HEALTHTEK:
technology for healthcare education using smart gamification

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Contents

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List of acronims

AI	–	Artificial Intelligence
AR	–	Augmented Reality
AWS	–	Amazon Web Services
CC	–	Communication and Collaboration
DCC	–	Digital Content Creation
DigComp	–	stands for Digital Competence
DigCompEdu	–	Digital Competence of Educators
EMG	–	Electromyography
IDL	–	Information and Data Literacy
LMS	–	Learning Management System
M-Learning	–	Mobile Learning
PS	–	Problem Solving
S	–	Safety
SCORM	–	Sharable Content Object Reference Model
SSC	–	Secure Socket Layer
VPN	–	Virtual Private Network
VR	–	Virtual Reality

Introduction

The project "Technology for Healthcare Education using smart gamification (HealthTEK)" was initiated in February 2022 (https://healthtek.online/). One of the actions of the project concerns the design and development of a Handbook / methodological interactive guide for learning to use the modules. The interactive book consists of games and video presentations already uploaded on the e-platform of the project's website and can contribute to the better exploitation of the interactive boards in the classrooms.

The interactive book is in pdf format, and on her are embedded various digital components with activities e.g. crosswords, quizzes, games, interactive exercises, powerpoint presentations, videos, and other similar sources etc linked with the ALUD platform https://alud.deusto.es/login/index.php. The digital components appear as small pictures on the interactive book. When the cursor is moved on the picture, a pop-up menu opens with all the information of the component (title or kind of the activity e.g. video). When clicking on it, a window opens with the activity and information about it e.g. chapter, lesson, title, guidelines of use etc).

Chapter 1. Digital education

1.1. Introduction to online digital education

Online digital education continually evolves, driven by technological advancements and the need for accessible and flexible learning options. It has become a transformative force in education, catering to diverse learners and opening up new possibilities for knowledge acquisition and skill development [1-3]. Technical and medical universities are facing a shift in their teaching paradigm in medicine and biomedical engineering, that is why the educational process needs to evolve beyond traditional approaches and infuse new tools into the curriculum. The innovative education method can be gamification. Gamified training platforms with games, mobile applications, and virtual patient simulations can be used in biomedical curricula for real-world applications, clinical decision-making, distance training, learning analytics, and swift feedback. Key components include [6, 8, 10, 12]:

a) Digital Content: Course materials, lectures, assignments, and assessments delivered in digital formats.
b) Learning Management System (LMS): Online platforms that manage and organise course content, assessments, and student interactions.
c) Multimedia Elements: Integration of videos, interactive simulations, and other multimedia to enhance engagement.
d) Communication Tools: Discussion forums, chat, and video conferencing for interaction between students and teachers.

Digital education requires different technologies such as Learning Management Systems (LMS) – platforms (Moodle, Canvas, and Blackboard) for course organisation and management. Additionally, video conferencing tools: Zoom, Microsoft Teams, and Google Meet for live interactions are required. Moreover, e-learning tools: Articulate Storyline or Adobe Captivate for creating interactive content should be provided. There are many challenges before digital education. One of them is ensuring both educators and learners are proficient in using digital tools. Maintaining student engagement in an online environment is also difficult to achieve. Finally, addressing connectivity problems, software glitches, and other technical challenges is an important issue. Besides this, digital education has many advantages. First, flexibility allows learners to access materials and participate in courses at their own pace and on their schedule. Secondly, learning can occur from anywhere with an internet connection,

breaking down geographical barriers. Finally, it is cost-effective and reduces the need for physical infrastructure, travel, and printed materials. Future trends in digital education should contain AI-driven adaptive learning systems for personalised education and also immersive experiences for enhanced learning.

1.2. Digital strategies for the education system: gamification

Gamification is a powerful digital strategy that can be applied to the education system to enhance engagement, motivation, and learning outcomes. Here are some digital strategies for incorporating gamification into the education system [4, 5, 8, 11, 13-15]:

a) Both entertaining and educational games and simulations that align with the curriculum. They integrate game mechanics, such as points, levels, and rewards, to motivate students.
b) Interactive Learning Platforms that incorporate gamified elements and include features like leaderboards, badges, and virtual rewards to recognize and motivate student achievements and allow students to track their progress and set personal goals.
c) Time quizzes and challenges with a competitive edge to add a sense of urgency and excitement.
d) Storytelling and narrative elements into the curriculum, making learning more cohesive and engaging.
e) Establish a comprehensive reward system with tangible incentives like virtual badges, certificates, or in-game currency for completing tasks or achieving milestones.
f) Fostering collaboration by incorporating team-based games and challenges to enhance the social aspect of learning.
g) Implementing a robust analytics system to track student progress with feedback on performance and suggest areas for improvement. Using data-driven insights to adapt and personalise the learning experience.
h) Integration with Learning Management Systems. Ensuring that progress, achievements, and rewards are synchronised across platforms for both students and educators.
i) Applying Augmented Reality (AR) and Virtual Reality (VR) to create immersive educational experiences and simulate real-world scenarios relevant to the curriculum.
j) Keeping content fresh and engaging by regularly updating games and challenges to maintain student interest and encourage a sense of continuous improvement and lifelong learning.

When implementing gamification in education, it's essential to strike a balance between entertainment and educational objectives. The goal is to create an environment where students are motivated to learn and can enjoy the process [18, 19].

1.3. Digital infrastructure and technologies in online education

Digital infrastructure and technologies play a crucial role in the success and effectiveness of online education. As technology continues to advance, educators and institutions have access to a wide range of tools and platforms that can enhance the learning experience. Here are key elements of digital infrastructure and technologies in online education [9, 10, 12, 17]:

- Learning Management Systems provide a centralised hub for course materials, assignments, assessments, and communication. They deliver discussion forums, gradebooks, content management, and collaboration tools to facilitate seamless online learning experiences. Examples of such LMS are: Moodle, Canvas, Blackboard, and Google Classroom.
- Video Conferencing and Webinar Tools enable live virtual classes, allowing for real-time interaction between instructors and students. Example of tools: Zoom, Microsoft Teams, and Google Meet.
- E-learning Content Development Tools to create interactive and engaging course content without advanced programming skills. It requires multimedia integration including incorporating videos, quizzes, simulations, and other multimedia elements into lessons (Articulate Storyline, Adobe Captivate, H5P).
- Mobile Learning (m-Learning) makes learning materials accessible on various devices. Students can learn on the go, facilitating flexibility in their study schedules (Edmodo, Kahoot!, Moodle Mobile).
- Virtual and Augmented Reality (VR/AR) provide immersive experiences, especially in fields like science, medicine, and engineering (Oculus for VR, ARKit for AR).
- Communication Platforms facilitate communication and collaboration among students, instructors, and peers. They allow the sharing of documents, presentations, and other files (Slack, Microsoft Teams, Google Workspace).
- Adaptive Learning Systems adapt to individual student needs and progress (Knewton, Smart Sparrow, DreamBox).
- Online Assessment and Proctoring Tools include tools for secure testing and plagiarism detection (ProctorU, Turnitin, ExamSoft).
- Cloud Computing Services provide the infrastructure needed for online education, allowing scalability to accommodate varying numbers of users. Cloud storage facilitates easy access to educational resources and materials (Amazon Web Services (AWS), Microsoft Azure, Google Cloud).

- Data Security and Privacy Measures for communication and data storage (Secure Socket Layer (SSL), Virtual Private Network (VPN), end-to-end encryption).
- Learning Analytics helps to analyse data to gain insights into student engagement, performance, and learning patterns (Learning analytics platforms integrated with LMS).

As online education continues to evolve, integrating these digital infrastructure elements and technologies contributes to a more dynamic and effective learning environment. Institutions should continually assess and update their digital strategies to stay current with technological advancements and best practices in online education.

1.4. European Standards followed in HealthTEK

1.4.1. DIGCOMP

"DigComp" stands for Digital Competence, and it refers to a framework developed by the European Commission to describe the skills and competences individuals need to navigate the digital world effectively. The DigComp framework is designed to be a reference tool for individuals, educators, employers, and policymakers to assess and develop digital competence. The framework is organised into five key areas, each representing a component of digital competence [20-22]:

a) Information and Data Literacy (IDL): This involves the ability to locate, assess, manage, and use digital information efficiently. It includes skills related to searching for information online, critically evaluating sources, and handling data.
b) Communication and Collaboration (CC): This area focuses on the ability to interact, share, and collaborate in digital environments. It includes skills such as effective online communication, collaborative document editing, and participation in online communities.
c) Digital Content Creation (DCC): Digital competence involves the ability to create and edit digital content. This area covers skills related to multimedia content creation, programming, and understanding intellectual property rights.
d) Safety (S): Safety in the digital context encompasses the ability to protect oneself and others from digital threats. This includes understanding cybersecurity, managing online identities, and being aware of privacy issues.
e) Problem Solving (PS): Digital competence also involves the ability to solve problems in digital environments. This includes critical thinking, troubleshooting technical issues, and adapting to new technologies.

DigComp provides a common language and set of reference points for discussions about digital competence across different sectors and countries. It is used to inform the development of educational curricula, training programs, and policies related to digital skills. The framework is not only applicable to formal education but also to lifelong learning, vocational training, and professional development.

1.4.2. DIGCOMPEDU

The European Framework for the Digital Competence of Educators (DigCompEdu) is a framework that describes digital competence for educators in Europe. It is directed towards educators at all levels of education, from early childhood to higher and adult education, including general and vocational education, training, non-formal learning, and special needs education.Here are the key components and principles of the DigCompEdu framework [16, 23]:

a) Areas of Competence:
   - Professional Engagement involves educators actively participating in professional communities, sharing knowledge, and staying updated on digital trends in education.
   - Digital Resources focuses on the ability to create, adapt, and use digital learning resources effectively.
   - Teaching and Learning encompasses the integration of digital technologies into pedagogical approaches and strategies.
   - Assessment involves the use of digital tools for formative and summative assessment.
   - Empowering Learners focuses on fostering learners' digital literacy and critical thinking skills.

b) Competence Levels:
   - Foundation Level – basic use of digital technologies for personal and professional purposes.
   - Intermediate Level – effective and confident use of digital technologies in teaching and learning.
   - Advanced Level – high-level skills enabling innovation and leadership in the use of digital technologies.

c) Professional Development:
   - Recognizes the importance of continuous professional development for educators to enhance their digital competences.
   - Encourages educators to engage in learning opportunities and collaborate with peers to improve their digital skills.

d) Self-reflection and Self-assessment:
   - Emphasises the role of educators in reflecting on their digital competences and engaging in self-assessment.
   - Provides a means for educators to identify areas for improvement and set goals for further development.

e) Integration with other Frameworks:
   - Aligns with other European frameworks, such as the European Framework for Key Competences and the Digital Competence Framework for Citizens (DigComp), to promote consistency and coherence in education.

