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Education of Sustainable Manufacturing in Curriculums: Evidence from Iraqi Colleges

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Abstract. Creating a generation with knowledge, abilities, and skills to meet the challenges of economic, environmental, and social sustainability is very important. In the context of the education of sustainable manufacturing, curricula should be directly related to sustainable manufacturing and its requirements. However, Iraqi colleges continue to suffer from the lack of sustainable manufacturing education in their curricula. Therefore, this study aims to explore the education of sustainable manufacturing for seven colleges in Baghdad, Iraq. Besides, this study used a qualitative method. The results of the study are indicated to a weak level, which is almost non-existent to sustainable manufacturing education into the curricula of these colleges.

1. Introduction

Nowadays, the education of sustainable manufacturing has become an essential requirement in the present and future curriculum. The world efforts involve the United Nations Decade of Education for Sustainable Development has reported that there are grand ambitions for integrating sustainability into the curriculum pursued by 370 universities within the global partnership [1]. Besides, the United Nations Report on Education for Sustainable Development Goals stated in Goal 4 that “the learner is able to use all opportunities for their own education throughout their life, and to apply the acquired knowledge in everyday situations to promote sustainable development” [2].

Moreover, Byrne, Desha, Fitzpatrick, and Hargroves [3] emphasized by the end of the 1980s, up to the past decade, the global trend towards integrating sustainability into college curricula has increased. Similarly, Nóbrega [4] highlighted the importance of sustainability education in curriculums now more than ever before. Also, Prevedouros, Mitropoulos and, Zhang [5] noted that integrating sustainability into college curricula leads to the development of students with the ability to address the planet's environmental and social challenges. However, Colleges of Engineering, Engineering/Technical, Electrical Engineering & Electronic Techniques, Applied Arts, Science, Administration and Economics and Technical College of Management in Iraq still today suffer from a significant lack of sustainable manufacturing education into the curriculum.

In fact, empirical evidence has demonstrated the importance of sustainability and sustainable manufacturing education in colleges. Most studies in several countries have dealt with the education of sustainability into the curriculum specifically in engineering colleges such as Byrne, Desha, Fitzpatrick and Hargroves [3], Nóbrega [4], Prevedouros, Mitropoulos and Zhang [5], Beheiry, Abu Lebdeh, Murtula and Al-Tamimi [6], Kamp [7], Ferrer-Balas and Mulder [8], Findler, Schoenherr, Lozano, Reider and Martinuzzi [9], Mathar [10], Palacin-Silva, Seffah and Porras [11], Tejedor, Segalàs and Rosas-Casals [12], Tang [13], Katiliute and Daunoriene [14], Salvioni, Franzoni and Cassano [15], Leal Filho, Manolas and Pace [16], Santos [17], Fahey, Verstraten and Berry [18],



Laurie, Nonoyama-Tarumi, Mckeown and Hopkins [19], Scott [20], Lindberg [21], Bilge, Seliger, Badurdeen and Jawahir [22], Arsath [23], Herrmann, Bogdanski, Winter, Heinemann, Thiede and Zein [24], Seliger, Reise and Bilge [25], Lozano García, Kevany and Huisingsh [26], Kumar, Haapala, Rivera, Hutchins, Endres, Gershenson, Michalek and Sutherland [27], and Waas, Verbruggen and Wright [28]. Additionally, a limited number of studies addressed sustainable manufacturing education in engineering colleges such as Garetti and Taisch [29], Cerinšek, Petersen and Heikura [30], Jawahir, Badurdeen and Rouch [31], and Badurdeen and Jawahir [32]. Nevertheless, by reviewing the literature and to the knowledge of the researcher, no prior study has attempted to address the education of sustainable manufacturing in the curriculum of Iraqi Colleges. Thus, this qualitative study aims to explore the education of sustainable manufacturing for Colleges of Engineering, Engineering/Technical, Electrical Engineering & Electronic Techniques, Applied Arts, Science, Administration and Economics and Technical College of Management in the city of Baghdad in Iraq.

The results of this study can benefit from several aspects in different areas. Academics will obtain a better perception of the importance of integrating sustainable manufacturing education into the curriculum. Additionally, policymakers will gain a better understanding of sustainability and sustainable manufacturing education issues into curricula that need to be addressed at colleges. Also, college students will recognize the importance of sustainability and sustainable manufacturing, and how it can help them to become critical contributors to sustainability in the present and the future.

2. Sustainable manufacturing (SM)

Nowadays, global manufacturing requirements have become more complicated when compared to the past manufacturing paradigms due to persistent global changes [33]. Besides, the manufacturing companies consume large amounts of non-renewable resources in addition to generating large quantities of waste and pollutants [34]. Jayal, Badurdeen, Dillon and Jawahir [35] emphasised that there is a very urgent need for sustainability in industrial operations because of decreasing of non-renewable resources, the stringency of environmental and safety regulations, and consumers' desire for environmentally friendly products. These causes and other make companies in a significant commitment to rethinking keep sustainability in their industrial operations [36].

