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Insertion of sustainability performance indicators in an industry 4.0 virtual learning environment

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Abstract

Despite the profound impact caused by the technological revolution of the 20th and 21th centuries, many training practices, especially in formal education, have experienced little change. More holistic and self-sufficient means of education and training are necessary to meet the needs of manufacturing industry, incorporating success factors besides technical knowledge and economic viability, and one of the tools capable of delivering are serious games. One relevant concern when developing these tools is how to assess the learner's development and which goals to set as the learning challenge. To address this matter, this article contains a review of the sustainability assessment theory, focusing mainly on the social and environmental dimensions, and discusses the possibilities for incorporating theses metrics in a virtual learning environment both regarding their role for learning and motivation, their learning advantages and disadvantages as well as their relation to real practice, all in the context of the fourth industrial revolution. It aims to illustrate the usage of sustainability awareness as a learning outcome and the incorporation of sustainability indicators as tool to promote this development.

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Keywords: Serious Games; Sustainable Manufacturing; Sustainability Assessment; Technical Education

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1. Introduction

Highly skilled workforces have been a key factor to companies and countries successes for a long a time, and this shows no signs of changing. In an economy where machines are being developed to perform a wide range of tasks of different complexity and are capable of intercommunicating, the very definition of highly skilled worker will change in many areas. Coupled with the fast-paced evolution that has kept going for decades in the manufacturing environment training and education will keep or perhaps increase their importance in the foreseeable future.

There are many challenges to address in the education and training needs some of them more recent then others. The overly technical and fragmented technical-focused teaching that engineers are normally exposed to has been one of the main concerns for almost a century [1,2], and to face it more holistic approaches to learning are being used, among them the usage of games and simulations [3–5]. In a traditional context, learners would have different subjects to address different topics and new learning needs may be dealt with by creating a new subject and adaptation of the existing ones. When working however, solving problems is central and the subject or area divisions in acquiring or developing knowledge for this purpose are blurred. To decrease the distance between learning and working environments, more holistic methods of educating are being used.

Problem, project and case based learning are some examples of more integrated approaches, however, despite their many advantages, all of those require tutors and a significant amount of preparation time to be effective. Common ways to solve the external time demand are recorded classes, videos, books, texts and online courses but many of these commonly fall into the fragmented approach. The need to incorporate learning practices that are more closely related to real practice, especially regarding the competences they develop, is clear specially in engineering and technical context [2,6]. Due to their interactivity, adaptability potential, and the experience-focused approach, virtual learning environments, simulations and serious games are some of the candidates to address these three issues: education-work distance, fragmented subjects, staff time-constraints. The education-work distance can be reduced by creating environments that represent the usage of learned concepts in relatable work experience. This closer relation makes it difficult to create overly fragmented topics. While the initial cost of developing these learning environments is high, they can be massively reproduced with a greater potential for interactivity and adaptation to different difficulties.

To develop a truly holistic approach, the education and training practices cannot limit themselves to dealing only with technical matters and content, they must transcend concepts and incorporate other concerns that are relevant not only to manufacturing and industry, but to the society at large [7–9]. Manufacturing industries are not concerned only with producing goods and the costs involved, but also about the impacts that the production and products have for their clients, machines, consumers, the environment and society, be it from a legal or moral standpoint. A sustainable future depends on sustainability awareness, both social and environmental.

Incorporating sustainability assessment in the very technical and management education is a way to present applied sustainability concepts. While broader sustainability awareness focused courses do have their place, the direct insertion of sustainability issues and practices integrated in technical subjects can provide a more tangible understanding on how to apply them, in the training of the professionals who should do so. The main objective of this article is to present ways to incorporate sustainability learning outcomes through the usage of KPIs in an industry 4.0 serious game and learning environment considering motivational effects, in-game function with its advantages and limitations.

In section 2 the ideas of sustainability assessment will be discussed based on the literature to establish feasible indicators and practices to incorporate in the learning environment. Section 3 describes the virtual learning factory, its goals and comparison with other education practices. The fourth section describes the various approaches to incorporate these factors in serious games, virtual learning environments and in the proposed virtual factory. Finally, the last section brings the conclusion and other considerations.

2. Sustainability Assessment and Industry 4.0

Much data is collected to assess the performance of organizations regarding many different areas. Some of them are common and widespread, such as financial health or production efficiency, but others still require further development to establish themselves. Environmental and social sustainability indicators are a developing research topic and much discussion on best practices and results are still ongoing [10–13].