The DigCompEdu framework aims to guide educational institutions, policymakers, and educators in enhancing digital competences across the European Union. It serves as a reference for the development of professional development programs, curriculum design, and the evaluation of educators' digital skills.

1.4.3. LMS

"LMS" typically stands for Learning Management System. A Learning Management System is a software application or web-based technology that provides a platform for managing, delivering, and tracking educational courses and training programs. LMS platforms are widely used in educational institutions, businesses, and other organisations to streamline the administration and delivery of learning content. Key features of Learning Management Systems include [21]:

a) Course Management:
   - Creation, organisation, and management of course content.
   - Assignment of learning materials, assessments, and activities.

b) User Management:
   - Registration and management of users, including students, instructors, and administrators.
   - User authentication and role-based access control.

c) Content Delivery:
   - Delivery of course materials, including text, multimedia, and interactive elements.
   - Support for various file formats and content types.

d) Assessment and Grading:
   - Creation and administration of quizzes, tests, and assignments.
   - Automated grading and tracking of learner performance.

e) Communication and Collaboration:
   - Discussion forums, messaging, and collaboration tools for interaction among learners and instructors.
   - Announcements and notifications to keep users informed.

f) Reporting and Analytics:
   - Tracking and reporting on learner progress, performance, and engagement.
   - Data analytics to assess the effectiveness of courses.

g) Integration with other Systems:
   - Integration with external tools and systems, such as video conferencing, authentication systems, and third-party applications.

  - Compatibility with standards like SCORM (Sharable Content Object Reference Model) for interoperability.

h) Mobile Compatibility:
  - Accessibility on various devices, including smartphones and tablets.
  - Responsive design for optimal viewing on different screen sizes.

i) Security and Data Privacy:
  - Secure storage and transmission of user data.
  - Compliance with data protection regulations and industry standards.

Popular Learning Management Systems include:

- Moodle: An open-source learning platform widely used in educational institutions.
- Canvas: A cloud-based LMS known for its user-friendly interface.
- Blackboard: A well-established LMS offering a range of educational tools.
- Google Classroom: Part of Google Workspace, designed for classroom collaboration.
- Microsoft Teams: Integrated with Microsoft 365, providing collaboration and educational features.

LMS platforms are essential for online and blended learning environments, offering a centralised hub for course management, content delivery, and learner interaction. They are valuable tools for educators, trainers, and administrators in facilitating effective and efficient learning experiences.

1.5. Summary

The integrated handbook is a methodological interactive guide for learning to use the developed modules and virtual campus, adapted to EU requirements following DIGCOMP and DigCompEdu standards and LMS systems. The handbook is a reference for using gamification. Audio, and video recordings, interactive collaborative places, book chapters, AI systems, etc in innovative ways were elaborated.

Chapter 2. HealthTEK – student's manual

2.1. Why is it worth using HealthTEK eLearning Platform with ALUD?

Currently, the health sciences sector is experiencing some difficulties in adapting to virtual education. The idea behind HealthTEK is to establish a "**Virtual Campus**" including a set of courses for "**Life and Health sciences and Technology**" addressed to **biomedical engineers and medicine students**.

The project of the virtual campus HealthTEK works around **4 ideas: gamified immersion, flipped learning, internationalization at home and personalized learning.** The gamified training platform will therefore include education games, biomedical mobile applications, and virtual patient simulations (Fig. 2.1).

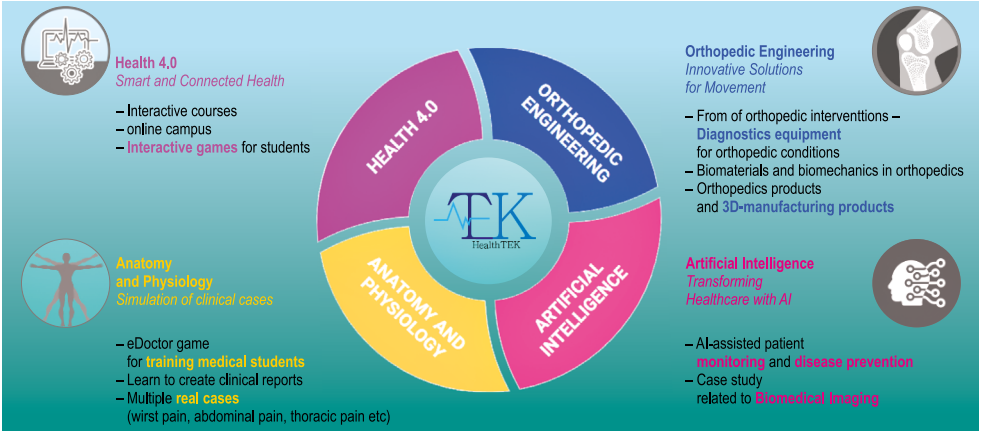


FIG. 2.1. The HeealthTEK platform

Some of the **reasons** to use the platforms are:

- **Gamified Experiences:** HealthTEK employs gamification, making learning more **engaging and interactive**. Gamified elements can enhance motivation and participation among students, making the learning experience enjoyable.
- **Global Accessibility:** HealthTEK promotes **internationalization** by allowing students to access the course globally and collaborate with peers from around the world without leaving their home institutions. This fosters a more **diverse and enriched** learning experience.

- **Customized Learning Paths:** the platform supports **personalized learning**, enabling students to progress at their own pace.

By combining gamification, global accessibility, personalized learning, and technology integration (ALUD, VR), HealthTEK aims to create a **complete and effective eLearning platform** for health sciences education.

2.2. Login

1. Search the following **webpage**: **https://alud.deusto.es/login/index.php** (Fig. 2.2)

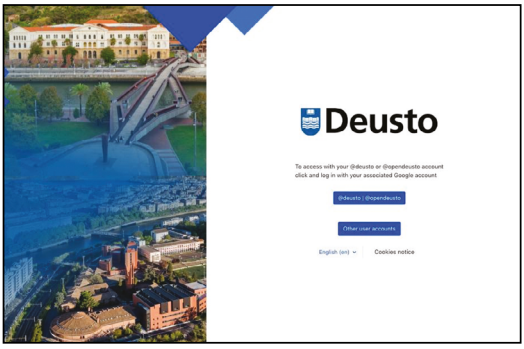


FIG. 2.2. The webpage of ALUD platform

2. **Log in** and access alud webpage using the generic account provided
3. Search the **course** "HealthTEK – Health 4.0" and access it (Fig. 2.3)

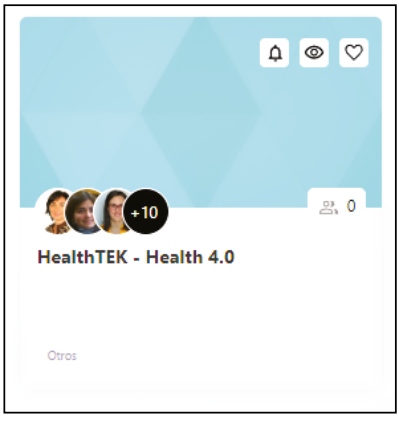


FIG. 2.3. The course HealthTEK- Health 4.0

4. Inside of it you will find the different **units and content** of the course

2.3. HealthTEK eLearning Platform's navigation

The HealthTEK course is made up of 7 units, each with a different topic. Below is a list of each unit with information on what you will learn in each one (Fig. 2.4).

FIG. 2.4. The list of units of the HealthTEK course

On the left side there is a navigation menu where you can access every unit. Within each unit there are different contents separated according to whether they are readings, videos or contents for the user to perform such as games or tests. Below is a list of each unit with information on what you will learn in each one (Fig. 2.5–2.11).

	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	

FIG. 2.5. The list of unit 1 content

	**Unit 2** **Engineering applied to orthopaedics as an example of the use of biomechanics and biomaterials**
Description A brief exploration of engineering applied to orthopaedics. As an example of the use of biomechanics and biomaterials.	
Chapters 2.1. Basics of foot biomechanics 2.2. Basics of foot assessments 2.3. Diagnostic equipment for foot orthopaedic condition 2.4. Orthopaedic foot supplies	

FIG. 2.6. The list of unit 2 content

	**Unit 3** **Biosensors and medical devices**
Description Analytical devices that convert a biological response into an electrical signal.	
Chapters 3.1. Introduction to biosensors 3.2. Medical Monitoring Devices 3.3. Sensor Application in Medicine 3.4. Use Case: Temperature Sensors	

FIG. 2.7. The list of unit 3 content

	**Unit 4** **Surgical technologies**
Description Exploring a broad spectrum of tools, instruments, and techniques that empower surgeons to perform intricate surgeries with precision, speed and safety.	
Chapters 4.1. Surgical Instruments 4.2. Biomaterials for surgical instruments 4.3. Care and handling of surgical Instruments 4.4. Instrument configuration on tissue	

FIG. 2.8. The list of unit 4 content

	Unit 5 Artificial Intelligence and health
Description Providing students with the understanding of different use cases of AI applied to healthcare and of the pipeline for a machine learning project (hands-on lab).	
Chapters 5.1. Introduction 5.2. Basics of Artificial Intelligence (AI) applied to health 5.3. Case study with Electronic Healthcare Records 5.4. Case study related to Biomedical Imaging	

FIG. 2.9. The list of unit 5 content

	Unit 6 Anatomy and physiology
Description Anatomy course about patient interactions and exams for wrist and chest pain scenarios.	
Chapters 6.1. Basics of the interaction with a patient with wrist pain: medical history 6.2. Physical examination in a simulated real case of wrist pain 6.3. Basics of the interaction with a patient with chest pain: medical history 6.4. Physical examination in a simulated real case of chest pain.	

FIG. 2.10. The list of unit 6 content

	Unit 7 Genetics and Genomics
Description Fundamentals of genomics	
Chapters 7.1. Fundamentals of molecular genetics 7.2. Structural genomics 7.3. Mapping variation 7.4. Functional genomics	

FIG. 2.11. The list of unit 7 content

2.4. Pedagogical strategies

Students are expected to work independently without interacting with a professor. The learning method insists on the following concepts:

- **Autonomy**: the course is designed to enable the student to work independently without the need of the professor to start the learning process. This implies the existence of sequential achievable goals that students can be reached autonomously with a reasonable amount of effort.
- **Encourage research and exploration**: Although the course provides a complete set of information for students that helps satisfy the learning outcomes, intentionally, the course is designed in a way that supports students to do further research to extend the obtained knowledge, especially in the practical part, which deliberately forces the students to search beyond what they got in the theoretical part.
- **Learning through play**: also called Learn & play, a type of learning that uses gamification to perform the learning process. The techniques used eliminate the classical classroom concept, where a teacher is indoctrinating students. Instead, it creates a playing environment where students can learn voluntarily and actively engage in activities that include both learning skills and pleasurable moments. In this system, the role of the teacher is to guide the game and help students complete the challenges they have.

