

Original Research Article

The Engineering of an Undergraduate Nuclear Education Program in Jordan

ABSTRACT

Recognizing the vital importance of nuclear knowledge, and that human capacity building is the first step in the effective planning and implementation of a successful nuclear power program, in 2006/2007 Jordan made the decision to establish a nuclear engineering education program. The establishment of such a program was the first step in Jordan's efforts to develop its nuclear infrastructure, and to introduce nuclear power as part of its energy mix.

The Nuclear Engineering department at Jordan University of Science and Technology (JUST), is the first and only such department/program in Jordan, to provide top quality nuclear education that will lead to realistic teaching instruction this department was engineered and designed based on four factors; curriculum, faculty, facilities, and students. This paper presents the establishment of nuclear engineering education in Jordan and the department role in building Jordan's human capacity to ensure the proper implementation of its nuclear power program; it further evaluates the department challenges and current status.

Keywords: nuclear engineering, education, Jordan, human resources, university, JUST

1. INTRODUCTION

In 2007 the world witnessed an unprecedented number of countries expressing their interest or declaring their intention to peruse a nuclear power program for the first time. The vast majority of the 65 countries that approached the IAEA for assistance in their nuclear programs are developing countries [1], fourteen are located in the Middle East, Jordan being one of them. The greatest challenge that most developing countries will face in their effort to introduce nuclear power will be the lack of qualified nuclear engineers and experts.

Recognizing the vital importance of nuclear knowledge, and that human capacity building is the first step in the effective planning and implementation of a successful nuclear power program. Immediately after Jordan declared its intention to introduce nuclear power as part of its energy mix [2], the decision was made to establish a nuclear engineering education program. The establishment of such a program was the first step in Jordan's efforts to develop its nuclear infrastructure.

The nuclear engineering department at Jordan University of Science and Technology (JUST), is the first and only such department/program in Jordan. The university itself is a leading Jordanian institution of higher education with more than 20,000 undergraduate students and 1800 graduates, including nearly 5000 international students from 60 different countries. The college of engineering is the heart of the university with eight different departments and approximately 7,000 students [3].

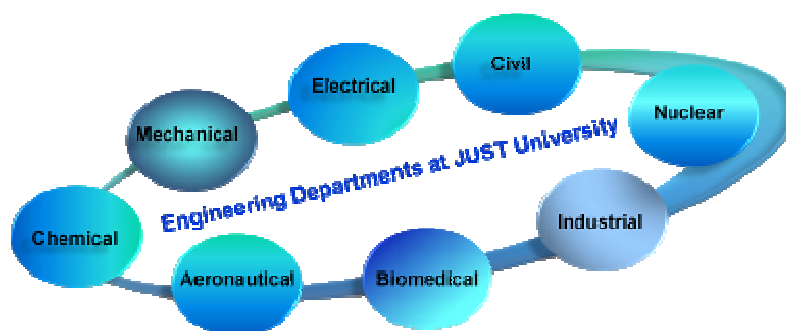


Figure 1. Engineering departments at Jordan university of science and technology

2. NUCLEAR ENGINEERING EDUCATION

[In 2007 following the announcement that Jordan plans to build and operate its first nuclear power plant by 2015 [4], the nuclear engineering department was established at Jordan University of Science and Technology (JUST).

Assuming the lead role of Jordan's nuclear human capacity building, through educating, training and graduating competent engineers that will ensure the proper implementation of Jordan's nuclear power program [5], the department accepted its first class of students in the same year.

The nuclear engineering department at Jordan university of science and technology is the first and only such department/program in Jordan. Aiming to provide top quality nuclear education that will lead to realistic teaching instruction the department was engineered and designed based on four pillars ; curriculum, faculty, facilities, and students [6,7].

2.1 Curriculum

The curriculum was designed to focus on nuclear power engineering, in particular nuclear power from fission reactors. It is intended to educate students in the basics of nuclear technology, radiation measurement, and power reactor engineering; furthermore, it gives the student a very strong background in basic sciences and engineering, the courses distribution base on their source is tabulated in table-1.

The curriculum prepares students for careers in nuclear power, in regulatory positions with the government, or for employment with electric utility company to work on the design, building, testing, maintenance and operation of nuclear power plants. The curriculum also prepares the graduate for work in many areas where a broad technical background is more important than specialization in a specific field.

Table 1. Nuclear engineering program courses distribution by type

Courses Type	Lecture Cr. Hours	Lab Cr. Hours	Total Cr. Hrs.	%
Humanities	24	1	24	15.7%
Basic Sciences	30	2	32	20.2%

General Engineering Sciences	25	4	29	18.2%
Nuclear Engineering Sciences	63	10	73	45.9%
Total	142	17	159	100%

59

60 The curriculum features an important course that distinguishes it from any other nuclear
 61 program worldwide [8] “Ethics and the introduction of nuclear energy”, is a course that
 62 introduces students to the ethical responsibilities that accompany working with nuclear
 63 energy. It also gives students a platform to discuss and debate nuclear issues such as the
 64 responsibility of nuclear engineers to protect the public from nuclear misuse, or to report any
 65 wrongdoing, or the dilemma of following orders rather than applying regulations and best
 66 standards.

