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HEALTHTEK eLEARNING PLATFORM: AN ONLINE APPROACH TO ON BIOMEDICAL ENGINEERING

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Abstract

Learning-related Bioengineering and Biomedical Engineering are increasingly becoming societal needs and challenges. The study plans for each of these degrees offered by universities allow for a certain specialization in the different sub-areas within biomedical engineering through electives: orthopedics, microbiology, robotics, biosensors, or artificial intelligence applied to clinical data, among others. However, society demands subject knowledge that is not as extensive as that of a degree but is sufficiently complete for the population to be empowered in the field of technologies applied to health and quality of life. The objective of the HealthTEK virtual campus is to design, implement, and validate an eLearning platform focused on open access training in different areas as an introduction to biomedical engineering: Health 4.0, biomechanics, surgical robotics, biosensors, genetics and genomics, anatomy and physiology, and artificial intelligence applied to health and wellbeing. The methodology followed was based on four steps: a) planning a gamified pedagogical strategy, building structures for the educational units; b) designing and implementing units; c) deploying with students/users; d) validation. The methodology included one iteration, adjusting content based on feedback obtained after assessment using SUS and USE standardized tests. An international co-teaching strategy has been implemented, as professors from four different institutions have participated in the co-creation of the content. This allows students to have a more realistic experience of the use of technologies for biomedical applications, but within an international network. The virtual platform presents the units under asynchronous access, which includes the use of gamified activities for both content presentation and evaluation. These stages promote students' active engagement in building the learning content and effectively integrating that knowledge, enabling its later retrieval, use, and transfer.

Keywords: *eLearning, biomedical engineering, asynchronous online teaching, gamification, international co-teaching.*

1. Introduction

Health has consistently been a central focus in education and research, particularly with the integration of digital technologies in recent decades. In this context, the HealthTEK: Technology for Healthcare education using smart Gamification project has been actively advancing over the past three years.

The project aims to establish a virtual campus for students in medicine and medical engineering, facilitating the development and hosting of interdisciplinary modules such as biosensors, data analysis, and artificial intelligence. A key deliverable of the project is a pedagogical manual that provides recommendations for effective teaching strategies, emphasizing gamification and interactive learning approaches (Van Gaalen et al., 2021; Dost et al., 2020; Subhash & Cudney, 2018). The manual underscores the importance of fostering an engaging and enjoyable learning environment while moving away from traditional classroom dynamics, where rigid teacher-student roles are prevalent.

An innovative smart module was developed to evaluate student knowledge acquisition through interactive methods. This module incorporates a time-based escape game with a variety of question types, including multiple-choice (single and multiple correct answers) and true/false formats.

The proposed methods were piloted in several European educational institutions, including the University of Deusto (Spain), ESTIA Institute of Technology (France), Francisco de Vitoria University (Spain), and Bialystok University of Technology (Poland). Student satisfaction was assessed through both quantitative and qualitative methods, providing essential insights for refining the teaching process

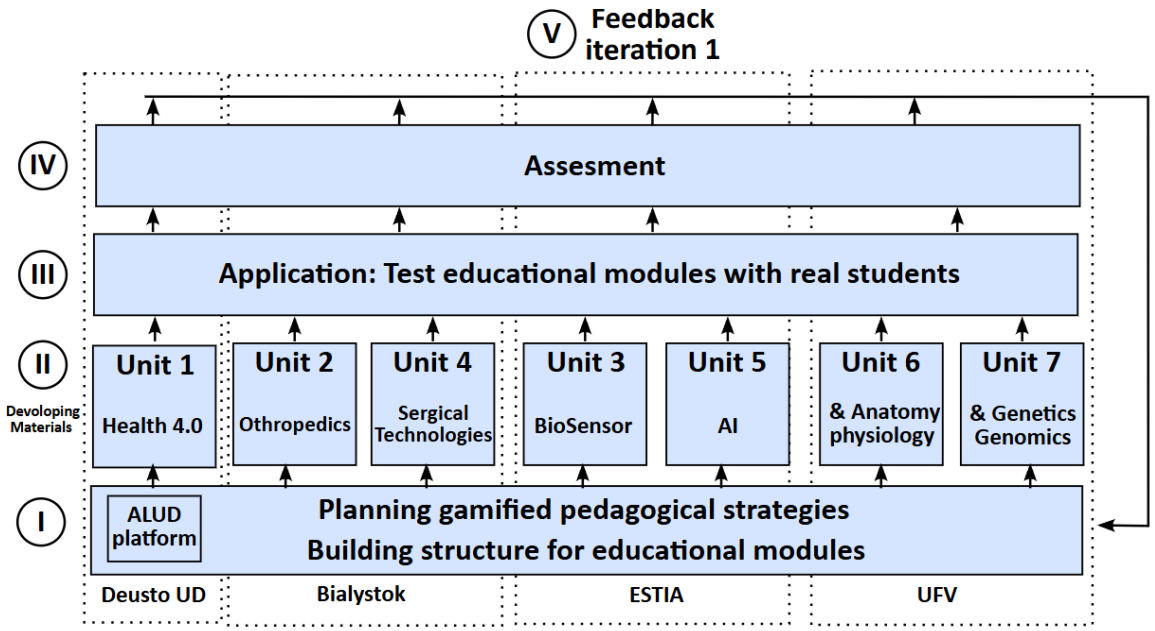
All materials developed through the HealthTEK project, including the pedagogical manual and smart module, are publicly available to educators and institutions, promoting broad adoption and adaptation of these innovative approaches in healthcare education taking as references previous works as Johnson & Patel, 2021.

