Erasmus Plus project 2021-1-PL01-KA220-HED-000031182

ErgoDesign course

"Improving digital skills for Ergonomics and Bioengineering Innovations for inclusive Health Care"

Handbook to implement ErgoDesign-like courses

by Katarína **Monková** & Peter Pavol **Monka**
Technical University of Košice, Slovakia

Co-funded by the European Union

Funded by the European Union.
Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Table of Contents

Abbreviations

ADDIE	Analyze – Design - Develop - Implement – Evaluate instructional design model
AGILE	Align - Get set - Iterate and Implement - Leverage - Evaluate instructional design model
ECTS	European Credit Transfer and Accumulation System
ErgoDesign	Erasmus Plus project 2021-1-PL01-KA220-HED-000031182 "Improving digital skills for Ergonomics and Bioengineering Innovations for inclusive Health Care"
IT	Information technology
NPS	Net Promoter Score
NTUA	National Technical University of Athens, Greece
OU	Óbuda University, Budapest, Hungary
PUT	Poznan University of Technology, Poland
SCL	Student-Centred Learning
TUKE	Technical University of Košice, Slovakia
TUV	Technical University of Varna, Bulgaria

Introduction

Welcome to the handbook of digital support-based course creating! The handbook was created as a toolbox to easily implement similar courses as part of the project "Improving Digital Skills for Ergonomics and Bioengineering Innovations for Inclusive Health Care" (Erasmus Plus project 2021-1-PL01-KA220-HED-000031182 – hereinafter referred to as the Project). The Project focuses on creating of digital-based educational environment mainly in newly emerging multi-disciplinary areas. The handbook summarised the knowledge and experience gained during the Project into the guidelines for effective replication of similar courses.

However, the handbook is also applicable for creating the learning environment in classic professional areas, where the educational content is stable or needs to be innovated to new conditions.

The guide lists all the experience gained in creating a training course on an electronic platform as part of the project solution in implementation guidelines steps.
If you are wondering about the unconventional format of this guide, our effort was to create a book for comfortable reading on the screen. Maybe this format will save a lot of paper for printing.

We - all members of the ErgoDesign project team – are open to your comments, notes and suggestions for improving the handbook.

We hope you enjoy the journey through the Handbook!

1 ErgoDesign project particulars

ErgoDesign project involves participants facing situations that make their participation more difficult – e.g. disability or chronic health problems. The project is responding to an unresolved social issue linked to the requirements of people with special needs (physical or mental illnesses) for whom access to care is often hindered by the difficulty in customizing care products, difficulties in the identification of their special needs, and - finally - high costs. Special attention was paid to involve and select participants whose obstacles could be transformed into needs the address project goals. This aspect was included as a transversal priority in the development of the project training contents and addressed in modules of the curriculum. The project partners created a new interdisciplinary Curriculum which covers related multidisciplinary topics with consideration of the requirements of people with special needs to increase inclusion and diversity.

The two main topics addressed by the Project are (i) creating a new innovative course of additive technology produced implants by (ii) building digital skills and competences.

The project results contributed to creating a more inclusive care system environment that can be responsive to the needs of the wider community, especially people with special needs. The elements of innovation include the formulation of a unique training framework with a holistic perspective, conducting research at different levels (theory, practice and design level). The project emphasised the importance of the collaboration of different organisations with different and specific backgrounds for creating a new professional profile that will be able to design and produce human implants focused on people with special needs requirements.

1.1 ErgoDesign course basics

Course Title: 3D printing for health care

Subtitle: Improving digital skills for Ergonomics and Bioengineering Innovations for inclusive Health Care

Course Description: The course provides a specialized interdisciplinary education concept of theoretical and practical aspects of additive technologies application in biomedical engineering to enhance human health and wellbeing. The graduates gain a comprehensive understanding of core engineering principles related to the implants and prosthesis produced by additive technologies. The education concept is built for the ability to start an interesting career for highly skilled personnel in 3D printing for inclusive health care.

Students will utilise knowledge from the biomaterials and their processing technologies, basic medical issues, digital support in medicine, medical and hospital instrumentation, ergonomics, as well management of process of the 3D printing for health care. The applied complex of the interdisciplinary engineering knowledge and skills enables the graduate of the course to design and to produce personalized implants and prosthesis for improvement of human life.

Course Level: Undergraduate / Graduate / Postgraduate / Lifelong education

Course Type: Mandatory (included in the already existing course) or Elective (to organize a specific new course)

Duration: On-site: 14 weeks + 1 week for final examination / On-line: self-paced

Admission Process (Attendants Selection criteria): Self-assessment test

1.2 ErgoDesign course topics

Project team research activities focused on the topic composition of the course from the point of view of the parties involved. The primary obtained composition consists of:

1. Biomaterials and their processing technologies
2. Design, imaging and digital support for medical device design
3. IT solutions in medicine
4. Basic medical issues
5. Medical equipment, hospital equipment
6. Soft skills + management + ergonomics

The primary composition was developed into the final course structure after project team internal discussions:

1 Introduction: The benefits of implantology in the health care system, management of patience and production process (Soft skills + management + ergonomics)
2 Introduction of the biomaterials and biocompatible materials
3 Processing technologies of the biomaterials and biocompatible materials
4 3D printing of the metals, ceramics and polymers
5 Anatomy of the implantology, geometry, sizes and general and special examples
6 Material selection for implant (use the knowledge of the biomaterials and biocompatible materials and their processing technologies) as a function of the anatomy of the application
7 Human implant compatibility test methods and surgery in implantology.
8 Databases, programming, AI
9 Telemedicine system, medical informatics
10 3D scanning, process and device
11 Medical Imaging (CT/MRI/USG)
12 Application of the 3D images for designing as a function of the processing technology (digital tools for designing)
13 Medical equipment, hospital equipment
14 Integrating exercise

1.2.1 *Introduction: The benefits of implantology in the health care system, management of patience and production process (Soft skills + management + ergonomics)*

Topic Description: Implantology plays a crucial role in modern healthcare, providing effective solutions for missing teeth and improving patients' quality of life. This field combines advanced technologies, ergonomics, and management principles to provide quality care while optimizing the production process and increasing patient satisfaction. This course delves into the world of implant dentistry and explores its positive impact on healthcare. Students will analyze the benefits to patients and the healthcare system as a whole. In addition, they will be equipped with the necessary skills to effectively care for patients and optimize the implant dentistry production process.

Topic Content Information: (1) The benefits of implantology in healthcare: improved oral function, preservation of natural teeth, increased patient satisfaction, and reduced bone loss; (2) The importance of soft skills in implantology: effective communication, patient management, and continuous learning; (3) The expanding applications of dental implants, particularly in older adults with medical conditions, and how implant therapy can support overall health and quality of life; (4) Practice management strategies: efficient scheduling, inventory control, and financial management; (5) Ergonomic considerations in implantology practices: workspace design and instrument selection.

Topic Prerequisites: This course is designed for students with a science or engineering background who are familiar with basic dental procedures and have a basic understanding of dental anatomy and physiology.

Learning Objectives: (1) Knowledge: Understand the physiological and functional benefits of dental implants for patients | Grasp the far-reaching impact of implant dentistry on healthcare systems | Gain insight into effective patient management strategies in implant dentistry | Learn techniques to optimize the production process in an implantology practice | Recognize the importance of ergonomics and its application in implant dentistry; (2) Skills: Communicate effectively with patients during implant treatment | Develop a patient-centred strategy based on trust and straightforward communication | Implement solutions for effective workflow management in implantology; (3) Social Competences: Show empathy and professionalism when dealing with patients | Work successfully with other dentists who specialise in implants | Manage patient expectations during the treatment process.

Teaching Methods: (1) Lecturing: presentations (ppt) + pdf lectures; (2) Video lectures; (3) Practice Exercises: Short Questions | Review questions; (4) Individual Work of Students: research | presentations.

Assessment and Evaluation: Short Questions (10 %); Review questions (10%); research (10 %); Online presentation (10%); Group project (10%); Online discussion (10%); Topic final quiz (40%).

1.2.2 *Introduction of the biomaterials and biocompatible materials*

Topic Description: The field of biomaterials science sits at the intersection of biology and engineering. This course provides a basic understanding of the materials used in medical devices and implants. Students will examine the different classes of biomaterials, their properties and their interaction with living tissue. A central concept is biocompatibility, which refers to the ability of a material to coexist peacefully in the body without causing harm. Through lectures, discussions and reading, students will look at design considerations, selection criteria and ongoing advances in biomaterials technology.

Topic Content Information: (1) Introduction to Biomaterials: Definition, classification, and historical perspective; (2) Biocompatibility: Factors influencing biocompatibility, testing methods, and regulatory considerations; (3) Properties of Biomaterials: Mechanical, chemical, and biological properties; (4) Applications of Biomaterials: Medical devices, implants, tissue engineering, drug delivery systems; (4) Future Trends: Emerging technologies and materials in the field of biomaterials.

Topic Prerequisites: This course is designed for students with a science or engineering background who are interested in how materials can be used to improve human health.

Learning Objectives: (1) Knowledge: Define biomaterials and their various classifications (metals, ceramics, polymers, composites) | Understand the concept of biocompatibility and its different aspects (cytotoxicity, immune response, tissue integration) | Identify the properties desired in biomaterials for specific applications; (2) Skills: Analyze the relationship between biomaterial properties and their interaction with biological systems | Evaluate the biocompatibility of different materials based on scientific data | Critically assess the ethical considerations surrounding the use of biomaterials in healthcare; (3) Social Competences: Collaborate with colleagues from various disciplines (biology, engineering, medicine) to develop innovative biomaterial solutions | Effectively communicate scientific concepts related to biomaterials to a diverse audience.

Teaching Methods: (1) Lecturing: presentations (ppt) + pdf lectures; (2) Video lectures; (3) Practice Exercises: Short Questions | Review questions; (4) Individual Work of Students: research | presentations.

Assessment and Evaluation: Short Questions (10 %); Review questions (10%); research (10 %); Online presentation (10%); Group project (10%); Online discussion (10%); Topic final quiz (40%).