Sustainability in manufacturing has become crucial for researchers and practitioners. A large number of research activities have been published in this new scientific field [37]. Besides, in practice, there are significant global efforts by companies in manufacturing, engineering and design to practice sustainability [36]. Furthermore, Garetti and Taisch [29] emphasised that one of the most critical concrete contributions to sustainability is its implementation in the field of manufacturing. Since the stage in which sustainability has entered into manufacturing activities, it has been to address environmental problems [33]. This came as a result of the society's awareness of the harmful environmental effects of manufacturing operations, prompting manufacturers in the world to take care of this subject to protect the environment from pollution and competition from this aspect [33]. Therefore, sustainability in manufacturing has received high global attention because it addresses the environmental impacts of sustainability.

The environmental effects of manufacturing activities are no longer just to be addressed, but there is an urgent need to look at social and economic factors at the same time. There are global challenges that manufacturers face regarding economic, environmental and social sides [38]. Which requires changes at various levels, including environmentally friendly production methods that emphasise reduce resource consumption and concern for society [39]. Industry companies can be sustainable through their implementation of sustainable manufacturing (SM) [40]. Thus, the industry can be sustainable by the trend towards the concept of SM.

At present, SM has become a great interest in the academic field [41], and one of the most discussed topics between scholars and practitioners [36, 40]. The field of SM is rapidly evolving [42]. This development is through the concept of sustainable development [40, 43, 44]. On the other hand, there are many environmental and social challenges in the industry that called for the adopted of SM. SM is an inclusive manufacturing paradigm capable of dealing with the environmental and social challenges in manufacturing in the 21st century [45]. Besides, SM is able of dealing with today's economy, which has been affected by environmental and social constraints [46]. It is a philosophy that

closely related to economic, environmental and social systems [47]. Additionally, SM provides a new way to produce excellent products [48]. Moreover, control of environmental impacts, social welfare, and economic growth depends on the level and type of education in universities. [31, 32]. Therefore, education in universities considered as one of the critical factors the implementation of SM.

3. Method

The current study uses content analysis [49-51]. This design is appropriate for the study of the educational system and curriculum [52]. This study includes Colleges of Engineering, Engineering/Technical, Electrical Engineering & Electronic Techniques, Applied Arts, Science, Administration and Economics and Technical College of Management in the city of Baghdad in Iraq. In addition, the electronic records available in colleges websites were used as a data collection instrument [52]. These electronic records include the names of colleges, departments, and curricula. Particularly, it has been adopted to help understanding what the curriculums lack on sustainable manufacturing topics.

4. Findings

The authors have collected the data using electronic records available at the websites of the Colleges of Engineering, Engineering/Technical, Electrical Engineering & Electronic Techniques, Applied Arts, Science, Administration and Economics and Technical College of Management in the city of Baghdad in Iraq. They have classified according to the name of the college and its departments, and the number of curricula studied, as shown in Table 1 and Figure 1.

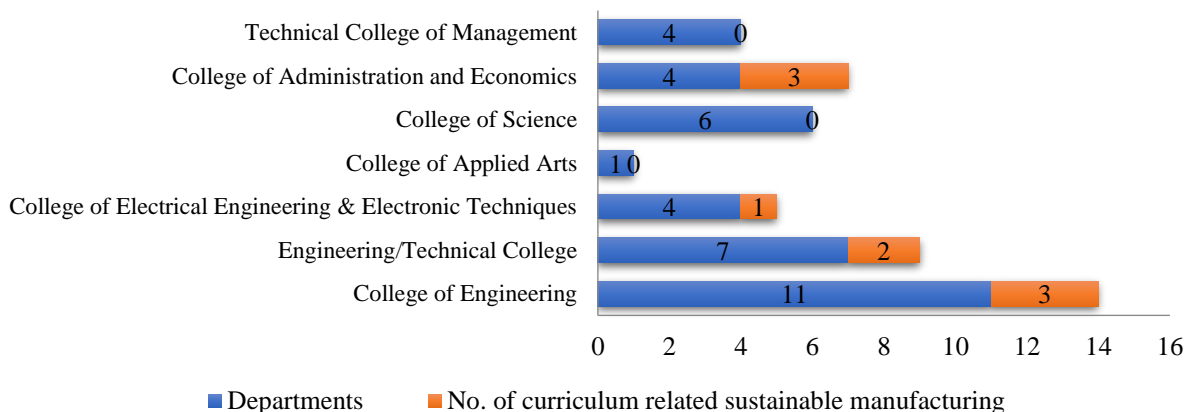


Figure 1. Colleges by their departments, their curricula about sustainable manufacturing

Although the College of Engineering, comprises of eleven departments and includes 381 curriculums, there are only three curriculums but directly not related to sustainable Manufacturing. The first curriculum “environmental pollution and industrial safety”, belongs to the Department of Chemical Engineering in the second year. The second curriculum “environment protection” belongs to the Department of Nuclear Engineering in the fourth year. The last curriculum “industrial safety” belongs to the Department of Environmental Engineering in the third year; further, most of the other curriculums in this department are related to the environment only.