2. Methodology and proposed design

The diagram of figure 1 outlines a structured process for developing and testing educational modules, focusing on health and medical technologies. It follows a phased approach, from planning to implementation, assessment, and feedback. The process is divided into five key levels: a) Level I: Planning and Structure Building, b) Level II: Developing Educational Materials, c) Level III: Application & Testing, d) Level IV: Assessment, e) Level V: Feedback & Iteration.

The diagram highlights a cyclical approach, where feedback from the assessment stage is looped back into the development process to ensure continuous improvement.

Figure 1. Proposed methodology of the HealthTEK learning platform.



Level I: Planning and Structure Building: this stage focuses on designing gamified pedagogical strategies and building the foundation for educational modules. The ALUD platform plays a key role in supporting this phase. Different institutions (Deusto UD, Bialystok, ESTIA, UFV) contribute to the development of these strategies.

Level II: Developing Educational Materials: Various units (topics) are created, each focusing on a specific area of health technology: Unit 1: Health 4.0, Unit 2: Orthopedics, Unit 3: BioSensor, Unit 4: Surgical Technologies, Unit 5: Artificial Intelligence (AI), Unit 6: Anatomy & Physiology and Unit 7: Genetics & Genomics.

Level III: Application & Testing: The educational modules developed in Level II are tested with real students to evaluate their effectiveness in learning environments.

Level IV: Assessment: This stage involves assessing the impact of the educational modules, gathering data on student engagement and learning outcomes.

Level V: Feedback & Iteration: Based on the assessment, feedback is collected and used to refine the educational modules in an iterative process to improve their effectiveness.

3. Results

The HealthTEK project successfully developed and implemented a virtual campus aimed at revolutionizing healthcare education through gamification. A key output was the creation of the HealthTEK virtual campus itself, a gamified learning platform designed to enhance student engagement and improve learning outcomes. This platform integrated a Moodle-based Learning Management System (LMS) with interactive modules, educational games, and virtual patient simulations. Key features included gamified games such as Clinical Cases Game, Biomedicine Game (an escape room), Genomics Case Game, and a Maze Game designed to reinforce knowledge. The platform emphasized flipped learning, personalized learning experiences, and international collaboration among students.

Regarding the evaluation of the Virtual Campus HealthTEK, we learned from previous experiences (Vaughan & Williams, 2025; Singh & Thomas, 2024) and designed a methodology based on various questionnaires, including the SUS questionnaire, USE questionnaire, and a private questionnaire, were used to gather quantitative indicators related to the assessment of the accessibility and usability of the virtual campus. The virtual campus HealthTEK engaged both staff and students. Indicators defined for this case included the number of students testing the virtual campus, the number of staff using it, and the number of stakeholders reviewing its content. In each category, we achieved a sample size of over 30 participants ("n = 30") for each indicator.

Another significant achievement was the integration of the HealthTEK platform into the academic programs of several partner institutions. Specifically, the platform was incorporated into three official degree programs at the University of Deusto, ESTIA, and Bialystok University of Technology for bioengineering specializations, as well as at the University Francisco de Vitoria and the University of Deusto for medical studies. This integration allowed a diverse group of students to benefit from the innovative teaching methods offered by the platform.

The project also focused on the creation of high-quality educational content. Modules were developed covering a range of topics, including cardiology, biomechanics, genomics, computer-assisted orthopedics, rapid prototyping, and digital radiology. In addition, a dedicated "Health 4.0 Unit" was created, which focused on advanced digital health technologies and included case studies on the application of gamification in healthcare and the improvement of quality of life. Interactive resources such as video tutorials, self-assessment tests, and gamified activities were designed to further enhance autonomous learning.

To support the effective use of the HealthTEK platform, a comprehensive methodological handbook was developed. This handbook provided EU-adapted guidelines for teaching biomedical engineers and doctors using immersive gamification techniques. The handbook served as a valuable resource for educators, ensuring they were equipped to effectively integrate the platform into their teaching practices.

A standout feature of the HealthTEK project was the development of a smart module to personalize suggestions adapted of every student using a gamified activity. This personalized learning system used gamified approach to adapt content to individual student profiles, providing a tailored learning experience. The system incorporated learning analytics capabilities to provide descriptive, predictive, diagnostic, and prescriptive insights into student performance, allowing educators to better understand and support their students' learning journeys.

To ensure the successful adoption of the HealthTEK platform, online practical training sessions were conducted for faculty members from partner institutions but there are still some challenges (Gupta, Sahu, & Sharma, 2020) to face. These sessions familiarized them with the platform's features and methodologies, enabling them to confidently integrate the platform into their teaching.

Dissemination activities played a crucial role in raising awareness and promoting the project's outcomes. Multiplier events were organized to inform the Life Sciences community about the innovative teaching technologies developed within the project. Additionally, publications and conferences were used as platforms to share insights on gamified learning in healthcare education.

4. Conclusions

The HealthTEK project laid the groundwork for long-term impact in the field of life sciences education. By offering virtual campus services to professionals seeking skill upgrades, the project fostered a culture of lifelong learning. It also facilitated the creation of international networks of educators and researchers interested in advancing technology-driven education in life sciences, ensuring the project's impact extends beyond its initial duration.

A gamified learning approach makes education more engaging by incorporating elements like points, badges, and challenges. By turning lessons into interactive experiences, students feel more motivated to participate and progress.

This method encourages a sense of achievement, reinforcing positive learning habits and making the process more enjoyable. Gamification also introduces friendly competition, problem-solving, and storytelling, which help keep learners focused and invested. Additionally, instant feedback allows students to track their growth and make improvements along the way, leading to a more dynamic and effective learning experience.

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