1.2.3 *Processing technologies of the biomaterials and biocompatible materials*

Topic Description: The aim of this topic is to give the basic knowledge about processing technologies of biomaterials and biocompatible materials. These technologies involve various methods to transform raw materials into usable forms for biomedical applications. Moreover, these technologies can modify the composition, structure, and properties of the materials to achieve specific functionalities and ensure compatibility with biological systems. Biomaterials, which can be defined as natural and synthetic, are integral in medical applications such as implants and organ replacements to restore functions and facilitate healing. These materials—ranging from metals and ceramics to polymers and natural tissues—can be shaped into parts, coatings, foams, and fabrics and must meet stringent biocompatibility standards while possessing the necessary mechanical, electrical, and biological properties. The manufacturing technology for biomaterials must ensure the preservation of the material's composition and microstructure to maintain their essential properties. For metallic biomaterials, this involves techniques like casting, powder metallurgy, and 3D printing. Polymers benefit from established methods in the plastics industry, while ceramics and glasses require specific synthesis methods like sol-gel processing. Composite fabrication technologies include hand lay-up, compression molding, resin transfer molding, and injection molding, taking into account biocompatibility and the typically low production volumes in the biomedical field. In conclusion, the careful selection of materials and manufacturing processes is crucial for developing effective and safe biomaterials for medical applications.

Topic Prerequisites: (1) Knowledge: Basics knowledge of properties biomaterials | Basics knowledge of manufacturing technologies; (2) Skills: Skills in finding information in scientific libraries | Logical thinking; (3) Social competences: None.

Learning Objectives: (1) Knowledge: Understanding the basic processing technologies of the biomaterials | Describing and giving examples of how biomaterials are used to fabricate for clinical use; (2) Skills: Ability to find information in scientific libraries | Logical thinking; (3) Social competences: Ability to self-develop new skills and knowledge.

Topic Content Information: 1. Introduction: Requirements of Biomaterials 2. Manufacture of Metals for Biomedical Applications 3. Manufacture of Biomedical Polymers 4. Manufacture of Bio-ceramics 5. Manufacture of Biomedical Composites

Teaching: Lecturing | Practice exercises | Individual work of students.

Assessment and Evaluation: Essay (100%).

1.2.4 *3D printing of the metals, ceramics and polymers*

Topic Description: The aim of classes is to learn about modern incremental manufacturing techniques in layers, also referred to as three-dimensional printing. It allows to acquire the ability to apply additive manufacturing for rapid fabrication of physical prototypes.

Topic Prerequisites: (1) Knowledge: information technologies and technical drawing, CAD/CAM, manufacturing technologies | orthopaedic and prosthetic supplies; (2) Skills: solid modelling of an object in a CAD 3D system | designing an orthopaedic or prosthetic supply; (3) Social competences: cooperation in a project team | awareness of responsibility for assigned tasks | understanding the need for new knowledge.

Learning Objectives: (1) Knowledge: student has an ordered, theory-based general knowledge about modern designing and manufacturing techniques | has knowledge of additive manufacturing and its advantages and disadvantages compared to other manufacturing techniques; (2) Skills: student is able to make appropriate changes in the technological process of additive manufacturing in order to change the value of specific technical coefficient of the product | is able to make a detailed assessment of the structure's technology and indicate the possibilities of its improvement | is able to communicate in this regard with technologists and designers | is able to prepare a team to carry out an innovative project, select a team of implementers, using project management methods, can define tasks related to the implementation process of the project and be a leader of the project team; (3) Social competences: student is able to properly set priorities for achieving the goal set by himself or other team members | correctly identifies and resolves dilemmas related to the performance of ongoing tasks | is aware of the need to prepare and organize the work of the members of the team.

Topic Content Information: 3D Printing - general issues of additive manufacturing technology in layers; Division and a brief presentation of the most important methods of incremental manufacturing. Case study; Manufacturing of products on FDM/FFF machines.

Teaching Methods: Informative lectururing | Multimedia presentation | Case study

Assessment and Evaluation: Laboratory-course: on the basis of the student's preparation for each laboratory activity; Lectures: evaluation of knowledge by written final test with open and closed questions; questions are assessed on a point scale, and to pass it is required to collect at least 50% of the total possible number of points.

1.2.5 *Anatomy of the implantology, geometry, sizes and general and special examples*

Topic Description: This topic provides a general information of the anatomical foundations crucial to implantology, focusing on the intricate relationships between bone, muscle, tendon, and connective tissue. It emphasizes the importance of understanding these structures for successful implant design, placement, and integration. The topic delves into the geometry and dimensional considerations essential for implants, illustrating these concepts with both general and special case examples. By integrating anatomical knowledge with practical applications, students will gain a thorough understanding of how to achieve optimal restoration of function and aesthetics in both dental and orthopedic contexts. The topic aims to equip learners with the necessary knowledge and skills to navigate complex anatomical scenarios and make informed decisions in implantology practice, fostering competence and confidence in clinical settings.

Topic Prerequisites: (1) Knowledge: Fundamental understanding of human anatomy, with a focus on bone and soft tissue structures. Familiarity with basic concepts in dental and orthopedic implantology is recommended. (2) Skills: Proficiency in conducting research and utilizing scientific databases to retrieve relevant information. Strong analytical and logical thinking skills are essential for assessing anatomical data and applying geometric principles in clinical scenarios. (3) Social competences: Students should demonstrate effective communication skills for collaboration within interdisciplinary teams and adherence to ethical standards in patient care.

Learning Objectives: (1) Knowledge: Develop a comprehensive understanding of the anatomical foundations essential to implantology, encompassing bone structure, muscle attachments, and the role of connective tissues. Gain insight into the geometric and dimensional considerations critical for successful implant design, placement, and integration. Acquire knowledge of various implant types, stability, and osseointegration. (2) Skills: Apply anatomical knowledge to analyze and interpret clinical data for effective implant placement and treatment planning. Demonstrate proficiency in integrating geometric principles and dimensional requirements to select appropriate implants tailored to individual patient needs. Communicate effectively within interdisciplinary teams, collaborating with professionals from different disciplines to optimize patient outcomes.(3) Social competences: Foster teamwork and interdisciplinary collaboration in implantology practice. Engage in continuous professional development, staying updated with advancements in implantology and contributing to the field's growth. Promote effective communication with patients.

Topic Content Information:1. Implantology in general 2. Implantology as a discipline 3. Anatomical foundations & significance of anatomy in implantology. 4. Human bone anatomy 5. Interplay of bone / jaws / connective tissue & osseointegration 6. Geometry, sizes and dimensionality in implantology 7. Special examples in implantology 8. Implementation of 3D design (digital & physical) & advanced technologies in implantology.

Teaching Methods: Monological (lecture, instruction) | Dialogic (Discussion and conversation) | E-learning, Practice exercises, Other

Assessment and Evaluation: Topic final quiz (100%).

1.2.6 *Material selection for implant (use the knowledge of the biomaterials and biocompatible materials and their processing technologies) as a function of the anatomy of the application*

Topic Description: The aim of this topic is to provide basic knowledge on the factors necessary to evaluate the suitability of a material as an implant, such as biocompatibility, mechanical properties, processing methods, and specific application requirements. It's crucial to understand that material and processing method selection should account for the patient's needs. Choosing the right materials is vital in biomaterial development due to their direct interaction with the physiological environment, significantly impacting patient health. Successful implants can lead to complete recovery, whereas failures can cause severe consequences. The complexity and dynamic nature of the physiological environment, involving structural, chemical, and biological factors, make understanding biomaterial-biological interactions challenging. Biomaterials engineers must identify essential characteristics for specific applications, including structural demands like strength and durability, and chemical properties that influence biological responses. Additionally, manufacturing costs and complexity must be considered to ensure economic feasibility. This comprehensive approach ensures biomaterials meet functional, safety, efficacy, and economic standards. Different tissues in the human body exhibit distinct mechanical properties based on their functions. For instance, load-bearing bones in the lower limbs support body weight and endure various forces during activities, while tendons and ligaments primarily withstand tensile forces. These properties are crucial for the biomaterial's interaction with the biological environment and its performance. When developing new biomaterials, it is essential to consider the mechanical property requirements for the intended application and how to achieve these properties. Understanding how the mechanical properties of biomaterials are determined is vital, and various mechanical tests can be used to assess different properties of bulk biomaterials. In addition to mechanical properties, the chemical characteristics of the potential biomaterial system must be considered. This is important for the general stability of the part and has a significant impact on the patient's physiological response to the implant, influencing the surgical outcome.

Topic Prerequisites: (1) Knowledge: Basics knowledge of properties biomaterials | Basics knowledge of manufacturing technologies; (2) Skills: Skills in finding information in scientific libraries | Logical thinking; (3) Social competences: None.

Learning Objectives: (1) Knowledge: Understanding the requirement of biomaterials and biocompatible materials |Selecting the most appropriate material for a real application; (2) Skills: Ability to find information in scientific libraries | Logical thinking; (3) Social competences: Ability to self-develop new skills and knowledge.

Topic Content Information: 1. Material selection for medical devices 2. Mechanical properties of biomaterials 3. Chemical properties of biomaterials 4. Human anatomy 5. Materials in orthopedic 6. Dental implants 7. Cardiovascular Devices

Teaching Methods: Lecturing | Practice exercises | Individual work of students.

Assessment and Evaluation: Essay (100%).

1.2.7 *Human implant compatibility test methods and surgery in implantology.*

Topic Description: The topic aims to provide basic knowledge about the biocompatibility and safety of implant materials before their use in surgical procedures. Human implant compatibility testing is crucial in developing and evaluating biomaterials for implantation. These tests assess the safety, biocompatibility, and performance of implant materials. The human body is a complex system with various tissues, cells, proteins, and other biological components. Each tissue has a unique extracellular matrix, influencing the local environment for cells. The body contains diverse proteins that can undergo changes when exposed to different biological materials and chemicals. Blood, a vital fluid, contains proteins and cells that initiate clotting, inflammatory reactions, and combat foreign materials. Functional biomaterials aim to prevent negative responses, such as toxicity or excessive wear, by integrating seamlessly into the biological environment and withstanding mechanical forces. "Biocompatibility" refers to the ability of materials to function without causing negative tissue reactions and is crucial for medical devices. It involves understanding tissue reactions that are essential for the successful use of biomaterials or medical devices and assessing adverse changes affecting the host response. Biocompatibility depends on the medical device's ability to function appropriately within the host environment, considering mechanical properties, corrosion resistance, and chemical stability. Biological responses to implants can vary due to changes in the host environment or device material post-implantation. Factors influencing biocompatibility include the chemical and physical properties of biomaterials, types and locations of host tissues, exposure duration, surface characteristics, and substances released from the device due to corrosion and wear. Rigorous testing, adhering to ISO and ASTM standards, is required to develop biocompatible medical devices before clinical trials. Biocompatibility also involves the design and geometry of medical devices. Poor design can lead to failures, and structural changes post-implantation due to corrosion, fatigue, or loading should be considered. The process of transitioning biomaterials from laboratory research to clinical trials includes multiple phases: processing, physical and microstructural characterization, in vitro cytocompatibility assessments, pre-clinical animal testing, and clinically relevant in vivo osseointegration tests, leading to human clinical trials.