2.5. Gamification in HealthTEK

HealthTEK has several gamified games with which you can learn different **aspects related to biomedicine and medicine** in general. These are:

- **Clinical Cases Game:** in this game you play the **role of a doctor** and you need to create a **medical report** for patients with different pathologies.
- **Biomedicine Game:** this is an **escape room game** for biomedical engineering students. In this game you need to solve different puzzles that will help you acquire knowledge about **real case biomedical projects made by eVida**.
- **Lud Game:** the goal of this game is to explore the concept of Health 4.0. To do this, you will be able to play **two games.** The first one involves **guessing a Health 4.0 project** from a list of options. The second one involves **building a solution** based on a problem.
- **Genomics Case Game:** this game simulates a **real case** in which a patient has **high cholesterol**. Your objective is to determine whether or not this patient can take the drug simvastatin. To do so, you must perform a **genetic analysis** before you can prescribe or not prescribe the drug.
- **Maze Game (ESTIA):** this game tasks players with navigating a labyrinth of rooms, **answering multiple-choice questions** to progress. It is aimed for students to **practise knowledge**. There's a 1-hour time limit with 30-40 questions. Points are earned

for correct answers, with bonuses for speed and streaks, but wrong answers result in penalties. The aim is to escape the labyrinth with a high grade.

To **install** these games you will need to follow the steps below:

1. First of all you must have a computer with **Windows** installed.
2. Go to the following **website**: **https://healthtek.evidagroup.es**
3. Inside you will see a section below with a list of **available games** (Fig. 2.12). For each one you can use the "**Download**" button to download the game installer and the "**User Guide**" button to download the user and installation guide for each game.

FIG. 2.12. The list of games

These games are **also accessible within ALUD** in the section that corresponds to each topic they deal with. Inside ALUD you will see the instructions to follow in order to download and play each game in the same way as on the web. There is also a section where you can create a user account to access the data of the games you have played.

To create an account you will need to provide a **username and password.** This account can be used for all HealthTEK games (Fig. 2.13).

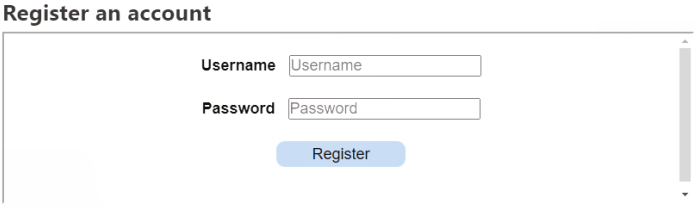


FIG. 2.13. Register an account

In the "**Game Results**" section you will be able to log in with the account you created to see the **score** obtained within the games (Fig. 2.14).

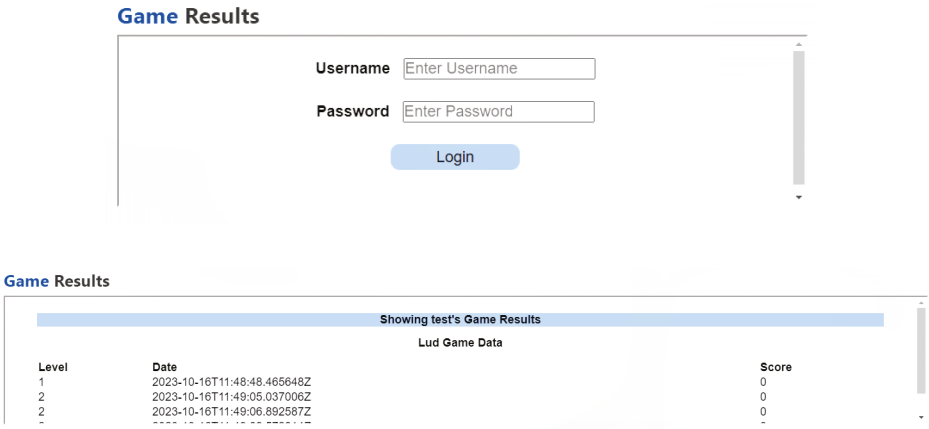


FIG. 2.14. Game results

2.6. Summary

ALUD is a virtual learning HealthTEK platform with online courses, that supports learning and enables communication with participants. The platform is flexible and allows for the creation of interactive courses, publish teaching materials, links to resources, videos, images, online meetings, etc. It makes it possible to monitor students knowledge and skills. The platform works around four ideas: gamified immersion, flipped learning, internationalization at home, and personalized learning. It includes a set of courses for "Life and Health Sciences and Technology" addressed to biomedical engineers and medicine students.

Chapter 3. Courses of the module Introduction to Biomedical Engineering

Below (Fig. 3.1) you will find a video in which we explain the different parts of the unit and the materials you will have available to succeed in it.

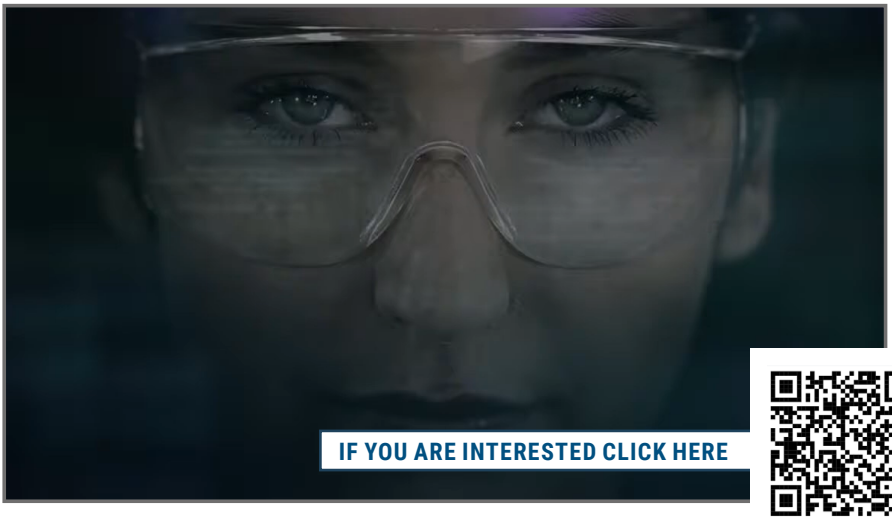


FIG. 3.1. Introduction to Unit 1

3.1. UNIT 1: Health 4.0

3.1.1. Introduction

This unit covers the principles of Health 4.0 approach based on the paradigm of Industry 4.0. In order to explain basics of the model, methodologies used for the design and validation and case studies, we have created different pedagogical resources including gamification.

The implementation of Health 4.0, which involves the integration of advanced digital technologies in the health sector, offers a number of significant advantages for citizens. Some of these benefits include:

- Improved access to healthcare: Health 4.0 facilitates access to healthcare by enabling virtual consultations, telehealth and telemedicine. This is especially beneficial for people living in remote areas or with mobility limitations.
- Faster and more accurate diagnosis: Advanced diagnostic technologies, such as artificial intelligence and big data analytics, can help healthcare professionals detect diseases faster and more accurately, which can improve outcomes for patients.
- Personalisation of medical care: Health 4.0 allows for more personalised medical care, using individual health data to adapt treatments and medical recommendations to the specific needs of each patient.
- Improved health management: Health tracking apps and devices can help people to monitor their health status and adopt healthier lifestyle habits, which can prevent disease and improve the management of chronic conditions.
- Cost reduction: If implemented effectively, Health 4.0 can help reduce costs associated with healthcare by streamlining processes, preventing illness and avoiding unnecessary hospital visits.
- Increased efficiency in healthcare: Automation of administrative and clinical tasks can improve efficiency in healthcare, allowing healthcare professionals to spend more time interacting with patients and delivering higher quality care.

In short, Health 4.0 has the potential to positively transform healthcare by improving access, accuracy, personalisation and efficiency of healthcare services.

3.1.2. Structure

Chapter 1.1 will introduce the history of Industry 4.0 and how it can be applied to healthcare. Chapter 1.2 will discuss participatory and inclusive methodologies that include both design for all and user-centred design and validation. Then, with the validation of systems in mind, different standard tests for usability and accessibility of technology as well as for assessing quality of life are presented in Chapter 1.4. Finally, some case studies of examples of the use of computer games for health and quality of life issues will be described in Chapter 1.4.

The contents of the unit has been structures as follows (Fig. 3.2–3.6):

	**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	

FIG. 3.2. The content of unit 1

	**Unit 1** **1.1. Basics of health 4.0**
Chapter description This chapter will introduce the history of Industry 4.0 and how it can be applied to healthcare.	
Resources • Presentation • Basics of Health 4.0 • Readings • Healthcare 4.0: trends, challenges and research directions, Production Planning & Control • Industry 4.0 and Health: Internet of Things, Big Data, and Cloud Computing for Healthcare 4.0 • Artificial Intelligence and Internet of Things Based Healthcare 4.0 Monitoring System • Impacts of Healthcare 4.0 digital technologies on the resilience of hospitals • Videos • Assessments • Further resources to deepen	

FIG. 3.3. The content of subunit 1.1

	**Unit 1** **1.2. Design For All and User Centered Design**
Chapter description In this chapter students will learn about participatory and inclusive methodologies that include both design for all and user-centred design and validation	
Resources • Presentation • Design for all and user centered design • User centered design • Readings • Designing Inclusion and Exclusion Criteria • Videos • Assessments • Further resources to deepen • CTN Webinar: Impact of Inclusion and Exclusion Criteria on Study Enrollment • Card Game	

FIG. 3.4. The content of subunit 1.2

	**Unit 1** **1.3. Assessment using tests and Social Impact**
Chapter description This chapter presents validation of systems in mind, different standard tests for usability and accessibility of technology as well as for assessing quality of life.	
Resources • Presentation • Basics of assessments tests • Social impact and sustainable goals • Readings • Handbook for Key Steps and Considerations in the Design of Technology Assessments • Videos • Quizz • Quiz about Questionnaires • Quiz about lab testing and Final Trials • Assessments • Further resources to deepen • Game parkour	

FIG. 3.5. The content of subunit 1.3

	Unit 1 **1.4. Case studies of Computer Games for Health**
Chapter description This chapter describes case studies of examples of the use of computer games for health and quality of life issues.	
Resources • Presentation • Case of study of frAAgiLe project • Living labs • Case studies of computer games for health • Readings • Abbreviated mental test score – Detection of frailty and indicators • COMPLEMENTARY Quality in Biomedical Engineering • Videos • Assessments • Further resources to deepen • Game Escape Room • Maze Game • Virtual reality	