In addition, despite the Engineering/Technical College, includes seven departments and involves 251 curriculums, there are only two curriculums but directly not related to sustainable Manufacturing. The first curriculum “environmental engineering”, belongs to the Department of Mechanical Power Engineering/ Refrigeration and Air Conditioning Engineering in the fourth year. The second curriculum “renewable energy” belongs to the Department of Mechanical Power Engineering/ Automotive Engineering in the fourth year also.

Moreover, notwithstanding the College of Electrical Engineering & Electronic Techniques, involves four departments and includes 149 curriculums, there is only one curriculum but directly not related to

sustainable Manufacturing. This curriculum “electric power generation and renewable energy”, belongs to the Department of Electrical power engineering techniques in the fourth year.

Further, even though the College of Applied Arts, involves one department and includes 29 curriculums, but no any curriculum related to sustainable manufacturing. Additionally, despite the College of Science, involves six departments and includes 314 curriculums, but not any curriculum related to sustainable manufacturing.

Besides, though the College of Administration and Economics, includes four departments and involves 180 curriculums, there are only three curriculums but directly not related to sustainable manufacturing. The first curriculum “environment management”, belongs to the Public Administration in the third year. The second and third curriculums “Sustainable development and environmental economics” belongs to the Department of Economics in the third year also.

Lastly, although the Technical College of Management, involves four departments and includes 124 curriculums, but not any curriculum related to sustainable manufacturing.

Table 1. Classification of colleges, their departments, their curricula about sustainable manufacturing

College	Department	No. of curriculums in bachelor	Curriculum related sustainable manufacturing	Year of study
College of Engineering	Civil Engineering	30	-	-
	Electrical Engineering	34	-	-
	Architectural Engineering	48	-	-
	Chemical Engineering	32	Environment Pollution & Industrial Safety	Second
	Mechanical Engineering	30	-	-
	Petroleum Engineering	34	-	-
	Water Resources Engineering	38	-	-
	Electronic and Communications Engineering	39	-	-
	Nuclear Engineering	31	Environment protection	Fourth
	Computer engineering	31	-	-
	Environmental Engineering	34	Most of the curricula related to the environment except industrial safety	Third
Engineering/Technical College	Mechatronics	35	-	-
	Engineering techniques			
	Computer Technologies	40	-	-
	Engineering Building & Construction Technology	35	-	-
	Engineering Mechanical Power	34		
	Engineering/Refrigeration and Air Conditioning Engineering		Environmental Engineering	Fourth
	Engineering Mechanical Power	34		
	Engineering / Automotive		Renewable Energy	Fourth

	Engineering			
	Materials Technology	37	-	-
	Engineering			
	Welding techniques	36	-	-
College of Electrical Engineering & Electronic Techniques	Engineering			
	Medical Instrumentation Techniques	34	-	-
	Engineering Control and Automation			
	Engineering Techniques	33	-	-
	Electrical power engineering techniques	33	Electric power generation and renewable energy	Fourth
College of Applied Arts	Computer Engineering Techniques	49	-	-
	Interior Design	29	-	-
College of Science	Mathematics Science	42	-	-
	Physics Science	70	-	-
	Chemistry Science	61	-	-
	Life science	47	-	-
	Computer Science	51	-	-
	Biotechnologies	43	-	-
	Science			
College of Administration and Economics	Business Administration	52	-	-
	Industrial Administration	29	-	-
	Public Administration	48	Environment management	Third
	Economics		Sustainable development, Environmental economics	
		51		Third
Technical College of Management	Financial And Accounting Technology	32	-	-
	Business Administration Techniques	28	-	-
	Total Quality Management Techniques	32	-	-
	Administrative Information Techniques	32	-	-

Note: Above curriculums without Human rights, Democracy, Arabic language and English language, because it is a general curriculum.

5. Conclusion

After completing the current study, researchers encourage the use of electronic records as a useful instrument for collecting data and information about colleges. When we talk about these records, we find that they have provided valuable data on the curricula of those colleges. Researchers have been able to discover the weak level, which is almost non-existent to the education of sustainable

manufacturing into the curricula of these colleges. These colleges can integrate sustainable manufacturing topics by updating their curricula by the curricula of colleges that integrate sustainable manufacturing in their curricula. In addition, these colleges can coordinate with one another to develop a specialty that integrates engineering, science, technical, administration and economics, and create an integrated multidisciplinary program for sustainable manufacturing [31]. One of the limitations that has prevented the inclusion of other faculties in this study is the lack of electronic records of the curriculum in college websites, in addition to the lack of time. We have recommend similar research on other colleges in other cities of Iraq or other countries.

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