Topic Prerequisites: (1) Knowledge: Basics knowledge of physics and chemistry | basics knowledge of biology; (2) Skills: Skills in finding information in scientific libraries | Logical thinking; (3) Social competences: None.

Learning Objectives: (1) Knowledge: Understanding basic knowledge about biocompatibility and safety of the implant material; (2) Skills: Ability to find information in scientific libraries | Logical thinking; (3) Social competences: Ability to self-develop new skills and knowledge.

Topic Content Information: 1. Human Body environment 2. Evolution of biomaterials 3. Medical devices 4. Biocompatibility 5. In Vitro Tests for Biocompatibility 6. In Vivo Tests for Biocompatibility 7. Inflammation, Wound Healing, and the Foreign-Body Response

Teaching Methods: Lecturing | Practice exercises | Individual work of students.

Assessment and Evaluation: Essay (100%).

1.2.8 *Databases, Programming, Artificial Intelligence (AI)*

Topic Description: The topic follows the essential digital competences in data processing professional area. Data is an essential part of the successful operation of a wide range of organizations and in health care is importance of data processing precision and safety very high.
In the area of the data management basement the topic builds basic knowledge through tabular database structures and elementary data processing in spreadsheet environment. Logical continuing of simple tabular database handling knowledge and skills led to their development into relational structures.
In the field of programming the topic learning objectives focus on developing basic programming knowledge and skills for specific health care issues. The topic is focused on low-code and no-code programming because the course is intended for professionals from very wide fields and therefore the requirements for previous programming knowledge and skills cannot be demanding.
The third topic education group are typical applications of artificial intelligence in healthcare. An important part of the education is the student's independent work focused on understanding the efficient storage and processing of data through a suitable data structure, basic programming techniques and simple applications of artificial intelligence.

Topic Prerequisites: (1) Knowledge: None; (2) Skills: Working in one of the common operating systems environments | Ability to create the data structure in spreadsheet processors; (3) Social competences: None

Learning Objectives: (1) Knowledge: Understanding the principles of the simple tabular datasheet and relational database | Understanding of the basic programming for the applications in health care | Understanding of the basic applications of artificial intelligence; (2) Skills: Ability to build simple tabular database | Ability to build simple relational database | Ability to use a simple programming for automation of data processing | Ability to use simple tools for artificial intelligence application for processing healh care data; (3) Social competences: Ability to work independently on simple database and data processing tasks.

Topic Content Information: 1. Simple tabular databases; 2. Relational databases; 3. Basic programming for the data processing; 4. Basic artificial intelligence tools for the data processing.

Teaching Methods: Lecturing | Dialogic (Discussion, conversation, brainstorming) | Practice exercises | Dealing with situational issues - learning in situations | Individual work of students.

Assessment and Evaluation: Project 1 - Table Database (30%); Project 2 – Relational Database (30%); Project 3 – AI Data Processing (40%)

1.2.9 *Telemedicine system, medical informatics*

Topic Description: The aim of this topic provides a comprehensive introduction to the field of telemedicine and its application in modern healthcare. Students will explore the use of telecommunication technologies to deliver healthcare services remotely, improving access to care, and enhancing patient outcomes. Additionally, the course covers the integration of medical informatics principles and technologies into telemedicine systems. Students will examine the historical development of telemedicine, its benefits and limitations, and the ethical and legal considerations associated with its practice. They will gain a solid understanding of the telecommunication technologies used in telemedicine, such as transmission systems, remote monitoring and mobile health applications.

Topic Prerequisites: (1) Knowledge: Basics knowledge of telemedicine system | Basics knowledge of medical informatics;; (2) Skills: Skills in finding information in scientific libraries | Logical thinking; (3) Social competences: None.

Learning Objectives: (1) Knowledge: Define and explain the concept of telemedicine, its scope, and its role in modern healthcare delivery| Evaluate the benefits and limitations of telemedicine in improving healthcare access, quality, and patient outcomes| Analyze the ethical and legal considerations involved in the practice of telemedicine and the protection of patient privacy and data security| Describe the telecommunication technologies used in telemedicine| Understand the principles of medical informatics and its applications in telemedicine; (2) Skills: Ability to find information in scientific libraries | Logical thinking; (3) Social competences: Ability to self-develop new skills and knowledge.

Topic Content Information: 1. Telemedicine in general 2. Telecommunication Technologies in Telemedicine 3. Medical Informatics in Telemedicine Information systems and people 4. Telemedicine Applications 5. Information and Communications technologies in the telemedicine. 6 Future Trends and Innovations in Telemedicine 7. Ethics in collaborating with technology 8. Telemedicine and healthcare transformation.

Teaching Methods: Lecturing | Practice exercises | Individual work of students.

Assessment and Evaluation: Topic final quiz (100%).

1.2.10 *3D scanning, process and device*

Topic Description: The aim of course is to get familiarized with techniques and methods of automated design of orthopaedic and prosthetic products, using reverse engineering and KBE and rapid manufacturing of these products using additive manufacturing technologies (3D Printing).

Topic Prerequisites: (1) Knowledge: information technologies and technical drawing, CAD/CAM, manufacturing technologies ׀ orthopaedic and prosthetic supplies; (2) Skills: solid modelling of an object in a CAD 3D system ׀ designing an orthopaedic or prosthetic supply; (3) Social competences: cooperation in a project team ׀ awareness of responsibility for assigned tasks ׀ understanding the need for new knowledge.

Learning Objectives: (1) Knowledge: student describes the role of design in modern design engineering process ׀ describes technological foundations of additive technology of FDM and possibilities of its application in orthopaedics and prosthetics ׀ describes possibilities of design using reverse engineering and KBE; (2) Skills: student creates 3D models, prepares and processes a triangular mesh file (STL), selecting resolution for the needs of additive manufacturing ׀ manufactures orthopaedic products using FDM technology ׀ prepares a batch file and selects parameters ׀ performs post processing ׀ processes triangular mesh and uses intelligent CAD models for generating a design of an orthosis/prosthesis; (3) Social competences: student is open to implementation of rapid manufacturing in engineering activities ׀ is able to develop knowledge on their own ׀ is able to work in a project team using rapid product development techniques.

Topic Content Information: Outline the main themes covered by the topic. Provide enough detail to give readers a sense of the subject matter. Mass customization in medical engineering - production of individualized supplies. Reverse engineering techniques (3D scanning) in medicine - hardware, software, methodology of gathering and processing data. Rapid manufacturing technologies - Fused Deposition Modelling in prosthetics and orthotics (basics, materials, applications, machines, software, planning and realization of a process, post processing). Design automation techniques - basics of KBE (Knowledge Based Engineering) and auto-generating models in medical applications. Presentation of a process of rapid design and manufacturing of orthopaedic and prosthetic supplies in Laboratory of Rapid Manufacturing. Openwork hand orthosis, leg orthosis, hand prosthesis.

Teaching Methods: Informative lectururing ׀ Multimedia presentation ׀ Case study

Assessment and Evaluation: evaluation of knowledge by written final test with open and closed questions; questions are assessed on a point scale, and to pass it is required to collect at least 50% of the total possible number of points; evaluation of advancement in realization of project of a given orthosis/prosthesis, evaluation of results, e.g. obtained product and a summarizing report, to obtain a pass, it is necessary to present a report describing the completed project of the orthosis /prosthesis, containing description of at least 3 out of 4 stages of the process (these are: obtaining and processing patient data, obtaining the base 3D model of the orthosis / prosthesis, model improvement, manufacturing and assembly of the product).

1.2.11 *Medical Imaging (CT/MRI/USG)*

Topic Description: This topic aims to provide a comprehensive exploration of medical imaging technologies—Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and ultrasound (USG). These modalities have revolutionized diagnostic capabilities in healthcare, offering detailed insights into human anatomy and pathology. The module delves into fundamental principles, diverse applications, and recent advancements in CT, MRI, and USG imaging. It emphasizes the integration of these technologies into clinical practice, highlighting their roles in diagnosis, treatment planning, and therapeutic monitoring across various medical disciplines. Students will gain a thorough understanding of imaging principles, technical proficiency, safety protocols, and ethical considerations essential for effective utilization and interpretation of medical imaging in healthcare settings.

Topic Prerequisites: (1) Knowledge: Prospective learners should have a foundational understanding of the principles and applications of medical imaging modalities such as: CT, MRI and USG. This includes basic knowledge of the physical principles underlying each modality, their typical clinical uses, and the differences in imaging capabilities among them. (2) Skills: Students should possess skills in interpreting medical images. Proficiency in using imaging software for analysis and manipulation of images is essential. (3) Social competences: Students should have effective communication skills necessary for conveying imaging findings to healthcare professionals and patients in a clear and comprehensible manner. They should be capable of working collaboratively in multidisciplinary teams, respecting diverse viewpoints and contributing to discussions on diagnostic and treatment strategies involving medical imaging. The students must keep ethical awareness and adherence to patient confidentiality and safety protocols in medical imaging practice.

Learning Objectives: (1) Knowledge: Understand the principles and applications of CT, MRI, and USG in medical imaging. Gain experience into safety protocols and ethical considerations. (2) Skills: Interpret and analyze CT, MRI, and USG images effectively. Apply imaging findings in clinical decision-making and communicate results clearly. Practice radiation safety and optimize imaging protocols. (3) Social competences: Communicate effectively with healthcare teams and patients. Show ethical behavior and professionalism in medical imaging practice. Collaborate in interdisciplinary settings and commit to continuous professional development.

Topic Content Information: 1. Medical Imaging (CT, MRI, and USG) in general 2. Importance of Medical Imaging 3. Significance of Understanding Medical Imaging Principles 4. Interdisciplinary Cooperation 5. Clinical Integration and Patient Health Care 6. Technical Proficiency 7. Applications and Advancements.

Teaching Methods: Lecturing and instructions | Dialogic | Presentation | E-learning |Methods of working with the text | Practice exercises

Assessment and Evaluation: Topic final quiz (100%).

1.2.12 *Application of the 3D images for designing as a function of the processing technology (digital tools for designing)*

Topic Description: The aim is to get familiarized with techniques and methods of automated design of individualized medical products, such as implants, prostheses, orthoses or rehabilitation devices, with use of knowledge engineering and intelligent CAD models.

