HEALTH 4.0 PARADIGM LEARNING USING HEALTHTEK VIRTUAL CAMPUS

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Abstract

The HealthTEK project is an open-access virtual training platform designed to provide education on the fundamental concepts of biomedical engineering. The initial focus of the project is to introduce students to the convergence between emerging technologies and the healthcare sector through the exploration of the key principles defining Health 4.0. The first unit of the project, titled *Unit 1: Health 4.0*, focuses on the Industry 4.0 paradigm as applied to healthcare and quality of life, covering a range of topics that provide students with a comprehensive understanding of digital transformation in the healthcare sector. This unit is organized into four core modules, each addressing a key topic within this context. The first module introduces the basic concepts of Health 4.0, providing a solid foundation on the advanced technologies that are reshaping healthcare. The second module focuses on inclusive and user-centered design approaches, particularly the "Design for All" models, which aim to ensure that 4.0 technological solutions are accessible and effective for all individuals, regardless of their characteristics and capabilities. This module emphasizes the importance of creating products and services that are inclusive, efficient, and tailored to the needs of users. The third module explores the most commonly used validation methods for assessing the effectiveness of technological solutions in healthcare. Through this module, students gain a detailed understanding of the validation processes required to ensure the safety, reliability, and effectiveness of technological innovations in the healthcare field. The fourth module focuses on the social impact generated by these technological solutions, analyzing how technology in the healthcare sector can improve the quality of life for patients, as well as raise new ethical, social, and economic challenges. At the conclusion, the unit includes a chapter presenting several case studies. From a methodological perspective, the course integrates a variety of interactive pedagogical resources, such as multimedia presentations, explanatory videos, case studies, recommended readings, and interactive quizzes, designed to assess student progress and ensure the acquisition of key knowledge. All content is structured within a gamification-based learning strategy. This approach promotes autonomous, personalized, and flexible learning, optimizing the educational experience and ensuring that students develop a comprehensive understanding of the fundamental concepts related to Health 4.0 and biomedical engineering.

Keywords: eLearning, Health 4.0, biomedical engineering, asynchronous online teaching, gamification.

1. Introduction

Education and research have long revolved on health, but the incorporation of digital technologies (Tang et al, 2021; Millar et al., 2023; Kumar et al., 2021) in the last several decades has really shifted the focus. Here, for the last three years, work has been steadily progressing on the HealthTEK: Technology for Healthcare education utilizing smart Gamification project.

By delving into the fundamental ideas that make up Health 4.0 (Mateus-Coelho, Cruz-Cunha, & Ávila, 2021), the initiative aims to familiarize students with the growing relationship between healthcare and new technology (Mateus-Coelho, Cruz-Cunha, & Ávila, 2021). Unit 1: Health 4.0 investigates the digital revolution of the healthcare business through the lens of business 4.0 (Bause et al., 2019), providing students with a comprehensive understanding of cutting-edge technologies and their impact on quality of life. This unit is organized into four modules that cover essential aspects of the subject. First, the fundamental foundations of Health 4.0 will be presented, establishing a solid foundation in the technological innovations that are revolutionizing the healthcare sector. Next, inclusive and user-centered design will be analyzed, highlighting the "Design for All" approach, which aims to ensure that technological solutions are accessible and effective for all people, regardless of their abilities. It then examines the

primary validation methods used to evaluate the safety, reliability, and efficacy of various healthcare technologies included in Health 4.0 paradigm. Finally, the societal effect of digitalization in healthcare will be studied, taking into consideration that health 4.0 paradigm is considered as a synonym of "Digital health". The lesson finishes with case studies of computer games for health (Garett, & Young, 2019; Krishnamurthy et al., 2022) that demonstrate the actual application of these principles in a variety of situations, giving students context and a better understanding of what they've learned.

The course includes a virtual approach (Kumar et al., 2021; Leadbeater et al., 2021; Masters et al., 2023) including a range of interactive pedagogical tools, such as multimedia presentations, explanatory videos, case studies, recommended readings, and interactive quizzes, all designed to track student progress and ensure critical knowledge acquisition. All content is grouped around a gamification-based learning approach. This strategy promotes independent, customized, and flexible learning, therefore improving the educational experience and ensuring that students have a solid understanding of the core concepts of Health 4.0 and biomedical engineering.

Unit 1: Health 4.0's content and techniques were evaluated in several European educational institutions, including the University of Deusto (Spain), the ESTIA Institute of Technology (France), Francisco de Vitoria University (Spain), and Bialystok University of Technology (Poland). Student satisfaction was assessed both objectively and subjectively, providing useful information for improving the teaching process and learning experience.