FIG. 3.6. The content of subunit 1.4

3.1.3. Gamification related to health 4.0

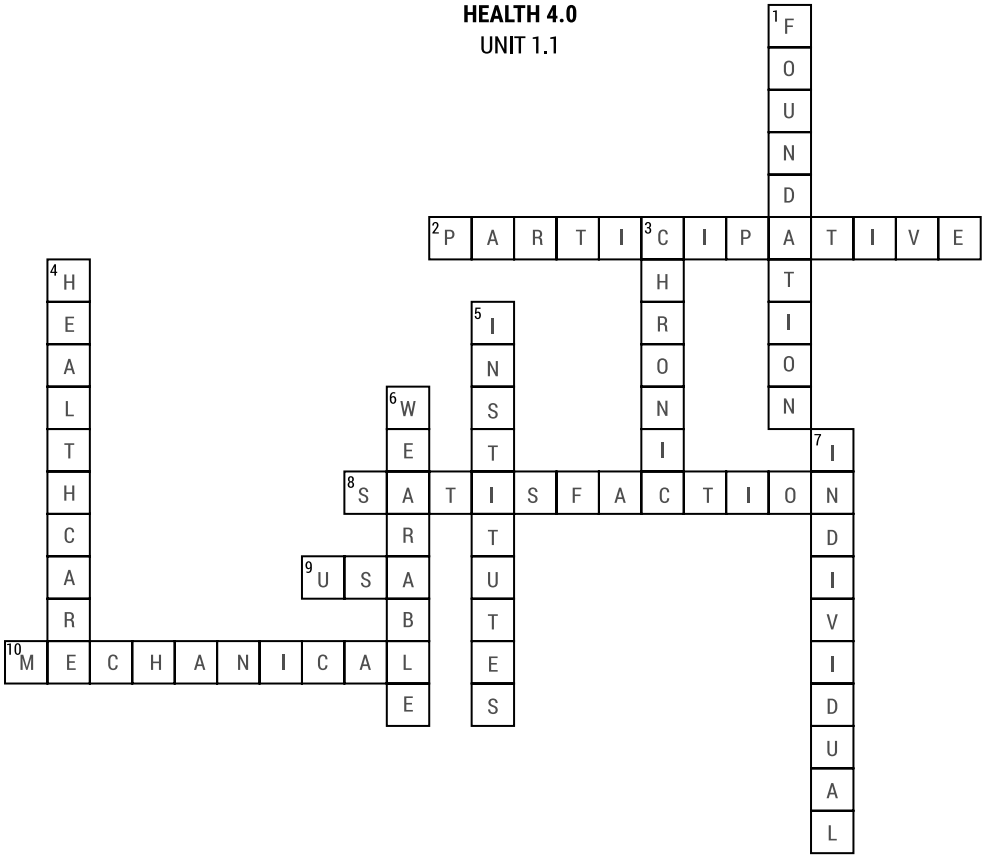
Gamification has been used in this unit taking advantage of 2 tools:

a) **Games h5p**

H5P is an open source tool for creating interactive content for websites and learning platforms. When combined with gamification, H5P can be a powerful tool for making learning activities more engaging and effective. Here are some ways in which H5P can help gamify learning activities:

1. Interactive quizzes: H5P offers different types of interactive quizzes, such as multiple choice, true/false, short answer questions, etc. These quizzes can be used to assess the learner's knowledge in a more interactive and entertaining way.
2. Word games: H5P allows the creation of word games such as crossword puzzles, word searches and riddles. These games can help reinforce vocabulary and key concepts in a playful way.
3. Simulations and hands-on activities: By using H5P's functionality to create simulations and hands-on activities, students can apply their knowledge in simulated situations, allowing them to learn by doing.
4. Scores and leaders: H5P allows scoring systems and leaderboards to be added to learning activities, motivating learners to compete with each other and improve their results.

5. Rewards and challenges: Course designers can use H5P to add virtual rewards, badges and challenges to learning activities, encouraging learner participation and engagement.
6. Narrative and progression: By creating learning activities that follow a narrative or progression of levels, learners can feel more immersed in the learning experience and be more motivated to progress.



HORIZONTALS

2. What is the 4P Model referring to Predictive. Preventive. Personalized and…?
8. A measure of the extent to which a patient is content with the healthcare they received.
9. In which country is the 'Smart and Connected Health' program located?
10. In How is Industry 1.0 from 1750 described as?

VERTICALS

1. What does the "F" in NSF stand for?
3. A disease that is persistent or long-lasting in its effects
4. Provision of medical services to maintain, restore. or enhance health,
5. What does the 'I' in NIH stand for?
6. Electronic device that can be worn as an accessory, embedded in clothing, implanted in the users body, or even tattooed on the skin.
7. In what level is Health 4 0 having an impact on clients and employees?

FIG. 3.7. The example of interactive tool based on h5p

In summary, H5P offers a variety of interactive tools that can be used effectively to gamify learning activities, making the knowledge acquisition process more fun, motivating and effective for learners. This unit contains some examples based on h5p to help the learning of the content in a fun way. One example is the following (Fig. 3.7):

b) **Games**

This unit contains different gamified activities that are described in next paragraphs.

b1) **Parkour Game**

In this game the user must go through a typical platformer scenario jumping and moving using different powers such as double jump or dash while completing a series of puzzles to reach the goal (Fig. 3.8). Each of these puzzles contains a test to detect the fragility of people with different physical and cognitive problems such as Alzheimer's disease. The objective is that the user knows the different types of tests available to detect these problems.

As can be seen in the following image, the player must go through a series of platforms jumping between them to reach the goal while performing a series of puzzles on different cards.

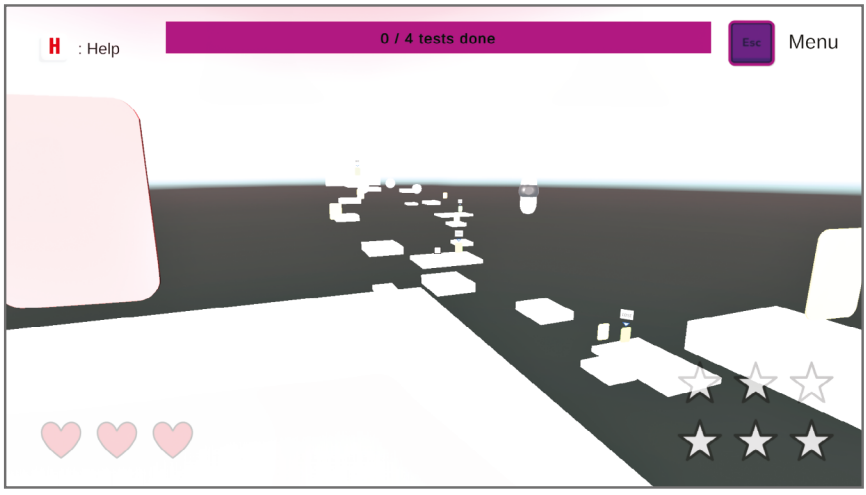


FIG. 3.8. Parkour game

In the following image you can see how one of the puzzles looks like (Fig. 3.9). To solve it the user must arrange three parts of a page (moving and rotating each part of the page) to form the correct page according to the clue given. In this case you have to find the page that corresponds to the test to detect diseases such as Alzheimer's disease.

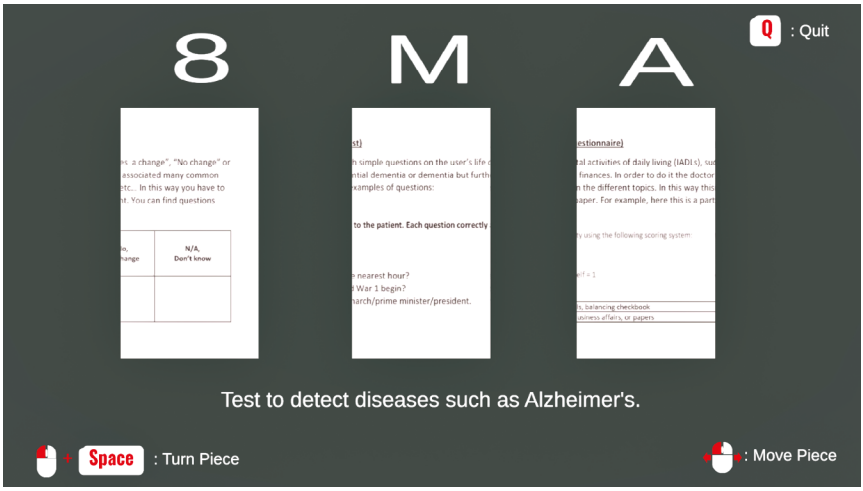
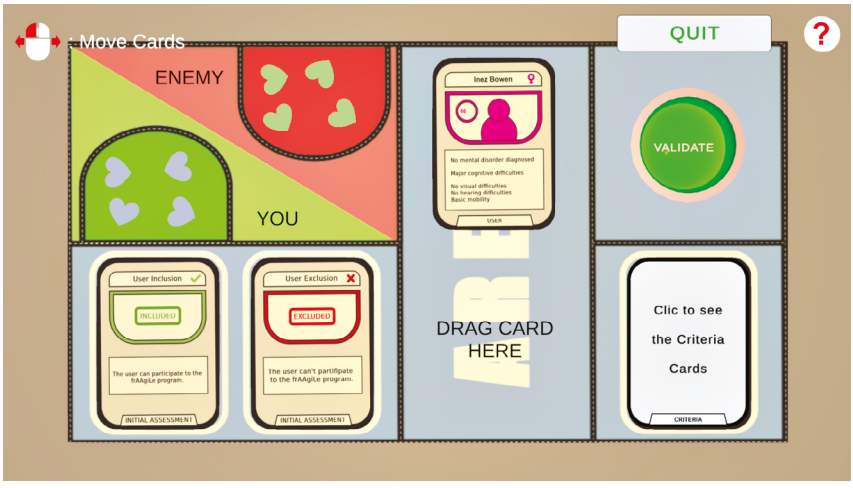


FIG. 3.9. Parkour game-test to detect diseases such as Alzheimer's

b2) **Card Game**

In this game users must determine if a user is suitable to participate in the frAAgiLe program. To do this the player must first read the characteristics of each user such as age, sex and cognitive and physical problems they present. Based on this and a series of criteria specified in the game should determine whether or not the user can be ncluded in the program for cognitive and physical rehabilitation known as frAAgiLe.