Topic Prerequisites: (1) Knowledge: information technologies and technical drawing, CAD/CAM, manufacturing technologies | knowledge of medical imaging technologies; knowledge of medical products: orthopaedic and prosthetic equipment, implants, rehabilitation devices etc.; (2) Skills: solid modelling of an object in a CAD 3D system | Designing a medical device (3) Social competences: cooperation in a project team | awareness of responsibility for assigned tasks | understanding the need for new knowledge

Learning Objectives: (1) Knowledge: student describes role of design in modern design engineering process | describes possibilities of design of individualized medical products using medical imaging techniques and 3D scanning | describes possibilities of automation of design of medical products with use of knowledge engineering and intelligent CAD models; (2) Skills: student creates 3D models of individualized medical products on the basis of medical imaging/3D scanning data | prepares intelligent CAD models of individualized medical products with use of KBE techniques and uses these models to generate projects of medical products for specific patients; (3) Social competences: student is open to implementation of advanced CAD systems in biomedical engineering | is able to develop knowledge on their own | is able to work in a project team using digital technologies.

Topic Content Information: Design of individualized medical products on the basis of medical imaging technologies and 3D scanning. Design automation techniques - basics of KBE (Knowledge Based Engineering) and auto-generating models in medical applications. Processing of medical imaging data and 3D scanning data (computer laboratory). Design of selected medical products on the basis of medical imaging data (2-3 examples: orthoses and prostheses).

Teaching Methods: Informative lectururing | Multimedia presentation | Laboratory method

Assessment and Evaluation: evaluation of knowledge by written final test with open and closed questions; questions are assessed on a point scale, and to pass it is required to collect at least 50% of the total possible number of points; evaluation of progress in realization of laboratory exercises, evaluation of results of a final assessment - an own intelligent model of a selected medical product; to obtain a pass, it is necessary to complete all laboratory exercises (attendance + follow the instructions provided) and present to the tutor an own intelligent model, which will be assessed on a point scale (points are awarded for: compliance with the subject of the classes, functionality, degree of automation and resistance to errors) - it is necessary to obtain at least 50% of the points.

1.2.13 *Medical equipment, hospital equipment*

Topic Description: The topic introduces Medical Devices - equipment in healthcare and hospitals – elementary knowledge. These devices are used by skilled people as per the manufacturer's instructions to prevent, diagnose, treat, monitor, alleviate the disease, compensate for an injury, investigate, replace, modify, or support the anatomy in human beings. Nowadays is the evolution of medical & hospital equipment progressing rapidly supported by artificial intelligence, virtual/augmented reality, 3D-printing, robotics and nanotechnologies developing. Medical devices cover a vast range of non-pharmaceutical products used for disease treatment, monitoring, or prevention. Medical device creation and usage have risen along with the rise in digital technology. However, the efficacy and safety standards for many medical devices are less strict than for medications. Consequently, novel medical devices are adopted within healthcare systems without adequate assessment of their cost-effectiveness or patient usage benefits. For pharmaceuticals, only the pharmacological effects and clinical efficacy are of interest. However, medical devices provide patient benefits (such as physical, mental, and social well-being) beyond clinical outcomes. Some current medical device industry trends are the rise in 3D printed devices (or device parts), the use of medical robotics, and connectivity increases for medical devices between platforms. Another topic related to medical device best practices is cybersecurity and how to keep medical information safe with increasing device connectivity.

Topic Prerequisites: (1) Knowledge: Mastering the basics of machine structures | Mastering the methods and means of technical and experimental research of machines as well as the means of controlling machines and processes; (2) Skills: Ability to use professional terminology and process technical documentation | Ability to read technical drawings of products or parts and propose the most efficient methods and procedures for their production | Ability to perform assembly, surface treatments, packaging and shipping | Ability to perform expert analysis of machinery and production technologies | Ability to analyze and evaluate technical solutions; (3) Social competences: None

Learning Objectives: (1) Knowledge: Understanding medical and hospital equipment regulations and standards | Understanding the principles of the basic medical and hospital equipment for implantology and prosthesis; (2) Skills: Ability to analyse technical, ergonomics and utilization properties of medical and hospital equipment for implantology and prosthesis | Ability to improve the properties of medical and hospital equipment for implantology and prosthesis; (3) Social competences: Ability to work independently on simple analytical and synthetical task of improvement of medical and hospital equipment for implantology and prosthesis.

Topic Content Information: (1) Medical devices background, (2) Principles and standards of MD, (3) Selected MD description.

Teaching Methods: Lecturing | Dialogic (Discussion, conversation, brainstorming) | Individual work of students

Assessment and Evaluation: Critical reflection (50%); Online discussion (15%); Online presentation (35%).

1.2.14 *Integrating exercise*

Topic Description: In this final lesson, students will integrate and apply the knowledge acquired throughout the course. The lesson focuses on the cohesive application of concepts learned in previous lessons. Students will independently select an implantology task and simulate its solution, covering material selection, imaging, design, print preparation, 3D printing, and implementation. This lesson builds upon previously practiced tasks and emphasizes practical application through a comprehensive case study involving the creation of a forearm support, from imaging to prototype printing. Successful completion of this task will unlock the final test, which will determine the overall grade for the e-learning course.

Topic Prerequisites: (1) Knowledge: Basic understanding of implantology principles | Familiarity with 3D printing technologies | Knowledge of material properties for medical applications; (2) Skills: Competence in 3D modeling software | Ability to follow detailed project workflows; (3) Social Competences: Ability to work independently | Effective time management | Problem-solving mindset.

Learning Objectives: (1) Knowledge: Understand the integration of various implantology concepts | Gain insight into the complete workflow from design to implementation | Comprehend the practical aspects of creating medical prototypes; (2) Skills: Independently manage an implantology project | Select appropriate materials for prototypes | Utilize 3D printing technologies effectively | Conduct thorough case study analysis; (3) Social Competences: Demonstrate initiative and autonomy in project execution | Collaborate effectively in simulated environments | Communicate project outcomes clearly | Adapt to challenges and propose viable solutions.

Topic Content Information: (1) Comprehensive review of implantology concepts covered in the course; (2) Steps for independent project selection and planning; (3) Material selection and its impact on prototype quality; (4) Imaging techniques and their role in project success; (5) Design and print preparation workflows; (6) Practical application of 3D printing in creating prototypes; (7) Case study: Forearm support creation from imaging to prototype printing.

Teaching Methods: Lecturing: Presentations and PDF lectures | Practice exercises: Project planning and design tasks | Individual work: Independent research and project execution

Assessment and Evaluation: Assessment methods for this topic include a variety of approaches to evaluate students' readiness, learning progress, skill acquisition, and educational needs: Project (60%): Comprehensive independent project covering all steps from material selection to prototype creation; Case Study Analysis (20%): Detailed analysis of the provided forearm support case study; Topic Final Quiz (20%): Final test to evaluate overall understanding and integration of course content.

2 Organizational tasks tips for digital-based/supported course design essentials

The project team devoted the necessary energy and time to the theory of how to define the online course. The intention was to prepare not only this course at the required level, but also to define generally applicable principles applicable to the preparation of similar courses. The results of this work are "Course replicating best practices", or "Organizational tasks tips" in other words. The best practice for organizing and executing innovative online (e-learning) training courses is a concise and informative overview of an educational offering that provides an efficient way of online training definition that meets the needs of the market (potential learners) with insights into a given area of expertise. The most important point of the design of a digital-based/supported training/course is to follow a logical action structure [8]:

1. Audience research;
2. Course topic designation;
3. Course outline;
4. Lesson plans structuring;
5. Course storyboard design.

2.1 Audience research

A little theory for beginning: Defining the audience first (analyses) and creating a persona (synthesis) of the ideal student (attendant) will help to produce the course for real market needs. A clear definition of who the ideal students (attendants) are and what they need is the most important for course features definition. It will be prospective to pick the right topic, design the right type of curriculum, and craft the most effective type of lesson plans.

I. **Audience profile research** can be prepared in two possible ways:

1. **Existing audience** – e.g. students of a major, social media followers, a group of any service subscribers, customers of any business etc. Research of existing audiences create insights useful to build a quick profile of what your audience looks like and what their main paint points tend to be. This is very important for design of course. It is possible to seek out about existing audience in two ways:
    a. **Quantitative** - demographic data points verifiable using analytics. Outputs are the basics, such as age, location, gender, education, preferences etc...
    b. **Qualitative** - insights going more deeply to knowing around needs, wants, likes, dislikes, struggles, and interests. Data can be collected by selecting some of customers (randomly or according to any criteria) and sending them a survey or by conducting a short interview. A more complex but reliable approach!

2. **New audience** –sources for audience exist and the main task is to know the type of audience for the course and how to reach them. The best way is to reach out to a few individuals within these sources and discover their goals and problems:
    a. What **results** they wanted to achieve;
    b. What **steps** have to be taken to go that;
    c. What **principal problem** they need to solve.

II. **Create a persona of ideal student** – by using collected information. This persona will be center point of course planning and creation process. The useful practice is to physically write a card with ideal student persona information (Table1).

Table 1 Persona of ideal course student information

Avatar / Typical photo	**Name**	**Age**
	Occupation	
	Education	
Likes / Dislikes	**Wants / Desires**	
Fears / Hesitations	**How the offer will help them. Benefits of the Offer.**	

2.2 Course topic

In the theory: It is necessary to carefully consider what to be presented as a topic in this action. Selection of the topic - based on the ideal student persona and educator's characteristics (specific areas of expertise, life experiences, and skill sets) – focuses on the course substantial matter allowing **student transformation to a higher quality level**.

The most important point is, that the ideal course student persona is looking not for obtaining information, but **she/he is looking for wanted transformation**. And courses have to be designed for the ideal student persona **transformation by the outcome** of the learning. The simplest scheme of the process is in Figure 1.

