accredited mining departments, with a total of 80 faculty members (44 professors, 29 associate professors, and seven assistant professors), were active in 1997. The number of B.Sc., M.Sc., and PhD graduates of these departments in the 1999-2000 academic year were 153, 21, and 11, respectively (Tables 4 and 5). In the the United States, the majority of post-graduate students are not American. For example, in 2000, only eight of 45 PhD students and 32 of 85 M.Sc. students were originally American. As sited by Kramis (1998), "the two current problems of mining education in the United States are the decline in research funds and the higher ratio of full professors (which soon will be retired) to associate and assistant professors."

In 2000, nine Canadian universities were active in mining engineering education (Tables 4 and 5). The full-time and part time academic members of the mining departments in these universities are 58 and 38, respectively. Also in 2000, 177 mining engineers graduated from these departments (Archibald, 2000). Here again, a good number of graduates are not Canadian. In Canada, the ratio of mining students to full-time professors is 11; the full-time and part-time professors is as low as 7. In recent years, the number of annual graduates of mining departments have exceeded the number of newly registered students (Archibald, 2000), leading to a steady decline in enrollment numbers.

Only six mining engineering departments, with 30 academic members, are operating in Australia. In 1977, a total of 196 mining engineers graduated from these departments, of which 21 were MSc. and PhD graduates (Lawson, 1997). A recent study in Australia showed that only three mining departments are sufficient to satisfy the present rate of graduation (Galvin and Roxborough, 1997; Golosinski, 2000). Although the Australian job market requires more mining engineers than currently graduate from existing universities, the tendency for high school graduates to study mining is not increasing (Galvin & Roxborough, 1997).

About 90 universities on the European continent and 30 universities in European Union countries are offering mining engineering education. The annual mining graduates of European Union universities is estimated to be about 450 to 600 (SMP, 1998). With the introduction of new mining technologies and the reduction of mining activities in recent years, the number of mining departments is gradually decreasing in EU countries. For example in the the United Kingdom, after a period of merging some departments, presently only four universities are active in mining education (Shaw, 1998). In the 1999-2000 academic year, these departments had 176 undergraduate students, a number of whom were from other countries (Tables 4 and 5). In recent years, two major pitfalls of mining education in the United Kingdom have been the declining number of new students as well as the absence of gov-

Table 4. Universities offering mining engineering education in selected countries

USA (16)	Alaska (Fairbanks), Arizona, Colorado School of Mines, Colombia, Idaho, Kentucky, Michigan Tech., Missouri-Rolla, Montana Tech, Nevada (Reno), Penn State, South Dakota, South Illinois, Utah, Virginia Tech, West Virginia
Canada (9)	British Columbia, Alberta, Laurentian, Toronto, Queen's, McGill, École Polytechnique, Laval, Dalhousie
Australia (6)	Ballarat, Curtin Tech., Queensland, New South Wales, South Australia, Wollongong
UK (4)	Imperial College, Leeds, Nottingham, Exeter
South Africa (4)	Witwatersrand, Pretoria, Technikon Witwatersrand, Technikon S.A.
Iran (23)	Tehran, Amir kabir, Bahonar, Shahroud, Esfahan Tech., Abadan Tech., Esfahan, Tarbiat Modares, Imam Khomeini, Sahand, Yazd, Birjand, Arak, IAU (ten branches)

Table 5. Comparison of socio-economic situation and mining engineering education in selected countries*

	United States	Canada	Australia	United Kingdom	South Africa	Iran
Population (million)	280	31.6	19.4	59.6	43.6	66
Population below poverty line (%)	12.7	–	–	17	50	53
Literacy (%)	97	97	100	99	81.8	72
Inflation rate (%)	3.4	2.6	1.4	2.4	5.3	16
Unemployment rate (%)	4	6.8	6.4	5.5	30	14
Budget (billion USD$)	1,828	126	94	555	31.1	27
Export (billion USD$)	776	272	69	282	30.8	25
GDP – per capita (USD$)	36,200	24,800	23,200	22,800	8,500	6,300
Number of institutes offering mining engineering education	16	9	6	4	4	27
Duration of B.Sc. programs (years)	4	4-5	3-4	3-4	4-5	4
Academic members of mining departments	76	58	30	–	–	53**
Number of undergraduate students	417	512	–	–	200	>2,800
Number of postgraduate students	130	132	44	–	–	>130
Number of annual graduates (BSc.)	153	109	175	176	38	645
Number of annual graduates (MSc. & PhD)	32	33	21	–	–	35

* Data have been gathered from different national and international sources (see bibliography). To ease the comparison, the socio-economic data have been rounded to the nearest number. Some of these data are best estimates. Statistics of different countries are from 1998, 199, and 2000.

** Excluding the number of academic members of IAU University

– Data are not available

ernment funding and the minute amount of funds from industry (SMP 15, 1999).

In South Africa, two universities and two other higher education institutes offer mining education (Table 4 and 5). In the past decade, about 38 students graduated annually from these two universities (Phillips, 1999).