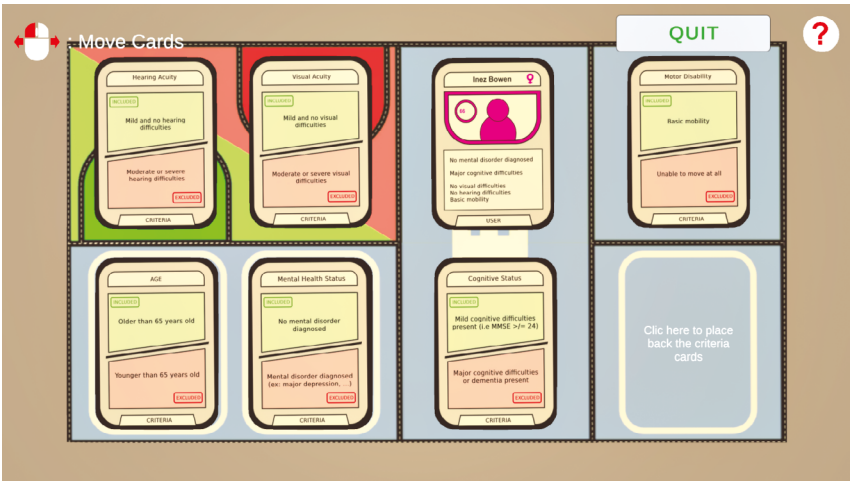
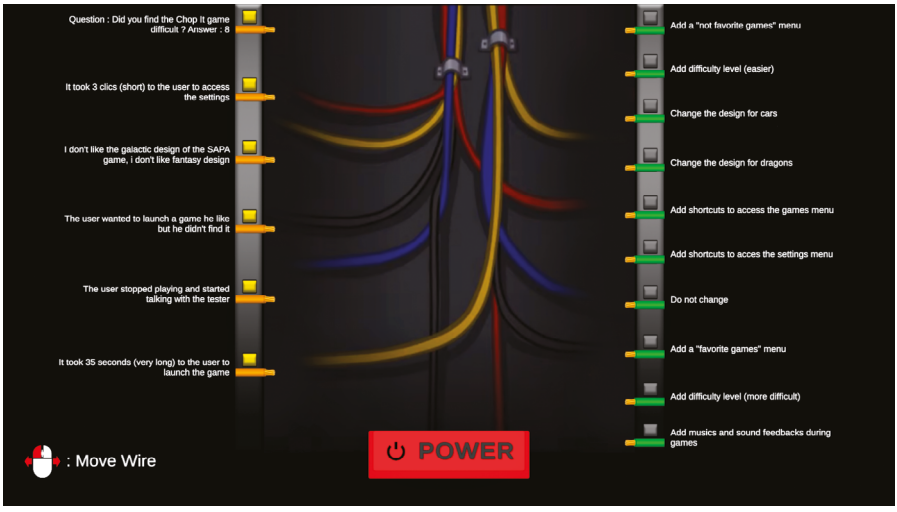


FIG. 3.10. Card game

b3) **Escape Room Game**

In this game (Fig. 3.11–3.12) the player must solve a series of puzzles in different rooms in order to get out, thus simulating a traditional Escape Room. Each of these rooms represents a part of the frAAgiLe platform creation process, such as the brainstorming phase, the selection of consortium participants, the design and implementation of the software and hardware solution and the tests with real users.

FIG. 3.11. Escape Room Game



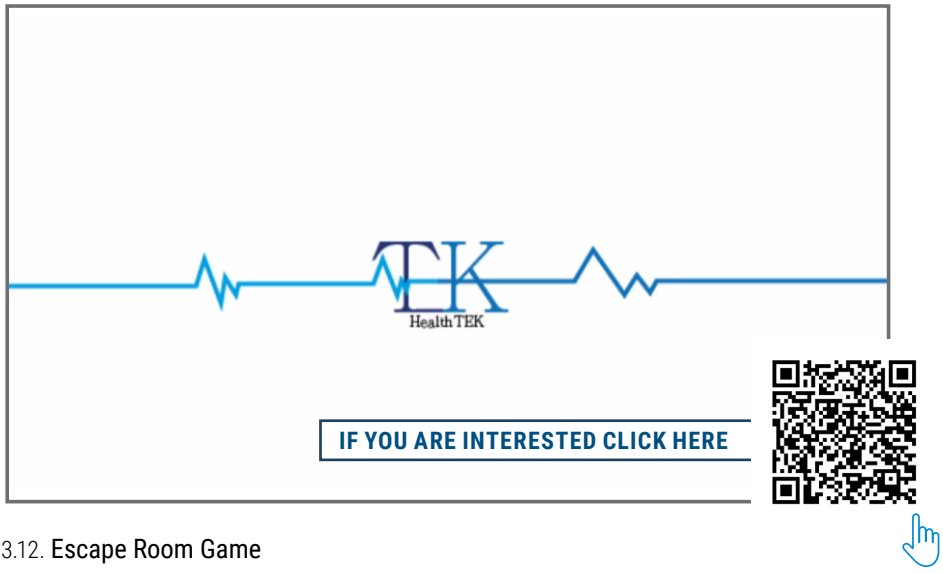


FIG. 3.12. Escape Room Game

3.2. UNIT 2: Introduction to Engineering applied to orthopaedics as an example of the use of biomechanics and biomaterials

Below (Fig. 3.13) you will find a video in which we explain the different parts of the unit and the materials you will have available to succeed in it.

FIG. 3.13. Introduction to Unit 2

3.2.1. Introduction

Biomechanics and biomaterials play a crucial role in orthopaedics. Biomechanics helps in understanding the mechanical behavior of the musculoskeletal system, such as how bones, muscles, and ligaments respond to various forces. This understanding is vital for developing implants, prosthetics, and treatment strategies for orthopaedic conditions. On the other hand, biomaterials are used to design implants and devices that can integrate seamlessly with the body, providing mechanical support and promoting healing. In orthopaedics, these materials are essential for joint replacements, fracture fixation, and tissue engineering. The combination of biomechanics and biomaterials has significantly advanced the field of orthopaedics, leading to improved patient outcomes and quality of life.

Unit 2 is entitled: "Engineering applied to orthopaedics as an example of the use of biomechanics and it can be followed by both engineering and medical students with no specific prerequisites. The most suitable audience for this course is students in the first year in both domains. However, the course can also be introduced to students in the 2nd year. Students who follow the course assumably have:

- Basic English level required in Academia,
- Information Technology equipment, notably a desktop computer, laptop, or tablet.
- Access to the Internet.

After following this course, the student is expected to earn the following learning outcomes:

- Understand the importance, and usage of orthopaedic engineering.
- Understand the importance, usage, and general structure of the design and evaluation of implants used in orthopaedic surgery;
- Understand the importance, and usage of monitoring systems in the human body apparatus assessment.

In the following sections, Unit 3 will be discussed in terms of structure, method, and gamification.

3.2.2. Structure

The unit is divided into 4 chapters, Table 1 shows the syllables:

- **Chapter 1** – Basics of foot biomechanics: the study of the structure and function of the foot, particularly how it moves and distributes forces during various activities. Key concepts in foot biomechanics include understanding the different bones, joints, muscles, and ligaments of the foot, as well as the dynamic interactions between them. One important aspect is the analysis of foot mechanics during gait (walking).

- **Chapter 2** – Basics of foot assessment: An overview of methods for assessing the foot such as observation, physical examination, Range of Motion and Strength Tests, Gait Analysis, and Diagnostic Imaging.
- **Chapter 3** – Diagnostic equipment for foot orthopaedic condition: This chapter dives deeper into several diagnostic tools and equipment used in foot orthopaedics such as Gait Analysis Systems, Podoscope, Foot Pressure Measurement Systems, Electromyography (EMG).
- **Chapter 4** – Orthopaedic foot supplies: The chapter focuses on Orthopaedic foot supplies and refers to a wide range of products used in the treatment and management of foot and ankle conditions. These supplies include: Orthotic Devices, Footwear, etc.

Each of the previously mentioned chapters includes three main parts:

- **Theoretical part:** where students are expected to obtain knowledge on the addressed subject, starting with, but not limited to, a slide deck. Each slide deck is supported with a set of further reading references so that the students can extend their knowledge on a specific point if needed.
- **Written part:** where students have to answer a set of questions, in a written form. The objective of this part is to draw the attention of the students to the section of the theoretical part that is most important. Since there is no teacher in the classroom to refer to those sections, insisting is performed indirectly via the written questions.
- **Practical parts:** where students will play a game to value their understanding of the subject. The game includes hidden and indirect tests for the obtained knowledge. The games are designed to allow the students to pause the advance, search for specific course-related pieces of information, and then advance again in a way that is visual to everyone else to create a competitive atmosphere on who can finish first.

TABLE 3.1. Outlines of the course 1

1. Basics of foot biomechanics	**3. Diagnostic equipment for foot orthopaedic condition**
1.1. Foot structure	3.1. Podoflash
1.2. Foot functions	3.2. Pressure mats
1.3. Foot biomechanics	3.3. Pressure insoles
1.4. Foot during gait	3.4. Force plates
1.5. Abnormal foot deformities	3.5. Instrumented gait analysis
2. Basics of foot assessment	3.6. Electromyography (EMG)
2.1. Foot classification	**4. Orthopaedic foot supplies**
2.2. The methods of foot assessment	4.1. Orthopaedic product division
2.3. Foot arches	4.2. Foot orthosis
2.4. Anthropometric measurement	4.3. Foot insoles
2.5. Biomechanical foot assessment	4.4. Foot shoes
	4.5. Exercises and surgical treatment

Chronologically, students are expected to spend 50% of the allocated time on the theoretical part, 20% on the written part answering questions, and 30% on the practical part playing the games. However, due to the autonomous nature of the unit, these expectations may not be respected completely as intended form the participants.

3.2.3. Gamification

An example of gamified content is shown highlighting the pedagogical goals of each. Figure 3.14 shows a crossword example used in the written part. The game objective is to find the correct answer.

Question	Possible answers	Correct answer
Which of these is not one of the subfields of biomechanics?	Cardiovascular, Nuclear, Forensic Biomechanics	Nuclear
Biomechanics deals with which of the following?	Force Motion Balance & stability, All of these	All of these

FIG. 3.14. Example of a crossword game

3.3. UNIT 3: Introduction to BioSensor

Below (Fig. 3.15) you will find a video in which we explain the different parts of the unit and the materials you will have available to succeed in it.