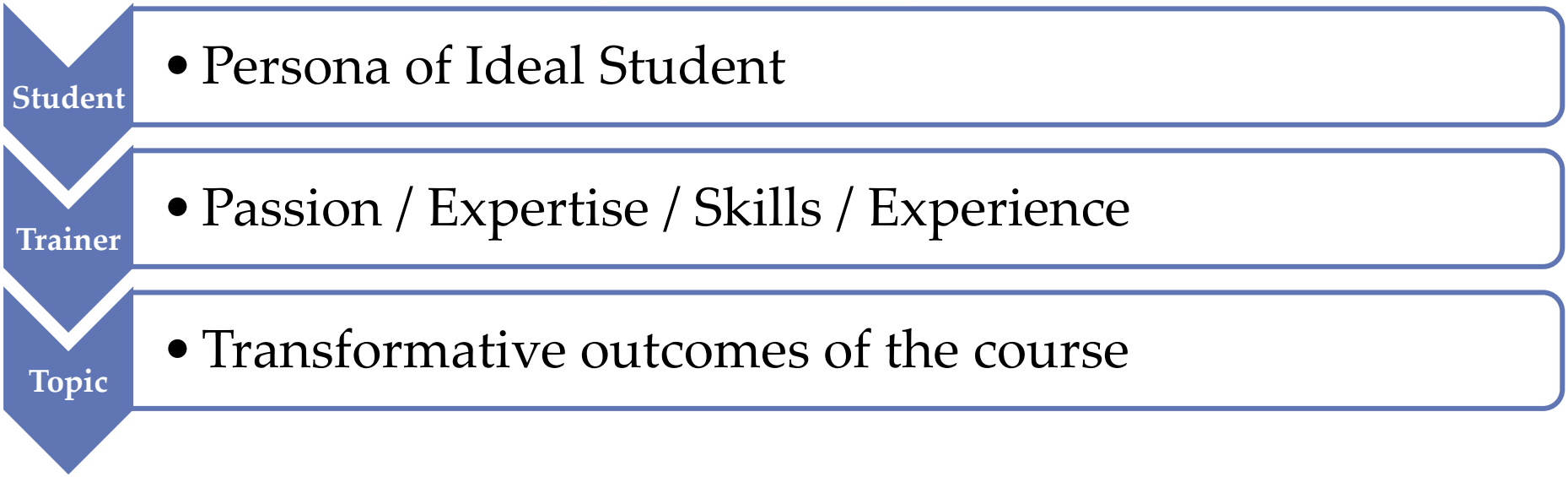


Figure 1 Scheme of inputs for creating transformative course topic.

The best method how to express the transformation to the audience is to create a one-sentence description following analysis and synthesis related to the ideal course student persona in the form:

The course on **TOPIC** →;

→ will help **AUDIENCE** to **LEARNING OUTCOME** →

→ so that they can **TRANSFORM**.

Learning Outcomes can be in form:

- Intellectual Skills
- Cognitive Skills
- Verbal Skills (Knowledge Sharing, ...)
- Motor Skill Development
- Individual´s Personal Growth (Attitude, ...)

The main focus of student learning outcomes is to make students/attendants transformation to be scholastically sound, skilful, and prepare them for life-long learning. Learning outcomes must pay attention to whether they are:

S - Specific
M - Measurable
A - Achievable
R - Realistic
T - Timely

In short, the learning outcomes must be “SMART" & clearly defined in terms of attainability!

ErgoDesing practice: Writing a transformation statement can help the course creator better focus course content to the main goal(s) that students want to achieve, e.g. for ErgoDesign course it is: “The course on **3D printing for health care** will help **attendants** to **be fully involved in 3D-printed human implant development chain** so they **can work on all engineering positions in the chain**.”

2.3 Course outline

In theory: The above-described transformation is a longer process consisting of some steps that need to be done. In this phase is important to describe a concise and informative overview of an educational offering that provides potential learners with insights into the content, objectives, and structure of the course. It aims to convey the key aspects of the learning experience, helping individuals make informed decisions about their educational or professional pursuits. [9]

By knowing **the persona of ideal student transformation to a higher quality level** is possible to state basic course description features. Table 2 describes differences between preparing features contents for Course Description and Syllabus.

Table 2 Basic comparison of Course description and Syllabus contents

	Course Description	Syllabus
Purpose	Provides a brief overview of the course content, goals, objectives, and often policies.	Offers detailed information about the course structure, schedule, assignments, and policies.
Content	A concise summary of the course.	A comprehensive document outlining weekly topics, readings, assignments, exams, and grading criteria.
Audience	Aimed at prospective learners to help them decide whether to enroll.	Intended for enrolled learners, providing specific information on how the course will be conducted.
Timing	Available before the course registration period.	Provide to learners after they have enrolled, typically at the beginning of the term.

One of the best ways how to start **writing a course description** is the key questions and answer them:

- ✓ **Who** is offering this course? → Individual instructor / Organization / …
- ✓ **Why** should a learner take this course? → Listing the Takeaways / Benefits / …
- ✓ **What** are the characteristics of transformation by the learning outcome? → Expression the transformation characteristics
- ✓ **How** are you going to offer the educational experience in this course? → Learning activities / Instruction methods / …
- ✓ **When** will this course take place? → If enrollment dates are available
- ✓ **How** much does the course cost? → Course price determination (if available)

The table below shows the **key elements of a course description** and can work as a checklist when creating your own course descriptions.

Table 3 Key elements of the course description

Key Elements	Information to Include
Course Title	Clearly state the title of the course.
Course Code (if applicable)	Include any identifying code or reference number associated with the course.
Brief Introduction	Provide a brief introductory paragraph that captures the essence of the course.
Course Overview	General overview of the course, outlining its purpose, goals, and relevance.
Learning Objectives	Clearly articulated specific learning outcomes and objectives of the course. What will learners gain by completing the course?
Target Audience	Intended audience and course prerequisites identification by specifying of level of expertise or background knowledge required.
Course Content Information	Outlining main topics, themes, or modules covered in the course. Providing enough detail to give readers a sense of the subject matter.
Teaching Methods	Describing used instructional methods – e.g. lectures, discussions, hands-on projects, or group activities.
Assessment and Evaluation	Detailing methods of assessment, including types of assignments – and their weighting (if applicable), exams, projects, or other evaluation criteria. Specifying how student performance will be graded.
Required Materials	Listing textbooks, readings, software, or other materials required for the course.
Unique Features	Highlighting unique aspects of the course, such as guest lectures, field trips, industry partnerships, or hands-on experiences.

Key Elements	Information to Include
Career or Academic Outcomes	Communicating how the course contributes to student learning goals – academic, career, or professional development. Describe the skills and knowledge they will gain.
Practical Applications	Explain how the course content is applicable in real-world situations. Provide examples of how the knowledge can be utilized.
Instructor Information	Information about the instructor, including qualifications, expertise, or relevant experience.
Contact Information	Providing contact details or directing readers to where they can obtain more information about the course.
Registration and Enrollment Information	Detailing the registration process, enrollment deadlines, or specific requirements.
Duration and Schedule	Specifying duration of the course and any relevant scheduling information.
Language and Format	Specifying language of instruction and the format of the course (e.g., in-person, online, hybrid).
Accreditation or Certification	Mention any accreditation or certification associated with the course.

In this activity, it is appropriate for courses focused on transformation through more extensive knowledge and skills to break down the learning process into partial topics (some authors use the term "milestones"**)**. This will give the course designer a better idea of how much content has to be created and will help obtain a direct focus on lesson plans and curriculum.

For partial topics (milestones) definition is important to build a logical course hierarchy from the simplest wanted outputs to more complex ones – the best way is to apply trainers' expertise, experiences, and skills.

ErgoDesign practice: The final course partial topics (milestones) for the ErgoDesign project course were defined by research and are presented in the chapter 0 of this handbook.

2.4 Lesson plans structuring

In the theory: It is the moment when an overall idea of course and learning milestones are created. The continuing of process involves breaking down each partial topic (milestone) into an individual lesson plan. For the lesson plan visualization can be used a text processor, whiteboard, or just a notebook and pen. Many educational/training institutions use online learning electronic platforms for designing and running courses. In this case start to structuring lesson plans in the platform is the easiest way.

Every lesson structure depends on the student's knowledge level. The lesson may require a different structure in accordance with the professional major and the most appropriate for the online training formats are:

1. Lectures
2. Practice exercises
3. Assessments
4. Learning sources

2.4.1 Lectures

The lectures cover mainly the knowledge needed for the topic. lectures should focus on WHAT and WHY before the next steps focus on HOW in simple words. The lectures cover the following:

- Any required concepts the students need to understand;
- Definitions and other need-to-know details;
- Anything that has to be shown or talked about to prepare for training activities.

2.4.2 Practice exercises

This stage is not necessary in every course, but it can be a great way to make your course more interactive and useful for students. The practical exercises cover the following:

- Demonstrate the how-to do it of the training;
- Try and show how to get one task done.

2.4.3 Assessments

The best way how to prove the quality of lectures and practice exercises is to do appropriate testing - just simple confirmation of attendants learning. This is key for long-term retention and engagement. The following elements are crucial when creating a quiz:

- Limitation the questions only to what students just learned;
- Design questions have to be easy to recall the answer to;
- Prepare topic assessments non-graded and explain answers.

2.4.4 Learning sources

Improving the efficiency of the lectures and practice exercises are appropriate learning sources very important part of education. The learning sources – e.g. cheat sheet, worksheet, workbook, or template - help to attendants put their knowledge into action. The following rules are very important:

- A reference guide for relevant information
- A community for the student to work on learned skills
- Resources that make the student's work easier

2.5 Course design

The crucial part of this step is the preparation of a solid plan for online training. This step focuses on creating training content: a storyboard for each lesson – in simple words - a solid idea of **what to say** and **how to say** it. The best way to design a course is to use:

- Storyboarding, and
- Instructional design models

Storyboarding originated from film production where storyboards assist in planning overarching plotlines to help the narrative flow from one scene to the next. In course design the function in a similar way – to describe the flow of educational activities.

Next tables (Table 4, 5 and 6) present a simple template for storyboarding in the frame of course design. The short help for using the next templates:

Table 4 Written storyboard template

Written Storyboard			
Course Name Name of the Course	**Chapter #** Number of the Chapter	**# and Name of Lesson/Module** # of Lesson / Module	**Name of Video Script** Video Script Name
Name of the creator		**Date**	
Outline (Delete or Modify in accordance with needs) ✓ **Intro** ✓ **Why** ✓ **What** ✓ **How** ✓ **Call to Action** ✓ **Outro**			
Narration		**Visual Cues**	
Text spoken in video sequence …		Description of the visual cues	
After watching this training video, students will be able to: Description			

Table 5 Simple visual storyboard template

Simple Visual Storyboard			
Course Name Name of the Course	**Chapter #** Number of the Chapter	**# and Name of Lesson/Module** # of Lesson / Module	**Name of Video Script** Video Script Name
Scene 1: Scene Name		**Scene 2:** Scene Name	
Visuals		Visuals	
Production notes:		**Production notes:**	
Scene 3: Scene Name		**Scene 4:** Scene Name	
Visuals		Visuals	
Production notes:		**Production notes:**	
After watching this training video, students will be able to: Description			

Table 6 Visual and Written storyboard template

Visual and Text Storyboard			
Course Name Name of the Course	**Chapter #** Number of the Chapter	**# and Name of Lesson/Module** # of Lesson / Module	**Name of Video Script** Video Script Name
Scene 1: Scene Name			
Visual Descriptions / Sketch			Narration / Script
Production notes:			**Misc Notes:**
Scene 2: Scene Name			
Visual Descriptions / Sketch			Narration / Script
Production notes:			**Misc Notes:**
After watching this training video, students will be able to: Description			

Instructional design is the discipline of designing profound learning experiences. It can lead online course creators on how subject matter becomes a successful educational source.

