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A Novel Framework for Achieving Sustainable Value Creation through Industrial Engineering Principles

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Abstract

Due to the lack of suitable approaches for sustainable development, over the years, a gap has evolved between the developed and emerging countries on innovation and technological development. At the same time, opportunities for value creation call for a collaborative framework for economic, environmental, and social industrial benefits among multiple countries to achieve sustainable value creation. Based on international cooperation in sustainable manufacturing, existing design and assessment methodologies can be adapted to increase innovation by utilizing the dynamics of competition and cooperation. This paper focuses on bridging this gap by implementing an approach for adaptively transforming the industrial engineering education principles and practices with the associated research methodologies from developed countries into manufacturing systems in emerging and developing countries. To achieve this transformative approach for sustainable development through education and research, developed countries promote their best practice education cultures in emerging and developing countries. Based on the need for technological and managerial methodologies for sustainable manufacturing, the set of capabilities for industrial engineering are analyzed, and educational principles are selected. As an example of the approach proposed in this paper, a new reformed program for industrial engineering merges the needs of the Turkish manufacturing industry with the German application-oriented education and research culture. The educational program guides stakeholders to generate a common understanding and utilize bilateral opportunities for sustainable value creation in manufacturing.

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1. Introduction

Caused by natural phenomena and human activity, the acceleration of climate change has already affected economics and human lives worldwide. Climate change damages properties and infrastructures, and results in lost productivity, mass migration, and security threats. Sustainable value creation can significantly contribute to the deceleration of climate change and the reduction of negative economic impacts. Manufacturing activities can be developed to run on renewable and non-renewable resources in closed-loop cycles to promote a circular economy. The design, operation, and assessment of such sustainable manufacturing systems within the limitations of renewable resource generation, and social compatibility, are the major challenges of the 21st century.

Most countries are already involved in global value creation to a certain degree, and they cooperate with international stakeholders. There is a positive correlation between participation of public and private service sectors in global value creation, particularly in manufacturing, and the growth rates of gross domestic product (GDP) per capita [1]. This can also cause challenges, as crises can be transmitted across borders quickly. Furthermore, a deeper gap regarding the resource generation and consumption has increasingly evolved between the developed, and emerging and developing countries. Developed countries create the most value, having a decreasing benefit on global well-being [2]. Since the second half of the 20th century, emerging countries have grown quickly

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to accommodate the consumption needs and aspirations of developed countries, often allowing an increase in irresponsible resource consumption.

However, developed and emerging/developing countries need opportunities to maintain and enhance their living standards (quality of life) while reducing their environmental footprint. At the same time, emerging/developing countries need opportunities to ensure and improve their living standards according to Maslow's hierarchy of human needs [4]. A wide range of growing threats to people's lives include wars, political and ethnic conflicts, terrorism, environmental and natural phenomena, industrial accidents, occupational injuries, and crime. Developments in science and technology, combined with major challenges such as climate change and access to resources, affect how products and services can be created, distributed and managed. Production and consumption methods need to change as developed, emerging, and developing societies deal with sustainability challenges.

In developed countries, the rate of population growth is lower, and in some European countries it is even negative. For example, the average age of German engineers is currently over 50. Over the next ten years, more than one in two German engineers will be working for German companies abroad, and almost one in four engineers working in Germany will retire. Because of this shortage of engineers in Germany, the job market needs more than twice as much graduates annually, 90,000 instead of 44,000 [3]. In terms of an European comparison, Turkey, with a population of 76 million people, represents the second largest demographic and – with an average age of 31 years – the youngest community [2].

A well-educated population is essential for a country's well-being and sustainable development. Education plays a key role in providing people with the capabilities needed to participate in advancing the society, environment, and the economy. The focused determination of engineers and decision-makers to sustainable development and its holistic implementation in practice heavily rely on manufacturing methodologies to design and produce, as well as manage, operate and evaluate, the impact of products and services.

Many scientists report the need for a sustainable approach to various disciplines [4]. A comparison of major disciplines in selected educational programs shows that business and legal studies, social sciences, computer sciences, and engineering only barely cover the important elements of sustainable value creation. While value creation through manufacturing is dominated by engineers, those looking to improve upon value creation have embraced the principles of industrial engineering using different manufacturing and management methodologies. Industrial engineering as a dynamically developing field of engineering that has risen to the top of manufacturing, services, and other areas of value creation in many developed and emerging countries [5]. This paper provides a closer look at industrial engineering in order to analyze how industrial engineering practices can change and how education in industrial engineering can enhance capabilities for sustainable value creation in practice.

The main goal of this paper is to propose a framework for bridging the gap between developed and emerging/developing countries through a reformed industrial engineering educational program. The proposed improvement of the program is discussed in three steps, first by exploring how industrial engineering programs need to change in response to sustainability challenges. The next section reviews the methodologies and capabilities of current industrial engineering programs, and identifies the major principles of industrial engineering, particularly in developed countries such as Germany and the United States (US). It then analyzes the gap between educational programs and practice, and synthesizes the need for transformation of industrial engineering principles for sustainable value creation. Finally, it presents a framework for an improved industrial engineering program to achieve sustainable value creation. The graduate industrial engineers are then shown as the drivers of sustainable development in global value creation as they contribute to bridging the gaps between different development levels worldwide.

2. Review of Industrial Engineering

This section discusses the current capabilities, and principles and methodologies in industrial engineering, and the value creation requirements involving efficiency and effectiveness (see Fig. 1).

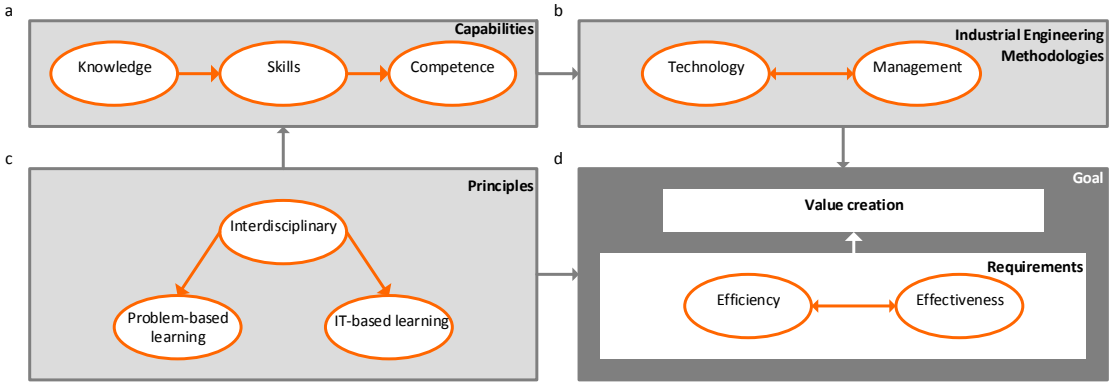

Fig. 1. Industrial engineering (a) capabilities; (b) methodologies; (c) principles; and (d) goal and requirements.