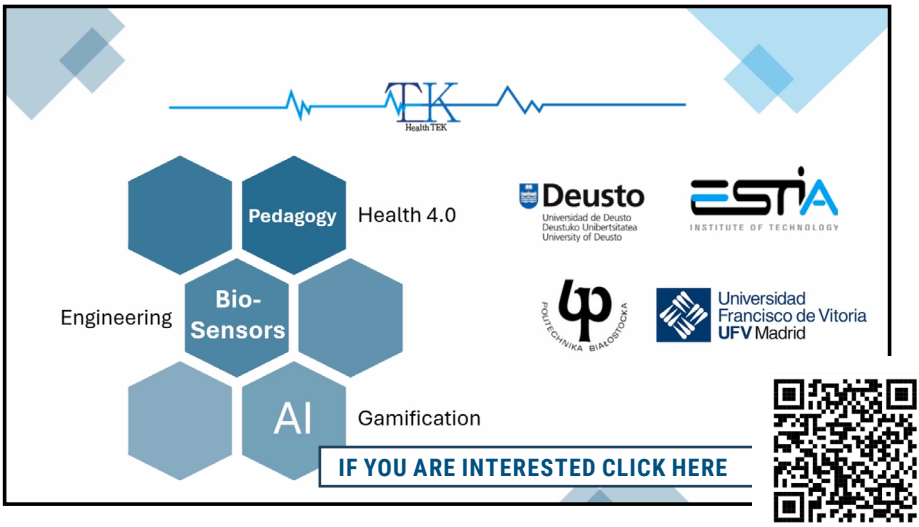


FIG. 3.15. Introduction to Unit 3

3.3.1. Introduction

Sensors are a major pillar in Health 4.0. They are essential for any smart machine to collect data on its environment in order to understand its conditions before making any decisions or performing action. However, In the medical domain, there are more restraints, starting from the need to protect the privacy of the patients and not ending the high accuracy level needed.

Unit 3 is entitled: "Introduction to BioSensors", it is designed as an entry-level course. It can be followed by both engineering and medical students with no specific prerequisites. The most suitable audience for this course is students in the first year in both domains. However, the course can also be introduced to students in the 2nd year.

Students how follow the course are assumably having:

- Basic English level required in Academia,
- Information Technology equipment, notably a desktop computer, laptop, or a tablet.
- Access to the Internet.

After following this course, the student is expected to earn the following learning outcomes:

- Understand the importance, usage, and general structure of the human-machine interface (HMI).
- Understand the analogue nature of the surrounding environment and environment, the digital nature of the pressing, and be able the justify the need for the conversion.
- Understand the use of monitoring systems in the medial domain and be able to analyse the structure of the system.
- Understand the structure of the monitoring system and be able to evaluate the human factor influence at the interface of the system and the electronic nature of the system at the micro-level.

In the following sections, Unit 3 will be discussed in terms of structure, method, and gamification.

3.3.2. Structure:

The unit is divided into 4 chapters, Table 2 shows the syllables:

- **Chapter 1** – Introduction to Biosensor: a general introduction that highlights the bidirectional interactions between humans and machines as well as the need to convert signals between the analog and the digital domains. The chapter also covers the different perspectives of the human body, e.g. physical and chemical
- **Chapter 2** – Medical Monitoring Devices: An overview of monitoring devices used in the health domain. Mainly, comparing the classical in-clinic monitoring systems to the remote monitoring systems highlighting the use of new emerging

technologies. The chapter also provides several examples of monitoring devices such as spirometers and glucometers explaining when to use them and where on the human body.

- **Chapter 3** – Sensor application in Medicine: This chapter dives deeper into monitoring devices to show the importance of sensing technology. The process is achieved through two use cases: Blood pressure and Body Temperature, each will be highlighted determining what to measure using sensors and how.
- **Chapter 4** – Temperature Sensors: a use case study of temperature sensors in the medical domain. The chapter focuses on the components used to measure human temperature from an electronic perspective, and shows several techniques used to perform that.

TABLE 3.2. Outlines of the course 2

1. Introduction to Biosensor 1.1. Human: a biological Ecosystem: 1.1.1. Biochemical perspective 1.1.2. Physical perspective 1.1.3. Electrical perspective 1.2. Human-Machine interaction: 1.2.1. Human-to-machine: Control 1.2.2. Machine-to- Human: Sensory 1.3. Sensory process: A/D converting **2. Medical Monitoring Devices** 2.1. Medical Monitoring & its purposes 2.2 Classification of medical devices 2.3 Type of Monitoring? 2.3.1. Classic monitoring System 2.3.2. Remote monitoring System 2.3.3. Comparison 2.4. What to monitor? 2.4.1. Weighing scale 2.4.2. Thermometer 2.4.3. Spirometer 2.4.4. Glucometer 2.4.5. Stethoscope 2.4.6. Sphygmomanometer 2.4.7. Pulse oximeter	**3. Sensor application in Medicine** 3.1. Introduction: Application in Medicine 3.2. Case Study 1: Blood pressure 3.2.1. Introduction 3.2.2. Measurements: 3.2.2.1. Oscillometer measurement 3.2.2.2. Sphygmomanometer 3.2.2.3. Applanation Tonometry method 3.2.2.4. Photoplethysmography 3.3. Case Study 2: Body Temperature 3.3.1. Introduction 3.3.2. Temperature Classification 3.3.3. Sensors Classification: 3.3.3.1. Placement 3.3.3.2. Technology **4. Temperature Sensors** 4.1. Definition 4.2. Benefits 4.3. Usage 4.4. Elements 4.5. Components 4.6. Types of Temperature Sensors 4.6.1. Thermistor 4.6.2. Thermocouple 4.6.3. RTDs 4.6.4. Semiconductor-based 4.6.5. Infrared Temperature Sensor 4.6.6. Thermometer

Each of the previously mentioned chapters includes three main parts:

- **Theoretical part:** where students are expected to obtain knowledge on the addressed subject, starting with, but not limited to, a slide deck. Each slide deck is supported with a set of further reading references so that the students can extend their knowledge on a specific point if needed.
- **Written part:** where students have to answer a set of questions, in a written form. The objective of this part is to draw the attention of the students to the section of the theoretical part that is most important. Since there is no teacher in the classroom to refer to those sections, insisting is performed indirectly via the written questions.
- **Practical parts:** where students will play a game to value their understanding of the subject. The game includes hidden and indirect tests for the obtained knowledge. The games are designed to allow the students to pause the advance, search for specific course-related pieces of information, and then advance again in a way that is visual to everyone else to create a competitive atmosphere on who can finish first.

Chronologically, students are expected to spend 30% of the allocated time on the theoretical part, 20% on the written part answering questions, and 50% on the practical part playing the games. However, due to the autonomous nature of the unit, these expectations may not be respected completely as intended from the participants.

3.3.3. Gamification

As mentioned previously, learning through play techniques is used in this unit. Gamification of the content is one of these techniques, it means that both written and practical parts will be introduced to the students as challenges that need to be fulfilled in order to advance forward.

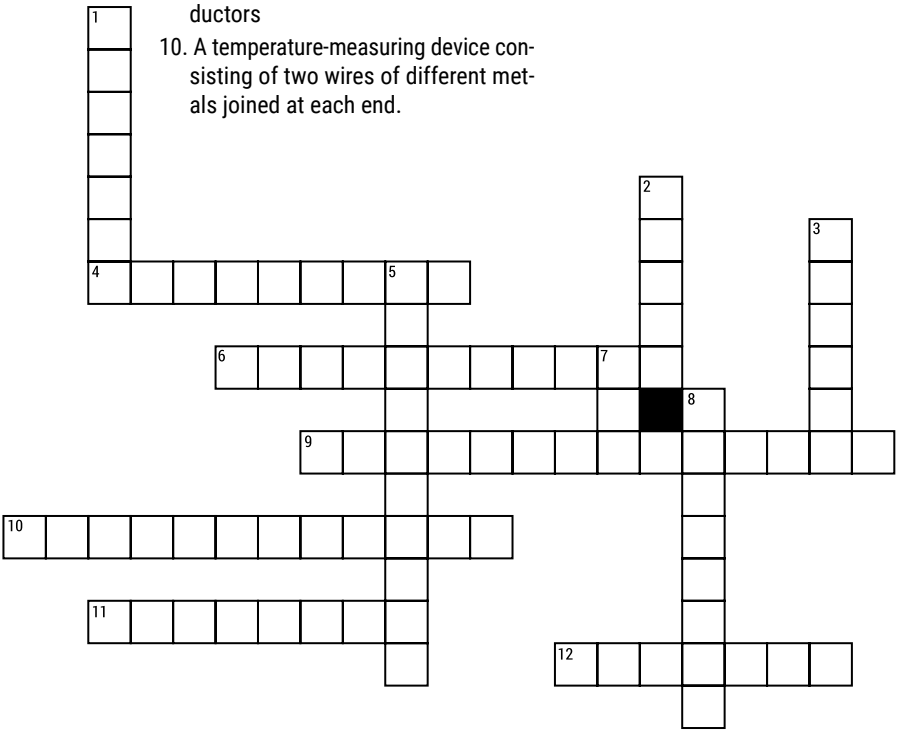
There are two aspects any gamified contents need to meet, they are:

- Pleasurability: Ot is the property of things being enjoyable when practiced. Students should have fun while using the gamified content passing time to remember.
- Compatibility: The gamified content needs to be built in a way that encourages students to compete with each other, individually or in teams. The content must define achievable goals inviting students to reach them in a competitive way: faster than the others, or having a greater score, etc.,

Next, briefly, two examples of gamified content are shown highlighting the pedagogical goals of each. Figure 3.16 shows a crossword example used in the written part. The game objective is to find the words referred to in the Across and Down sections.

ACROSS

4. The ability of a sensor to respond to changes in a measured variable in the same way across the full range.
6. A measure of cold or heat
9. Materials that have a conductivity between conductors and nonconductors
10. A temperature-measuring device consisting of two wires of different metals joined at each end.
11. In thermometers, it consists of a connected gauge and stem.
12. the only metallic element that is known to be liquid at standard temperature and pressure.



DOWN

1. Expressed as a series of the digits 0 and 1
2. Any definite numerical quantity.
3. devices that produce a measurable change in output to a known input stimulus.
5. Used for contactless temperature sensing
7. It is the most accurate when it's made from Platinum
8. The trueness of a quantity

FIG. 3.16. Example of a crossword game

Crossword example

Pedagogically, the game pushes students to search for details in the slide decks they have. One of the common difficulties with medical terms is the unfamiliar terminology, such as photoplethysmography and sphygmomanometer. A crossword game encourages students to handle these complex words letter by letter, orienting them to discover the common suffixes and prefixes used in the domain and their meaning, helping in the overall understanding of the addressed subject.

To amplify the competitiveness factor, crossword games are better introduced as a challenge to students, individually or in groups. A simple goal is to finish first, but more sophisticated targets can be established as well.