2. Methodology and proposed design

A series of stages has been proposed to facilitate access to and interaction within the platform. The main steps that users must follow to access HealthTEK and make the most of the educational experience are detailed below:

1. **Registration on the Moodle platform that hosts HealthTEK**: The first stage consists of creating an account on the Moodle platform, which is the system that hosts the HealthTEK educational tool. This registration is essential to guarantee that users can access the available content and resources in a secure and personalized way, creating a unique profile that will allow them to interact with the material effectively.
2. **Access to the unit**: Once registered on the platform, users will be able to access the specific learning unit within HealthTEK. This phase involves navigating the platform, where participants will be able to view and begin exploring the Health 4th training unit, which includes documents, videos and gamified learning activities. It is a crucial step in familiarizing themselves with the structure and content of the course or training they have enrolled in.
3. **Assessment of learning outcomes based on gamified activities**: After interacting with the Health 4.0 learning unit, participants will be assessed through gamified activities. This approach aims not only to measure the knowledge acquired, but also to motivate users through game dynamics. The activities are designed to offer continuous and fun evaluation, allowing users to reflect on their progress and performance while learning in an active and interactive way.

The following figures show the content that students will learn in the Health 4.0 unit.

Figure 1. Content of the Health 4.o unit in HealthTEK learning platform.

	Unit 1 Health 4.0
Description This unit presents the basics of the new paradigm of health 4.0.	
Chapters 1.1. Basics of health 4.0 1.2. Design For All and User Centered Design 1.3. Assessment using tests and Social Impact 1.4. Case studies of Computer Games for Health	

Throughout the Health 4.0 unit, a diverse set of content will be presented that will allow students to gain a comprehensive understanding of the key topics within this field. First, the most basic concepts of Health 4.0 will be addressed, offering a detailed introduction to this innovative approach and its application in the field of digital health. Next, two fundamental concepts will be explored: Design For All and User Centered Design, which are essential approaches for the development of accessible technological solutions focused on user needs. These approaches will ensure that students understand the importance of designing products and services that are inclusive, usable and effective for everyone, regardless of their abilities or characteristics. Thirdly, we will discuss how to use standardized tests during evaluations, which will allow students to become familiar with the tools and methodologies that can be used to objectively measure the effectiveness and impact of interventions in the Health 4.0 field. Finally, case studies will be presented that use video games and similar technologies as tools for evaluation and learning, demonstrating how games can be used to analyze and improve the user experience in healthcare contexts.

3. Results

During the learning process, students will be involved in the execution of various fun activities designed to reinforce their understanding and skills in the topics being taught. These activities, which have a dynamic and entertaining approach, are structured in such a way that students can actively participate while reinforcing the knowledge they have acquired. Below are some examples of these fun activities, which are detailed in the following figure, to illustrate how they are integrated into learning. These activities not only seek to teach effectively, but also to provide a fun experience that fosters students' motivation and interest in their educational process.

Figure 2. Range of recreational activities for gamified learning.

To effectively evaluate the usability and accessibility of the contents of the Health 4.0 unit, the SUS (System Usability Scale) and USE (Usefulness, Satisfaction, and Ease of Use) tests were administered to assess how engaging is the environment (Bucholz, 2020). These tests were used to obtain an accurate measurement of the user experience, thus allowing us to know their perception of the usability and usefulness of the educational unit. Through these questionnaires, valuable information has been gathered about users' opinions and suggestions, which has been crucial in identifying areas for improvement. In this way, the feedback received has been carefully considered, with the aim of adjusting and optimizing the content of the unit, guaranteeing a more satisfactory and effective experience for future students.

4. Conclusions

The growing integration of digital technologies in healthcare education and research has redefined the way these fields are approached. In this context, the HealthTEK project: Technology for Healthcare Education Utilizing Smart Gamification has worked for the past three years to develop innovative approaches. Unit: Health 4.0 has shown to be an effective tool for introducing students to the convergence of technology and healthcare with promising results aligned to the new role of technology in medical sciences (Rahman, & Rahman, 2021; Syokumawena, & Jaya, 2022). The knowledge includes the provision of a systematic knowledge through a Health 4.0 unit that covers everything from technological principles to social and ethical implications.

The incorporation of interactive pedagogical strategies and a gamification-based approach has enabled more autonomous, flexible, and personalized learning, facilitating the acquisition of fundamental knowledge in Health 4.0 such as the integration of internet of things, virtual and augmented reality, artificial intelligence, biosignal processing or 3D manufacturing among others applied to health and wellbeing. Furthermore, evaluations of content and technique at several European universities have provided valuable information for the continued improvement of the teaching process. The findings describe a pleasurable and effective educational experience, underlining the importance of continuing to research and improve training in technology applied to the health profession.

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