The example of Iran is presented in this article. Comparing the statistics of mining education in Iran with the above examples shows that the number of active mining engineering departments in Iran (27) is more than in the combined number of mining departments in Canada, Australia, the United Kingdom, and South Africa (23; Fig. 3). Similarly, the number of annual BSc. graduates from Iranian mining departments (645) is more than the total of graduates of the United States, Canada, Australia, and the United Kingdom combined (613; Fig. 4).

DISCUSSION

The obstacles against a mining engineering education in a developing country like Iran is different from those of the industrialized world. Declines in first-year registration and the lack of funding, especially from government, are the two major pitfalls of mining education in most western countries. The consequences of these trends are the closure of some departments and layoff of faculty members and support staffs. In Iran, in spite of the recent expansion of higher education, the number of applicants far exceeds the available seats. Mining departments are still employing new faculty members, mostly among those sponsored scholarship students who had been sent abroad by the Iranian government in the past two decades. On the other hand, a part of untouched allocated research funds of some universities, is returned to the government at the end of each fiscal year.

The two major factors responsible for the high number of students and graduates in Iran are the determination of the country to expand higher education and the pressure from the ever-increasing number of high school graduates who fail to find a decent job. After the 1979 revolution, the population

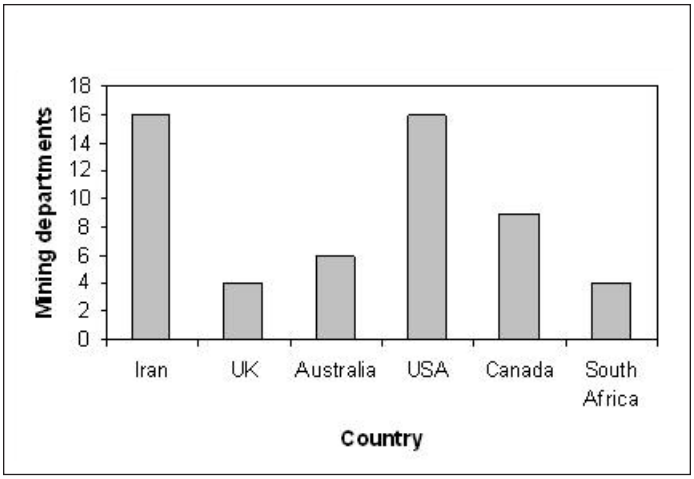

Fig. 3. Comparison of the institutions active in mining engineering education in selected countries.

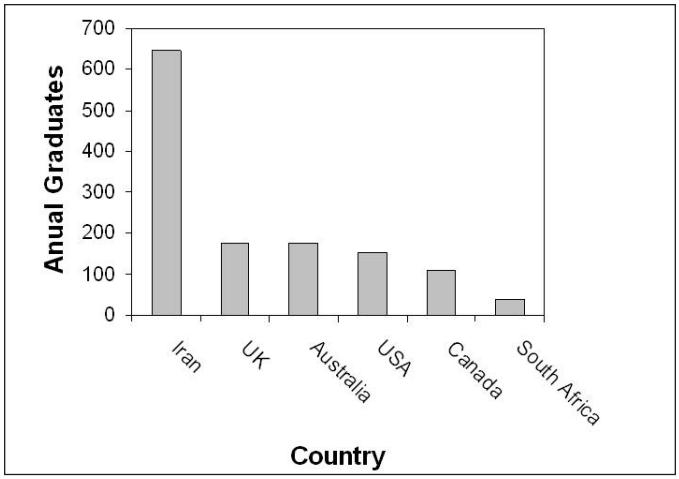

Fig. 4. Comparison of the number of mining engineering graduates in selected countries (graph from Table 5).

growth rate in Iran had jumped to a high annual rate of 3.6%, increasing almost 1% from the previous decade (SCI, 2000). Although the population growth has notably decreased since then and is presently claimed to stand below 1%, the population wave produced in the early 80's recently hit the Iranian universities and job market. Two consequences of this fact are the long queues of those wanting to enter universities and the 16% rate of unemployment among university graduates, which was as low as 4% before the revolution (SCI, 2000).

Soon this sector of the population will have completed university and the declining numbers of applicants will make it possible to take proper measures to overcome some of the existing problems. Among these relieving measures are: a) reducing the number of available seats in mining departments; b) merging existing departments to create fewer but more powerful centres; c) specializing each department in a specific field; d) correcting the present ratio of students to professors; e) leaving more spare time for academic members to spend on research and scientific promotion; and f) developing a system of independent accreditation.

CONCLUSIONS

1. The number of active mining engineering departments in Iran (27) is more than the sum of similar departments in Canada, Australia, the United Kingdom, and South Africa (23). Also, the annual mining graduates in Iran (645) are more than the cumulative graduates of the United States, Canada, the United Kingdom, and Australia (613).
2. The motivation of the country for development and the excessive number of high school graduates, which are the results of a sector of high population growth in the early 1980s, are the two prime factors influencing the significant expansion of mining engineering education in Iran.
3. Reducing the number of seats for new students, merging smaller departments, and developing a system of independent accreditation are some of the main issues that should be considered to make a balance between the needs of industry and the mining graduates.

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