It is huge number of different instructional design models nowadays – e.g Bloom's Taxonomy, Gagné's 9 Events of Instruction, ADDIE, Successive Approximation Model (SAM), Merrill's First Principles of Instruction, Action Mapping, Dick and Carey Model, Kemp Design Model, AGILE and Rapid Prototyping, and last but not least 70-20-10 Model. In ErgoDesign project were used these scientifically tested and backed models:

- Blooms taxonomy
- ADDIE
- Nine Events of Instruction
- 70-20-10
- AGILE and Rapid Prototyping

2.5.1 Blooms taxonomy

Bloom's taxonomy stimulated a way to align educational goals, curricula, and assessments that are used in education, and it structured the range and depth of the instructional activities and curriculum that educators provide for students. Benjamin Bloom was American educational psychologist. He critically examined his own work firstly published in 1956.

Understanding and utilizing Bloom's taxonomy allows educators and instructional designers to create activities and assessments that encourage students to progress through the levels of learning. These activities allow students to go from the acquisition of basic knowledge and work their way through the levels of learning to the point where they can think critically and creatively.

The progression of knowledge matters because each level builds on the previous ones. Students must have a solid foundation before continuing to build higher-order thinking skills. The basic knowledge they learn at the beginning of the process allows them to think about this knowledge in progressively more complex ways. To successfully use Bloom's taxonomy is essential to follow the steps in the correct order because the taxonomy's steps naturally progress and reinforce learning at every level.

Bloom´s taxonomy of educational objectives in the cognitive domain is presented in Table 7. The educational objectives start with knowledge and are gradually led to the evaluation. Learning objectives storyboard using Bloom´s taxonomy template is presented in Table 8.

Table 7 Bloom´s Taxonomy of Educational Objectives in the Cognitive Domain

Level (arranged from the lowest to the highest)	**Cognitive Process**	**Question Word**	**Learning Strategies**
Knowledge – Remembering (rote memory, recall of specifics)	Retrieve relevant knowledge from long-term memory RECOGNIZING (identifying) RECALLING (retrieving)	define, describe, enumerate, identify, label, list	Rehearsal strategies: Highlight key vocabulary from text or lecture notes, generate flash cards, devise mnemonic devices.
Comprehension - Understanding (basic understanding, putting an idea into your own words)	Construct meaning from instructional messages, including oral, written, and graphic communication INTERPRETING (clarifying, paraphrasing, representing, translating) EXEMPLIFYING (illustrating, instantiating) CLASSIFYING (categorizing, subsuming) SUMMARIZING (abstracting, generalizing) INFERRING (concluding, extrapolating, interpolating, predicting) COMPARING (contrasting, mapping, matching) EXPLAINING (constructing models)	discuss, explain, restates, traces	Explain a concept to a classmate; associate material with prior knowledge; summarize key concepts from lecture notes and compare to a "model."
Application - Apply (applying a general principle to a new and concrete situation)	Carry out or use a procedure in a given situation EXECUTING (carrying out) IMPLEMENTING (using)	illustrate, classify, compute, predict, relate, solve, utilize	Generate original examples; design and complete classification systems; solve and analyze new problems; predict test questions.
Analysis - Analyze (breaking the information into component parts in order to examine it and develop divergent conclusions)	Break object into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose DIFFERENTIATING (discriminating, distinguishing, focusing, selecting)	contrast, generalize, illustrate, diagram, differentiate, outline	Generate comparison and contrast lists and use these to predict test questions; identify themes or trends from text or case studies; organize material in more than one way.

Level (arranged from the lowest to the highest)	**Cognitive Process**	**Question Word**	**Learning Strategies**
	ORGANIZING (finding coherence, integrating, outlining, parsing, structuring) ATTRIBUTING (deconstructing)		
Synthesis - Create (creatively or divergently applying prior knowledge and skills to produce a new or original whole)	Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure GENERATING (hypothesizing) PLANNING (designing) PRODUCING (constructing)	categorize, contrast, design, formulate, generate, design a model, reconstruct	Predict test questions and outline the answers; locate evidence to support a thesis; generate a thesis to support certain evidence.
Evaluation - Evaluate (judging the value of material based on informed personal values/opinions resulting in an end product without a distinct right or wrong answer)	Make judgments based on criteria and standards CHECKING (coordinating, detecting, monitoring, testing CRITIQUING (judging)	appraise, conclude, justify, criticize, defend, support	List supporting evidence; listing refuting evidence, generate concept maps, debate; find weaknesses in other arguments.

Table 8 Learning objectives storyboard using Bloom´s taxonomy template

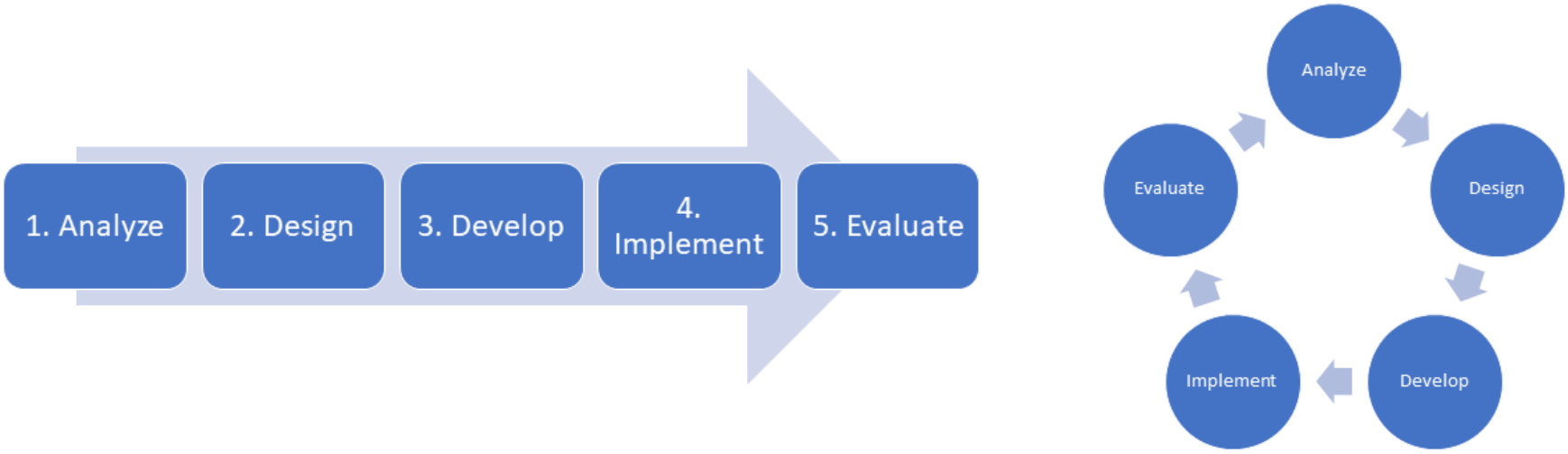
Learning Objectives Storyboard Using Bloom´s Taxonomy			
Course Name Name of the Course	**Chapter #** Number of the Chapter	**# and Name of Lesson/Module** # of Lesson / Module	**Name of Video Script** Video Script Name
Name of the creator		**Date**	
Remember Remember a list of facts	**Understand** Demonstrate your understanding	**Apply** Apply to actual situation	
Recognize, List, Describe, Identify, Name, Locate	Interpret, Summarize, Paraphrase, Compare, Classify, Explain	Execute, Use, Illustrate, Solve, Modify, Calculate	
Analyze Break down ideas into simpler parts to understand how they fit together	**Create** Design and produce new things	**Evaluate** Use your knowledge to propose solution to a problem	
Compare, Contrast, Categorize, Differentiate, Investigate, Deconstruct	Design, Construct, Plan, Produce, Invite, Write, Propose	Critique, Hypothesize, Check, Experiment, Judge, Test	

2.5.2 ADDIE

This model's name is an acronym that stands for the 5 steps of instructional design:

1) **Analyze** – Course goal / Inventory of existing content / Feedback from business partners.
2) **Design** – Course delivery method – in person ׀ online ׀ blended ׀ cohort / Who will be delivering the content / What is the timeline for creation / What tools are being used to create / Storyboard and assets collection
3) **Develop** – Gather assets / Develop individual courses, chapters, lessons, and modules from storyboard/ Video recording / Audio recording / Uploading to the learning portal / Create worksheets
4) **Implement** – Online or hybrid load to the learning portal / In-person schedule sessions / Assign learners / Track completion / Monitor
5) **Evaluate** – Survey learners / Evaluate if goals are met / Evaluate behavior change / Determine changes needed and revise course

Originally, the framework was hierarchical. The design of the learning process started with an analysis (e.g., of the audience or the market fit for an educational program) and ended with a post-implementation evaluation of the final, fully developed training. Over time, it morphed into more of a loop. Teachers and course builders who follow the ADDIE model can use the 5 steps over and over again, ultimately coming up with a fine-tuned, optimal course design.



a) b)

Figure 2 Changes in ADDIE model framework application: a) hierarchical, b) loop

ADDIE is **the best model for beginners in course design**. It helps to well-organize the steps needed to efficiently develop a great learning experience.