Another example is the labyrinth-based games suggested for the practical part. Students, individually or in groups, start inside a labyrinth, and the goal is to get out. Two examples of labyrinths are shown in Figure 3.17, Each labyrinth is divided into rooms, separated using thick black lines representing the walls. There are doors that connect the rooms. The red rectangles represent entry doors and the green rectangles represent exit doors. Students have to make their way through the labyrinth with different possible routes available, the chose is for the students to make.

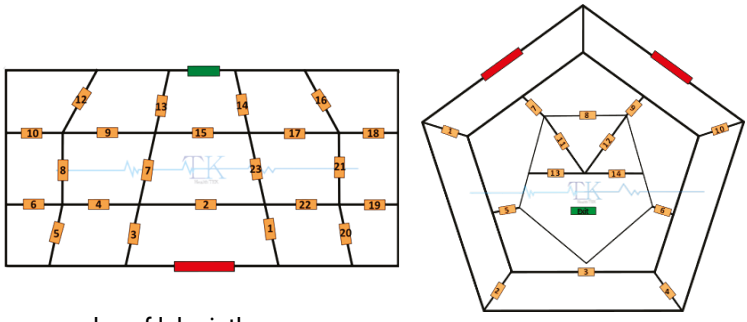


FIG. 3.17. Two examples of labyrinths

Labyrinth examples

The labyrinth is shown to everyone, students play in turns. When a door is chosen, a challenge will be raised. If the student satisfies the challenge, he can advance and the turn passed to another player, if not he is stuck in the room for the next turn when he can try again. Students can see each other's advances, this is done on purpose, to add a competitive factor.

This game can be developed in countless ways, for example, multiple questions, True/false questions, or problems that require calculations to be solved can be used as challenges. The level of difficulty can also be added making the questions harder when close to the exit. Other obstacles like closed doors (cannot be open) or penalties such as double, or triple questions can be introduced. Different labyrinth styles, including multi-leveled, can also be used.

3.4. UNIT 4: Surgical technologies

Below (Fig. 3.18) you will find a video in which we explain the different parts of the unit and the materials you will have available to succeed in it.

FIG. 3.18. Introduction to Unit 4

3.4.1. Introduction

Surgical technologies encompass a broad range of tools, equipment, and techniques used to perform surgical procedures with precision, efficiency, and safety. They represent a transformative shift in surgical care, offering innovative solutions to challenges and opportunities in modern healthcare delivery. Continued research and development in this field promise further advancements in surgical techniques, patient care, and surgical outcomes.

It can be followed by both engineering and medical students with no specific prerequisites. The most suitable audience for this course is students in the first year in both domains. However, the course can also be introduced to students in the 2nd year. Students who follow the course assumably have:

- Basic English level required in Academia,
- Information Technology equipment, notably a desktop computer, laptop, or tablet.
- Access to the Internet.

After following this course, the student is expected to earn the following learning outcomes:

- Identify various surgical instruments and instrument sets by explaining the differences between a minor and major set 2; describing retractors and their use 3; explaining reasons of particular instrument sets and why they are selected for specific surgical procedures.
- Demonstrate passing surgical instruments by explaining a neutral zone and its significance; demonstrating passing a scalpel correctly and receiving back on the mayo tray; demonstrating passing suture correctly and receiving back on the mayo tray;
- Understanding of the principles of decontamination and sterilisation by describing different types of sterilisers; demonstrating wrapping various surgical instruments and sets of instruments; demonstrating the sterilisation process with the steris and autoclave.

In the following sections, Unit 3 will be discussed in terms of structure, method, and gamification.

3.2.2. Structure

The unit is divided into 4 chapters, Table 1 shows the syllables:

- **Chapter 1** – Surgical Instruments. It is focuses on specially designed device or apparatus uses to carry out a specified task during a surgical procedure
- **Chapter 2** – Biomaterials for surgical instruments. This chapter is focused on biomaterials used in surgical instruments that must meet specific requirements such as biocompatibility, mechanical strength, durability, and sterilizability. Here are some common biomaterials used in the manufacturing of surgical instruments: Stainless Steel, Titanium and Titanium Alloys, Ceramics, and Polymers.
- **Chapter 3** – Care and handling of surgical instruments. Proper care and handling of surgical instruments are essential to maintain their functionality, sterility, and longevity, as well as to ensure patient safety. The chapter presents some guidelines for the care and handling of surgical instruments: Cleaning, Decontamination, Inspection, Maintenance, Sterile Storage, and Handling.
- **Chapter 4** – Instrument configuration on tissue. Configuring surgical instruments on tissue involves organising them in a manner that optimises efficiency, accessibility, and safety during surgical procedures. The chapter focuses on a general guideline for instrument configuration on tissue eg. Layout Instruments, Instrument Tray Organisation.

Each of the previously mentioned chapters includes three main parts:

- **Theoretical part:** where students are expected to obtain knowledge on the addressed subject, starting with, but not limited to, a slide deck. Each slide deck is supported with a set of further reading references so that the students can extend their knowledge on a specific point if needed.

- **Written part:** where students have to answer a set of questions, in a written form. The objective of this part is to draw the attention of the students to the section of the theoretical part that is most important. Since there is no teacher in the classroom to refer to those sections, insisting is performed indirectly via the written questions.
- **Practical parts:** where students will play a game to value their understanding of the subject. The game includes hidden and indirect tests for the obtained knowledge. The games are designed to allow the students to pause the advance, search for specific course-related pieces of information, and then advance again in a way that is visual to everyone else to create a competitive atmosphere on who can finish first.

TABLE 3.3. Outlines of the course 3

1. Surgical Instruments 1.1. Introduction to surgical instruments 1.2. Basic surgical tools 1.3. Classification of surgical instruments 1.4. Criteria of ideal surgical instruments 1.5. Parts of instruments 1.6. Example of surgical instruments 1.7. Autoclave 1.8. Instruments for electrosurgery 1.9. Laparoscopy instruments **2. Biomaterials for surgical instruments** 2.1. Introduction to biomaterials 2.2. Classification of biomaterials 2.2.1. Metallic biomaterials 2.2.1.1. Austenitic stainless steel 2.2.1.2. Martensitic stainless steel 2.2.1.3. Ferritic stainless steel 2.2.1.4. Titanum alloy 2.2.1.5. Chromium-cobalt alloy 2.2.2. Ceramics 2.2.3. Polymers	**3. Care and handling of surgical instruments** 3.1. Introduction to infection control 3.2. Technique of infection control 3.2.1. Ventilation of operation theatre 3.2.2. Aseptic technique 3.3. Sterilisation and Care of Surgical Instruments 3.4. Care and handling 3.5. Sterilisation and disinfection 3.6. Other methods **4. Instrument configuration on tissue** 4.1. Hallux valgus surgery 4.2. Case study 4.3.Different techniques for Hallux valgus correction 4.4. Big toe arthritis correction

Chronologically, students are expected to spend 50% of the allocated time on the theoretical part, 20% on the written part answering questions, and 30% on the practical part playing the games. However, due to the autonomous nature of the unit, these expectations may not be respected completely as intended form the participants.

3.4.3. Gamification

An example of gamified content is shown highlighting the pedagogical goals of each. Figure 3.19 shows a crossword example used in the written part. The game objective is to find the correct answer.

Question	Possible answers	Correct answer
What are the materials used in surgical instruments?	• wood • stainless steel • metal	stainless steel
What metal is best for surgical instruments?	• carbon steel • stainless steel • aluminium	stainless steel

FIG. 3.19. Example of a crossword game

3.5. UNIT 5: Artificial intelligence applied in Healthcare

Below (Fig. 3.20) you will find a video in which we explain the different parts of the unit and the materials you will have available to succeed in it.

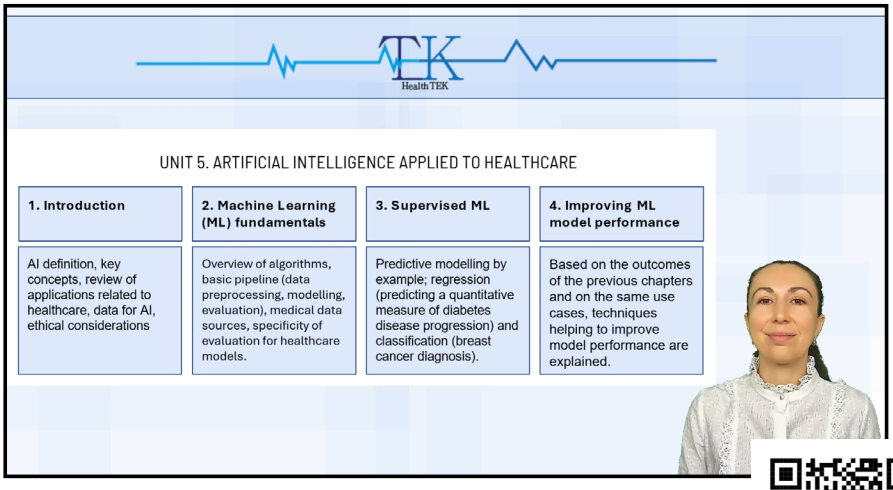


FIG. 3.20. Introduction to Unit 5

IF YOU ARE INTERESTED CLICK HERE

3.5.1. Introduction

Artificial Intelligence (AI) applications for healthcare have been expanding rapidly in recent years. This introductory unit aims at providing students with the understanding of different use cases of AI applied to healthcare and of the pipeline for a machine learning project. Students will realise two guided practical tasks and will finish the unit with a basic toolkit for entering this field.

To understand the concepts presented in the unit and complete the exercises, students are expected to meet the following prerequisites:

- To have basic knowledge in Python programming,
- To be familiar with linear algebra, statistics, and calculus on a basic level.

By the end of the unit, student will be able to:

- Understand the benefits of AI for healthcare, along with the risks and the ethical issues, through different use cases.
- Understand the whole pipeline of a Machine Learning project and the key principles of each step.
- Implement a simple pipeline for regression and classification tasks using structured data (clinical records).
- Understand how Machine Learning can be improved with regularisation techniques and ensemble methods.

In the following sections, the unit "AI applied to healthcare" will be discussed in terms of program and teaching methods.

3.5.2. Structure

The unit is divided into four chapters:

- **Chapter 1** – Introduction: AI definition, key concepts, review of application use cases related to healthcare, data for AI, supervised and unsupervised learning, overview of main ML algorithms, ethical considerations.
- **Chapter 2** – Machine Learning (ML) fundamentals. Basic pipeline of a ML project: data preprocessing, modelling, evaluation. Medical data sources. Specificity of evaluation for healthcare models.
- **Chapter 3** – Supervised ML: Regression and Classification by example. Guided practical assignments: regression task (predicting a quantitative measure of diabetes disease progression) classification task (breast cancer diagnosis). The main concepts are explained based on concrete examples in a Jupyter Notebook environment combining code, formatted text, and code execution outputs, and in particular graphics.
- **Chapter 4** – Improving ML model performance: Regularization and Ensembles. Model parameters and hyperparameters. Train-test-validation. Overfitting

and underfitting. Based on the outcomes of the previous chapters and on the same use cases, techniques helping to improve model performance are explained.