67 Another important course is an introductory course about nuclear energy that does not
 68 require any technical prerequisite. The course gives new students the opportunity to interact
 69 with the department in their first or second year of admittance, it also expose students to the
 70 historical and current development of nuclear energy at an early stage of their education.

71 Table 2. Credit hours required to obtain B.Sc. degree in nuclear engineering

	Mandatory Cr. Hr.	Electives Cr. Hr.	Total Cr. Hr.
University Requirements	16	9	25
College of Engineering Requirements	32	0	32
Nuclear Engineering Department	60	14	74
Other Engineering Department	28	0	28
Total	136	23	159

72

73 The undergraduate curriculum consists of a 159 semester credit hours, which are required to
 74 obtain the B.Sc. degree in Nuclear Engineering, these requirements are summarized in
 75 Table 2.

76

77 2.2 Faculty

78 The quality of teaching at any institution depends largely upon the quality of the faculty and
 79 academic staff. To ensure a top quality educational program, the department has to be
 80 staffed by faculty and academic staff whose graduate and undergraduate work is in nuclear
 81 engineering, or graduates with practical experience in the nuclear field, and who have
 82 gained enough nuclear knowledge, to be transferred to students.

83 The enormous challenge that will face the university will be staffing the department with such
 84 high caliber people. The present university salary system where all professors regardless of
 85 their achievements or qualifications and whether they teach music, or rocket science earn

the same salary, is obsolete and would definitely undermine the department strategic plan, and hinder its success.

Search to recruit qualified faculty members should be a top priority, as this method makes more economic sense than sending individuals to obtain higher degrees at the expense of the university and contract with them to comeback and teach at the university, which seems to be the preferred method of most third world countries.

Straight through school PhD graduates do not necessarily make the best faculty for a startup department like the one in Jordan, especially in the absence of nuclear facilities, or basic nuclear and industrial infrastructure. With the lack of any nuclear experience and in the absence of supportive nuclear institutions, candidates with BSc degrees in other disciplines would remain poor in nuclear engineering since they missed most of the basic and fundamental education in that field.

Table 3. Faculty and students numbers of the nuclear engineering department

Academic year	Number of students		Faculty Number	Student to faculty ratio	NE Cr. Hrs. taught
Admitted	Enrolled				
2006/2007	20	20	1	20	0
2007/2008	37	57	2	29	9
2008/2009	33	90	3	30	19
2009/2010	27	117	4	29	44
2010/2011	20	130	5	26	66
2011/2012	15	126	3	42	66
2012/2013	17	112	3	37	66
2013/2014	23	112	4	28	66
2014/2015	n/a	n/a	6	n/a	66

The department started in the year 2006/2007 with one professor, and has grown to have six professors in the year 2014/2015. The number of faculty have fluctuated randomly as a result of administrative decisions, and not necessarily based on the department needs. As can be seen in table-3, the year 2011/2012 had 127 students and merely 3 faculty members, resulting in a student to faculty ratio of 42. [9, 11]

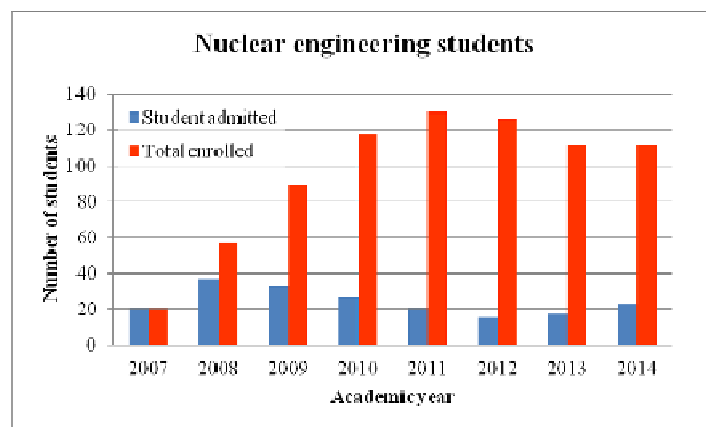
Currently 50% of the faculty members are from the same family as the university president [9]. In fact, the majority of students sent by the university to study abroad were from that same family, which raises the question if the criterion was academic excellence or kinship and cronyism. The lack of integrity and equal opportunity will undermine any education system, and will definitely affect not only nuclear engineering education but also the safety and security of the whole nuclear program in Jordan.

2.3. Students

The program is designed to fulfill Jordan's needs for nuclear engineers and scientists, thus the students populace and department size was set to remain within the boundaries that serve this purpose.