2.5.3 Gagné's Nine Events of Instruction

Gagné's nine events of instruction can help to build a framework to prepare and deliver instructional content while considering and addressing conditions for learning. Course goals and learning objectives can be prepared before implementing the nine events—the goals and objectives will help situate the events in their proper context. The nine events of instruction can then be modified to fit both the content and students' level of knowledge. The model consists of the following steps:

Before presenting instruction:

1) **Gain the attention of the students** - Ensure the learners are ready to learn and participate in activities by presenting a stimulus to capture their attention. These are a few methods for capturing learners' attention:
   a) Stimulate students with novelty, uncertainty, and surprise
   b) Pose thought-provoking questions to students
   c) Have students pose questions to be answered by other students
   d) Lead an ice breaker activity
2) **Inform students of the objectives or outcomes** for the course and individual lessons to help them understand what they are expected to learn and do. Provide objectives before instruction begins. Here are some methods for stating the outcomes:
   a) Describe required performance
   b) Describe criteria for standard performance
   c) Have learners establish criteria for standard performance
   d) Include course objectives on assessment prompts
3) **Stimulate recall of prior learning** - Help students make sense of new information by relating it to something they already know or something they have already experienced. There are numerous methods for stimulating recall:
   a) Ask questions about previous experiences
   b) Ask students about their understanding of previous concepts
   c) Relate previous course information to the current topic
   d) Have students incorporate prior learning into current activities

While presenting instruction:

4) **Present the content** - Use strategies to present and cue lesson content to provide more effective instruction. Organize and group content in meaningful ways, and provide explanations after demonstrations. The following are ways to present and cue lesson content:
   a) Present multiple versions of the same content (e.g. video, demonstration, lecture, podcast, group work, etc.)
   b) Use a variety of media to engage students in learning
   c) Incorporate active learning strategies to keep students involved
   d) Provide access to content on Blackboard so students can access it outside of class

5) **Provide learning guidance** - Advise students of strategies to aid them in learning content and of resources available. In other words, help students learn how to learn. The following are examples of methods for providing learning guidance:
   a) Provide instructional support as needed – i.e. scaffolding that can be removed slowly as the student learns and masters the task or content
   b) Model varied learning strategies – e.g. mnemonics, concept mapping, role playing, visualizing
   c) Use examples and non-examples – examples help students see what to do, while non-examples help students see what not to do
   d) Provide case studies, visual images, analogies, and metaphors – Case studies provide real world application, visual images assist in making visual associations, and analogies and metaphors use familiar content to help students connect with new concepts
6) **Elicit performance (practice)** - Have students apply what they have learned to reinforce new skills and knowledge and to confirm correct understanding of course concepts. Here are a few ways to activate learner processing:
   a) Facilitate student activities – e.g. ask deep-learning questions, have students collaborate with their peers, facilitate practical laboratory exercises
   b) Provide formative assessment opportunities – e.g. written assignments, individual or group projects, presentations
   c) Design effective quizzes and tests – i.e. test students in ways that allow them to demonstrate their comprehension and application of course concepts (as opposed to simply memorization and recall)

<u>After presenting instruction:</u>

7) **Provide feedback** - Provide timely feedback of students' performance to assess and facilitate learning and to allow students to identify gaps in understanding before it is too late. The following are some types of feedback you may provide to students:
   a) Confirmatory feedback informs the student that they did what they were supposed to do. This type of feedback does not tell the student what she needs to improve, but it encourages the learner.
   b) Evaluative feedback apprises the student of the accuracy of their performance or response but does not provide guidance on how to progress.
   c) Remedial feedback directs students to find the correct answer but does not provide the correct answer.
   d) Descriptive or analytic feedback provides the student with suggestions, directives, and information to help them improve their performance.
   e) Peer-evaluation and self-evaluation help learners identify learning gaps and performance shortcomings in their own and peers' work.
8) **Assess performance** - Test whether the expected learning outcomes have been achieved on previously stated course objectives. Some methods for testing learning include the following:
   a) Administer pre- and post-tests to check for progression of competency in content or skills
   b) Embed formative assessment opportunities throughout instruction using oral questioning, short active learning activities, or quizzes
   c) Implement a variety of assessment methods to provide students with multiple opportunities to demonstrate proficiency
   d) Craft objective, effective rubrics to assess written assignments, projects, or presentations
9) **Enhance retention and transfer** - Help learners retain more information by providing them opportunities to connect course concepts to potential real-world applications. The following are methods to help learners internalize new knowledge:
   a) Avoid isolating course content. Associate course concepts with prior (and future) concepts and build upon prior (and preview future) learning to reinforce connections.

b) Continually incorporate questions from previous tests in subsequent examinations to reinforce course information.
c) Have students convert information learned in one format into another format (e.g. verbal or visuospatial). For instance, requiring students to create a concept map to represent connections between ideas.
d) To promote deep learning, clearly articulate your lesson goals, use your specific goals to guide your instructional design, and align learning activities to lesson goals.

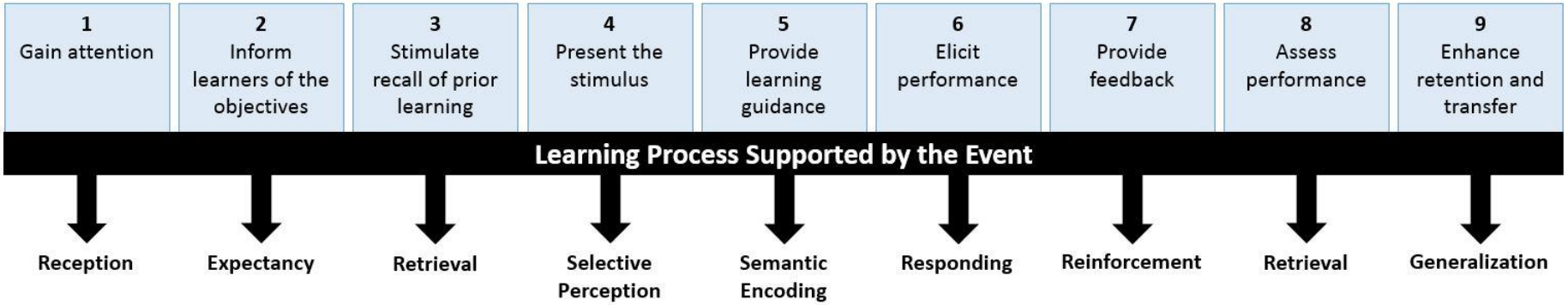


Figure 3 Gagne's 9 Events of Instruction and related learning process

The 9 events of instructions developed by Gagne are easy to follow and help you stay focused to keep your course tight and on target. It is important to keep the training straight on point to keep learner's attention. Gagne's model ensures to apply different strategies to reinforce learning.

Specific learning strategies can be implemented on each step of this model of instruction. These strategies can be applied in face-to-face, online or blended training.

2.5.4 70-20-10 model of learning and development

The model was created by McCall, Lombardo,and Morrison. It identifies three different ways in which people learn and assigns weight to each of them. This model was primarily developed to help employers effectively train employees to perform better and progress in their roles. That means this model is one of the best **for training-oriented courses**. It does rely on tasks and interactions specific to the workplace. According to the model:

- 70% of knowledge comes from **experience, experiment and reflection**.
- 20% of knowledge comes from **working with others**.
- 10% of knowledge comes from **formal, planned learning**.

It means that about 70% of courses focus on the practical application of knowledge. This can be done mainly by examples analysing or solving real conditions-related problems. The next 20% should be guided learning: think group conversations, brainstorms, or activities in breakout rooms. The remaining 10% should be spent on self-study, such as reading or "homework." (Figure 4)

<table>
<tr>
<td rowspan="2">70% Examples of learning by working
☑ Problem-solving
☑ Challenging tasks
☑ Other roles and responsibilities
☑ Auditing / Reviewing
☑ Innovation
☑ Reflection</td>
<td>20% Examples of learning by working together
☑ Coaching colleagues in the workplace
☑ Collaboration and continuous improvement
☑ Giving and Receiving feedback
☑ Learning in networks
☑ Action learning
☑ After-action reviews</td>
</tr>
<tr>
<td>10% Examples of learning by formal intervention
☑ Courses
☑ Modules
☑ Workshops/Masterclasses
☑ E-Learning
☑ Seminars
☑ Reflection</td>
</tr>
</table>

Figure 4 Scheme of 70:20:10 model structuring

Implementing the 70:20:10 model helps generate real business impact, by adjusting the organizational focus from solely developing formal learning solutions to integrating learning in the workflow (Table 9).

Table 9 Paradigms comparison for Learning & 70:20:10 performance

Learning paradigm	70:20:10 performance paradigm
Focus on learning solutions: the 10	Focus on creating effective connections between working and learning, learning by working together and formal solutions, or 70:20:10
	Learning tackles performance problems within organisation
Analyses the learning need	Analyses organizational and performance needs
Develops and delivers formal learning solutions	Develops and delivers solutions to improve organisational performance and learn from this
Focus on learning goals	Focus on performance goals
Focus on content	Focus on context and content
Focus on theoretical knowledge (what)	Focus on practical knowledge (how)
Focus on the classroom. workshop or learning management system	Focus on the entire organisation
Focus on the participant or 'learner' in formal learning situations	Focus on work, employees and the organisation
Learning is an event in itself	Learning is a constant process and part of overall performance
Learning is separated from work	Learning and working are integrated

2.5.5 AGILE and Rapid Prototyping

Agile and Rapid Prototyping is a good instructional design model for larger teams and projects. It can help projects with multiple stakeholders move forward in a fast and resource-efficient way. Using this model, the team is "aligned" and "set" and designers and developers can produce deliverables in small, frequent batches. It can be easily reviewed and refined in the course design process. Working with **this model for a solo course creator adds more work and complicates the process**.

The Agile framework has 5 key elements:

- **Align** - Analyze the market need for your course. Get your team on board and agree on goals and objectives.
- **Get set** - Gather the knowledge and resources necessary to build your training program. Plan your project timeline and assign tasks.
- **Iterate and Implement** - Build out a prototype of your course. Revise existing prototypes.
- **Leverage** - Make optimal use of your project resources, including people, technology, and data.
- **Evaluate** - Have an assessment strategy in place and apply it to each prototype your team produces.

Rapid Prototyping aligns the Agile framework with the 3 essential steps of the course design process:

- Design,
- Development, and
- Evaluation.

Course designers produce course prototypes (sample, scaled-down models of the final product) with this approach. After course prototype preparation, the stakeholders (including educators, designers, and developers) evaluate each prototype and create revised iterations until they reach a desired outcome (user-friendly, engaging and effective training). This translates to 3 repeatable steps to designing a learning program:

1) Prototyping
2) Reviewing
3) Refining

The above-described approach indicates that the roots of this instructional design model are in the field of IT.

3 Guidelines and Tools for Monitoring and Evaluation

The basic course creator approach has to be permanently improving the courses. One of the best ways to do this is to listen to learners. The problem is that many of your learners won't always tell about how it's going in the course. Learners will drop out, cancel their subscription, or complete the course and disappear, and the course creator's task is to obtain crucial information about their motivation to do it.

Putting in place the right course metrics helps to determine what learners think of the course and how the course designer can make it better. Metrics are not only important for building a better course, but it's vital for business. Learners are always looking for what they get for their investment (time and money). The task of the metric is not only to add up the ratio of successful graduates to unsuccessful ones. The basic eight online course metrics that can be tracked and how to use their results to improve success are presented below [9].

3.1 Assessment versus Evaluation

There have been many arguments about the correct use of the term evaluation versus the term assessment. One position is that evaluation is different from assessment. Some researchers, especially in North America, use the term evaluation to refer to studies implemented to examine and report on the strengths and weaknesses of programs, policies, organizations, and the like to improve their effectiveness. Assessment, on the other hand, is used to refer to "the formation of value judgments to determine the significance, the importance, the value of learning and knowing", and using "a variety of procedures to obtain information about individual's learning". Another position regards assessment as a subset of evaluation and a valuable tool in the larger evaluation activity. The simplest definition can be: "Assessment asks 'How much?' whereas evaluation asks 'Is it good enough?' and 'If not, why not?'" [3] Assessments diagnose learning gaps and progress, while evaluations are judgmental, emphasizing the quality of outcomes. Basic features comparison of Assessments and Evaluations is in Tab 10.