3.5.3. Teaching methods

The teaching on the above-mentioned chapters is organised as following:

- Concepts, methods, and tools are presented to students with the relation to concrete case studies. Students have access to all the course materials structured in chapters and subchapters in the learning management system where the course is deployed. For every chapter there are references to further reading and to some additional videos so that the students could extend their understanding on some specific topics.
- During synchronous sessions, the lecturer provides explanations, guidance on the available materials, and handles live-coding sessions. Based on the practical tasks on AI applied to healthcare, there are interactive exercises organised in small groups. It helps stimulate students' motivation and allows them to test or reflect on what they have learnt.
- Additional practical exercises are provided to students to deepen their understanding and improve their skills.

Two main use-cases are used for practical tasks:

- Prediction of a quantitative measure of diabetes disease progression,
- Breast cancer diagnosis.

A brief description of each use case and the main principles of their use in the unit are presented below.

Diabetes use-case

Ten baseline variables were obtained for each of 442 diabetes patients, as well as the response of interest, a quantitative measure of disease progression one year after baseline. Predictive variables include age in years, sex, body mass index, average blood pressure, total serum cholesterol, low-density lipoproteins, high-density lipoproteins, total cholesterol / HDL, possibly log of serum triglycerides level, and blood sugar level.

Breast cancer use-case

The dataset contains 30 numeric, predictive attributes and the class for 569 patients. Each patient is labelled as Malignant or Benign. Predictive variables include radius of a tumour, texture, perimeter, area, smoothness, compactness, concavity, and symmetry.

Based on these use cases, students learn to:

- Explore clinical records,
- Plot graphs representing distributions and relationships, interpret them, and communicate relevant information,
- Prepare data for machine learning algorithms,

- Train models and tune them,
- Evaluate models using relevant metrics, interpret the results, and communicate them.

The coding environment used for labs is an online platform that allows to execute code directly in a browser, with easy sharing and zero configuration required. Students are provided with textual explanations along with the code.

Interactive exercises are set up based on these use cases. Some examples of this kind of exercise include:

- Represent graphically some relationships between variables,
- Experiment with a different algorithmic configuration and compare the results,
- Test another evaluation metric, interpret, and compare the results.

These exercises can be organised in multiple ways. Some of them can be used during synchronous online sessions with small groups of students, others can be provided with an automatic correction through test activities in a learning management system or an external tool, such as the question based labyrinth game developed for the course.

3.6. UNIT 6: Anatomy and physiology

Below (Fig. 3.21) you will find a video in which we explain the different parts of the unit and the materials you will have available to succeed in it.

FIG. 3.21. Introduction to Unit 6

3.6.1. Objectives

The aim of the **Anatomy and physiology** unit is to enable the student of Medicine or Biomedical Engineering to establish an appropriate relationship with the patient during the clinical interview, to understand what is happening to the patient through anamnesis and physical examination, and to take the first steps to be able to make a correct initial diagnostic approach.

3.6.2. Contents

The unit is divided into the following subunits:

- **Basics of the interaction with a patient with wrist pain**: basic content on the medical history
- **Physical examination in a patient with wrist pain:** basic contents of anatomy and physiology of the upper extremity. A simulated real case of wrist pain.
- **Basics of the interaction with a patient with chest pain**: basic content on the medical history
- **Physical examination in a patient with chest pain:** basic contents of anatomy and physiology of the thoracic cavity. A simulated real case of chest pain.

3.6.3. Learning resources

Each subunit contains the following training resources:

- Presentations in order to facilitate a better reception and understanding.
- Readings: Further resources that raise current issues, related to the content of the sub-unit.
- Video tutorials in which physical examination techniques will be practised.
- Gamified content: Clinical cases with video games and avatars to practise anamnesis, physical examination and medical history writing.

3.6.4. Game description

For a more detailed game description and user guide, log on to:

- **Installation**: To run this activity, you need to access the link provided and download the game. After that execute the installer and follow the instructions that will appear during the installation process. Once installed, open the application.
- For a more detailed game description and user guide, log on to:
- **https://drive.google.com/file/d/1y9KSXSnnOmiwbdgE4nUBCFL20B_nqpb2/view**

Concept: This game simulates a real case with a patient. The student has to act as a doctor and solve the patient's problem by asking different questions about different topics. Before playing you must have completed the ALUD Anatomy and physiology course material.

Structure: The game consists of four different stages.

- In the first phase you need to introduce yourself and collect the clinical history of the patient by asking common questions about for example her personal and family medical history, her lifestyle and socio-labour. Students have five minutes to collect everything they need.
- In the second phase students need to solve the patient specific problem. Students need to ask the patient different questions to detect the symptoms and the cause of the pain. Students have five minutes to collect everything they need.
- In the third phase students have to explore the patient's body to detect where it hurts or not.
- In the last phase students need to write a clinical report indicating all the information collected about the patient in the previous phases.

Learning aspect: This game will allow the student to self assess and revise contents and tools previously worked with the readings, video tutorials and videos.
Requirements: PC with Windows system

3.6.5 Assessment

After each game the student will receive a score evaluation depending on how many correct questions they asked and how good the report was.

3.7. Genetics and genomics

Below (Fig. 3.22) you will find a video in which we explain the different parts of the unit and the materials you will have available to succeed in it.

FIG. 3.22. Introduction to Unit 7

3.7.1. Objectives

The aim of the Genetics and Genomics unit is to provide the student of Medicine or Biomedical Engineering with a self-learning tool to interpret the structure and variation of the human genome and to understand the procedures related to precision medicine.

3.7.2. Contents

The unit is divided into the following subunits:

- Fundamentals of molecular genetics: basic content on the structure and expression of genetic material is covered.
- Structural genomics: the structure of the human genome and of a specific gene is analysed using the European genome browser Ensembl.
- Mapping variation: an alteration in a gene is located within the human genome using the Ensembl genome browser and the OMIM and ClinVar databases.
- Functional genomics: tools and procedures for precision medicine are introduced.

3.7.3. Learning resources

Each subunit contains the following training resources:

- Video tutorials in which the contents of the sub-unit are developed.
- Videos or cartoons to facilitate the learning of the contents in the video tutorials.
- Quizzes or exercises for self assessment (solutions provided).
- Further resources to deepen: articles that raise current issues, related to the content of the sub-unit.
- Gamified content.

3.7.4. Game description

For a more detailed game description and user guide, log on to:

- **https://drive.google.com/file/d/17y2bEVXd3Iwhl_T5P7RNPBJ1v-QrlIcn/view**)
- **Concept:**This game simulates a real case in which a patient has high cholesterol. Your objective is to determine whether this patient can take the drug simvastatin. To do so, you must perform a genetic analysis before you can prescribe the drug.

Structure:

- You will have to select the level you want to play: "Pharmacogenomics of statins (part 1)" or "Pharmacogenomics of statins (part 2)"
- Before playing you must have completed the ALUD Genetics and Genomics course material.
- To be able to complete the first part you need to complete before the units 7.1 and 7.2 and for the second part the units 7.3 and 7.4.
- There are different types of questions that you will have to answer:

- Text input question: in this type of question you need to write down the answer inside the input box.
- Multiple choice question: in this type of questions you will be presented with four different answers (text or image) and you need to choose the correct one.

Learning aspect: This game will allow the student to self assess and revise contents and tools previously worked with the video tutorials, videos and quizzes: gene structure and gene and variant mapping in Ensembl and use of OMIM and ClinVar databases.

Requirements: PC with Windows system

Installation: To run this activity, you need to access the link provided and download the game. After that execute the installer and follow the instructions that will appear during the installation process. Once installed, open the application. To start playing, simply log in with your ALUD account and enter your username and password.

3.7.5. Assessment

Each sub-unit will be assessed as follows:

- **Fundamentals of molecular genetics**: two quizzes.
- **Structural genomics**: Exercise on gene structure. Game: Pharmacogenomics of statins (part 1)
- **Mapping variation**: Game: Pharmacogenomics of statins (part 2)
- **Functional genomics**: Exercise on functional genomics.

3.8. Summary

The chapter presents a new way of education through innovative Virtual Platform Gamification. The e-learning courses and Virtual Event Gamification include fields such as Health 4.0, biomechanics, biomaterials, biosensors, medical devices, artificial intelligence and health, anatomy and physiology, genetics and genomics.

Conclusions

The proposed HealthTEK platform is directly aligned with the Horizontal priority "Addressing digital transformation through development of digital readiness and resilience" as it aims at transforming the educative sector within the Life Sciences and Health Technology field through the empowerment of students and professionals in their digital skills thanks to the use of a virtual platform and immersive gamified modules for training clinical cases (artificial intelligence for personalized learning and monitoring and smart gamified pedagogical activity). Clinical cases and virtual rotation allow students to go through their tasks in an enjoyable and overall safe and effective environment. Nowadays, it is difficult to arrange students to have direct contact with patients, making sure that there is no risk for patients and that students have a profitable experience. The gamified immersive experience with active feedback allows to improve these situations. The virtual campus environment is integrated with the LMS, Learning Management System and the principles of DIGComp and DigCompEdu. With the virtual campus, professors and students canfind the perfect support to teach and learn clinical cases in bioengineering and medicine degrees. This campus has been started as a proposal after finding out that this need is relevant in the educational sector and specially more in the new paradigm.

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Summary

The Health Technology sector is rapidly growing worldwide, and the European Commission has recognized this phenomenon, placing it amongst its priorities in Horizon Europe, Erasmus +, and many other similar programs. Moreover, the Health Science sector is finding some troubles while adapting to educational programs, as moving clinical cases to the virtual space needs a development and innovation effort focused on gamification of the learning and the personalization using artificial intelligence. The proposed HealthTEK platform is directly aligned with the Horizontal priority "Addressing digital transformation through the development of digital readiness and resilience" and can be the resolution of the problems. The virtual campus HealthTEK works around four ideas: gamified immersion, flipped learning, internationalization at home and personalized learning, and includes a set of courses for “Life and Health Sciences and Technology” addressed to biomedical engineers and medicine students. It consists of education games, biomedical mobile applications, and virtual patient simulations from fields such as Health 4.0, biomechanics, biomaterials, biosensors, medical devices, artificial intelligence and health, anatomy and physiology, genetics and genomics.

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