115 In view of the fact that Jordan does not have any nuclear industry, the department vision was
 116 to maintain the number of students at about 100 for the first ten years, thus accepting 20–25
 117 new students every year, such a small program size would have many advantages:

- 118 1. It will help all graduates in having a job opportunity, for the next ten years based on
 119 current market needs for Jordan
- 120 2. It will help the department in keeping a competitive edge, by attracting the best
 121 students to the program
- 122 3. It will ensure that most graduates will be employed, even in the worst case scenario
 123 where Jordan does not go forward with its nuclear power program
- 124 4. The student to professors ratio would be maintained at an acceptable level



125 **Figure 2. Number of students in the nuclear engineering department**
 126
 127

128 Since its inception, the department succeeded in attracting the best students with A
 129 averages, in its first year students admitted to the program were from the top 5% of
 130 secondary school graduates. This was made possible by public awareness and the
 131 infatuation of Jordanians for science and technology education in general.

132 The positive public acceptance of the nuclear program did not last long, and it took a
 133 nosedive in 2012, following years of empty promises, disinformation, mismanagement, and
 134 corruption allegations against Jordan atomic energy commission, that resulted in a
 135 parliamentary vote to suspend the nuclear program [10].

136 The first nuclear engineering class of 19 students graduated in 2011, this was followed by 30
 137 students in 2012 and 23 students in 2013. Making the total nuclear engineering department
 138 graduates 72 students, 70% of which are male and 30% are female, the annual number of
 139 graduates is illustrated in figure-3. [11]

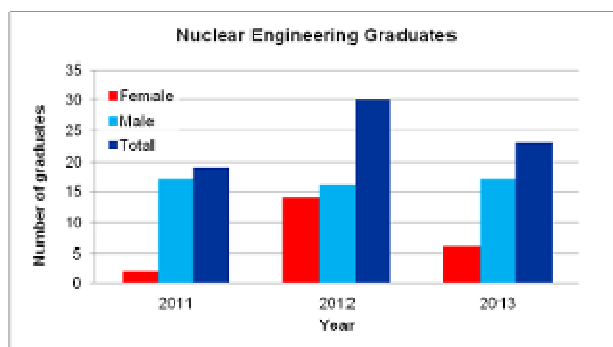


Figure 3, Number of students that graduated with BSc degree in nuclear engineering

2.4. Facilities

Since its inception, the department planned to be equipped with all necessary laboratories and facilities that support the curriculum, and which offer students a hands-on experience in basic nuclear engineering fundamentals, the following laboratories were established in the nuclear engineering department:

2.4.1 Radiation Detection and Measurement Laboratory:

This is a basic radiation science laboratory that exposes students to experiments in nuclear electronics, radiation detection, gamma spectroscopy, radiation survey, radiation attenuation and shielding.

2.4.2 High Speed parallel computational Laboratory:

This is a computer cluster consisting of 96 processors that enable student to perform parallel computation of nuclear engineering problems and to run design and simulation exercises of nuclear systems via vpn terminals.

2.4.3 Subcritical Reactor Laboratory:

This is a small reactor designed to provide nuclear engineering students with practical training in nuclear fission process, in a safe laboratory setting and with minimum exposure to radiation, it is one of the most effective tools for educating and training. It's simple construction (Fuel & Moderator) in an open tank, allows students to modify core configuration, work very close to the core, observe and see every part of the reactor, and obtain a clear physical picture of the basic features of a reactor in a way that is impossible in power or research reactors. Students are able to perform of the basic nuclear reactor experiments [12] such as; approach-to-criticality experiment, axial and radial flux distribution measurement, absolute flux measurement, Rossi- α method, Feynman- α method, source-jerk experiment, fuel void effect, and control rod (poison) effect.



Figure 4. Subcritical reactor laboratory at the nuclear engineering department in Jordan

4. CONCLUSION

In 2007 the first university nuclear engineering department was established in response to Jordan's assertion that it plans to build a nuclear power plant by 2015. Recognizing the vital importance of nuclear knowledge in the successful and safe implementation of any nuclear power program, the department assumed the lead role of Jordan's human capacity building, by educating and graduating competent engineers that will help in designing, building, regulating and operating of Jordan's first nuclear power plant.

The department was designed to fulfill Jordan's needs for nuclear professionals; thus the curriculum focus was on nuclear fission reactors rather than a comprehensive nuclear science and technology, the students' population was also maintained at a level to serve that purpose. In light of the continuous postponement of the nuclear power plant building date from 2015 to 2017, 2019, 2020, in addition to public rejection and corruption allegations of the country's nuclear program [10], it is recommended that the nuclear engineering education plan be revised and updated to include nuclear sciences, health physics, and fusion.

Staffing the department with high caliber faculty based on academic excellence, rather than cronyism remains to be a big challenge, particularly in light of the mismanagement that the whole nuclear program in Jordan has witnessed.

Nuclear engineering is a very specialized education and training field which must adhere to the highest international standards, especially that graduates might end up working worldwide in a zero tolerance industry.

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