The complexity of the issue of assessment and evaluation is due to the fact that the focus of education through online courses can be in very different domains of learning and development. The basic domains of learning and development are:

- ✓ Language & Communication Development
- ✓ Cognitive Development
- ✓ Health & Physical Development
- ✓ Emotional-Social Development
- ✓ Approaches to Learning

Table 10 Comparison of Assessments and Evaluations features [10]

Aspect	Assessments	Evaluations
Nature	Diagnostic; identifies learning gaps and progress.	Judgmental; emphasizes overall quality and success.
Purpose	Guides individual learning paths, measures understanding.	Determines overall success, informs decision-making.
Timing	Can be ongoing (formative) or specific points (summative).	Can be formative or summative, often at the end of an academic period.
Feedback	Provides continuous feedback for improvement during learning.	Offers feedback for overall improvement and decision-making.
Scope	Focuses on specific skills or broader understanding.	Encompasses a holistic view of performance and outcomes.
Involvement	Involves both the assessor and assessee in a dynamic process.	Involves an assessor making judgments about the assessee's performance.
Goal	Aims at enhancing learning, individual development.	Aims at determining worth, success, and informing broader training decisions.

Many modern authors prefer to use "evaluation" as a generic term to include evaluation done at the program level, the course level, and the student learning level. The simplified structure of this approach consists of [3]:

1. **Macro-level evaluation** - refers to the evaluation of the entire online education program. Such evaluation is important for an online education program for several over-arching purposes which include: (a) justifying the investment of resources, (b) measuring progress toward program objectives, (c) measuring issues of quality and effectiveness, (d) providing a basis for improvement, and (e) informing institutional strategic planning and decision making. From these general purposes, several pertinent evaluation questions can be drawn:
   - ✓ Is the program consistent with the institutional mission?
   - ✓ Does the program have clear goals and objectives, and are there agreed upon provisions and measures for program oversight, accountability, evaluation and assessment?
   - ✓ Are resources allocated for infrastructure and communication technologies, faculty training and support, and student recruitment, retention and support?
   - ✓ Are criteria in place when deciding upon the allocation for competing interests?
   - ✓ Is the program cost-effective? Can a positive return on investment be shown for fiscal costs?
   - ✓ Is the technology delivery system as reliable and secure as possible, including plans for backup and disaster recovery?

2. Meso-level evaluation Meso-level of evaluation refers to the evaluation of individual online education courses. Central to this level of evaluation is the question of what criteria should be used to evaluate online courses and instruction. Based on the available literature were identified and developed ten key questions (criteria) for the evaluation of online courses:

- ✓ Are course objectives, instructor's expectations, and evaluation criteria of assignments well communicated to the learner?
- ✓ Does the course provide students with sufficient support (including instructional and technical) for meeting the course objectives and other relevant needs of students?
- ✓ Does the class encourage students to be active learners?
- ✓ Does the online course encourage learner-instructor contact?
- ✓ Does the online course encourage interaction and collaboration between and among learners?
- ✓ Does the course encourage meta-cognitive skills?
- ✓ Is learning grounded in effective (contextual, authentic) examples?
- ✓ Is the instructor's feedback appropriate for supporting learner learning (e.g., not too much nor too little, just in time, etc.)?
- ✓ Does the class use multiple evaluation methods aligned with course objectives and designed activities?
- ✓ Does the course use technology effectively in supporting learning and teaching?

3. Micro-level evaluation - the focus of micro-level evaluation is on the individual online learner. The evaluation of the individual learner typically falls into one or more of the following three categories:

a) **Learner's Perception** - When learners enroll in an online course, they enter into an educational experience very different from the usual classroom-based face-to-face environment. Current online education courses are usually mostly or entirely text - based, asynchronous, and have multiple discussion threads. As such, course administrators and instructors are usually interested to know how their learners "feel" about the course experience. Because of the difficulty of reaching online learners who are often separated by space or time, evaluation of learners' perception typically involves questionnaire surveys. Some of the common evaluation questions pertinent to this purpose include:

- ✓ Does the learner enjoy the whole course?
- ✓ What attitudes do the learners have towards online learning before, during, and after the whole course?

b) **Learner's Process** - while the learner's perception of online learning can be helpful and useful information, it is usually not sufficient to end just there. Most instructors would also want to know about their learners' engagement in online learning through many different processes such as collaboration, cognition, problem-solving and others. One common method of determining such processes is through a content analysis of the learners' online discussion transcripts. The use of content analysis, however, is not without some problematic issues. Some of these issues include:

- ✓ What kind of unit of analysis should be used - entire message postings, thematic units, or sentences?

- ✓ How is high reliability insured in content analysis?
- ✓ How are "passive" learners evaluated? Passive learners do not participate often in the discussion but consider themselves to have learned a lot from reading and reflecting on the comments and responses posted by others.
- ✓ How is the validity of the content analysis insured? Do the indicators of the content analysis models describe what they purport to describe?

c) **Learner's Product** - typically the evaluation of the learner's product of online learning is used to determine how much knowledge or skills he or she has acquired after the course. This is typically administered in traditional ways such as end-of-course tests, final papers, and final projects. Alternative methods include portfolios and performances.

Assessment

Ensuring quality assessment in online courses is essential for effective verification of participants' knowledge and skills. A quality assessment should be fair, relevant, reliable and adapted to the online environment. Quality assessment in online courses depends on thorough preparation, clearly defined criteria, the use of diverse assessment methods and a fair approach. Regular feedback, minimizing cheating and continuous improvement of evaluation procedures are also important. By combining these elements, assessment can provide not only knowledge testing, but also supports the development of participants and the improvement of their skills. ErgoDesign project output proposal for online course assessment structure:

1. Diversity of assessment methods
   - ✓ **Mix formal and informal assessments**: Include different types of assessments, such as quizzes, tests, assignments, projects, discussion papers, and self-assessments. Diversity gives a better picture of the participants' abilities and eliminates one-sidedness.
   - ✓ **Tests and quizzes**: Use automated tests with different types of questions (multiple choice, short answers, matching, true/false) to allow for instant assessment and feedback.
   - ✓ **Open-ended assignments and projects**: They allow for a deeper assessment of the understanding of the content, especially in skills that require analysis, creation, and critical thinking.

2. Clearly defined evaluation criteria
   - ✓ **Rubrics and grading scales**: Create rubrics with clearly defined grading criteria that explain how different assignments will be evaluated. This way, students will know exactly what is expected of them, and the assessment will be consistent and transparent.
   - ✓ **Clarity of requirements**: Inform participants in advance about the requirements for completing tasks so that they know what the goals of the assessment are and what skills or knowledge are being assessed.

3. Regular feedback
   - ✓ **Prompt and constructive feedback**: Give participants regular and specific feedback to help them improve. Automated systems can provide immediate feedback after the tests, but manual feedback from the instructor should also be part of the assessment.

- ✓ **Self-assessment and peer-assessment**: Involving participants in self-assessment and peer assessment promotes self-reflection and the development of critical thinking.

4. Authenticity and applicability of the evaluation
   - ✓ **Authentic tasks**: Create assessment tasks that are realistic and applicable to real-world situations. For example, project tasks, simulations or solving practical problems help participants better apply what they have learned while also assessing practical skills.
   - ✓ **Formative vs. summative assessment**: Combine formative assessment (ongoing assessment to provide feedback and support) with summative assessment (final assessment after course completion). Formative assessment promotes continuous improvement.

5. Reliability and fairness of the assessment
   - ✓ **Minimize cheating**: Use technologies such as proctoring tools (e.g., online monitoring) or time-limited tests that limit the possibilities of cheating.
   - ✓ **Q&A randomization**: For tests and quizzes, use a random order of questions or answers to reduce the possibility of collaboration or repetition of the same questions.
   - ✓ **Time limits and open-book tests**: Time limits can limit cheating, but consider open-book tests that focus more on applying knowledge than memorizing facts.

6. Technical integrity and accessibility
   - ✓ **Testing Technologies**: Use reliable assessment tools that allow for seamless assignment and grading. In case of technical problems, the availability of technical support is important.
   - ✓ **Accessibility for all**: Ensure that all tests and assessment tasks are also accessible to participants with special needs (e.g. providing alternative forms of assignments or subtitles for videos).

7. Continuous assessment and adaptive approach
   - ✓ **Mid-Term Tests and Quizzes**: Allow participants to test themselves regularly through small tests so that they can continuously assess their knowledge and course progress.
   - ✓ **Adaptive Testing**: Use adaptive tests that adapt to the knowledge level of participants. The complexity of the questions changes according to the previous answers, which gives a better picture of their actual abilities.

8. Transparency and fairness
   - ✓ **Communicate results**: Ensure attendees have clear access to results and feedback. Information about the evaluation must be clearly communicated, including any appeal processes.
   - ✓ **Anonymization of evaluation**: For written works or projects, evaluation may be anonymous in order to minimize any prejudice on the part of the evaluators.

9. Continuous improvement of evaluation procedures
   - ✓ **Satisfaction survey**: Gather feedback from participants on evaluation processes so that you can continuously improve the evaluation and ensure that it is fair and effective.
   - ✓ **Evaluation of assessment**: Regularly review the effectiveness of assessment methods and their adaptation to the course objectives.

Evaluation

A simple framework suitable for easy evaluation of online courses is focusing mainly on the following aspects of "what" to evaluate:

- ✓ participants' individual characteristics;
- ✓ the participative dimension;
- ✓ message analysis and evaluation from the viewpoints of contents and of collaborative work;
- ✓ analysis of interpersonal communication;
- ✓ effectiveness of the support offered by tutors and experts;
- ✓ participants' reaction to the methodological approach adopted for running the course;
- ✓ quality of the learning material;
- ✓ the learning environment in all its forms – local, virtual, social, etc;
- ✓ communication technology;
- ✓ return on investment compared with similar face-to-face courses

Based on the above framework the below listed procedure "how" and "when" to carry out the evaluation – every assessment goal is coupled with the corresponding mode of operation for evaluation:

1. Submission of entry questionnaire - gauge:
   1.1. pre-knowledge and any previous experience in the topic
   1.2. area participants might bring to the course;
   1.3. reason for enrolling and expectations;
   1.4. each participant's learning environment;
   1.5. ICT know-how
2. Monitoring of exercises - verify the outcome of exercises undertaken –
3. Monitoring of computer conferences - verify participation in discussions and contribution to collaborative activities
4. Request for brief progress reports - bring to tutors' attention any useful information for calibrating or reinforcing parts of the course, etc.
5. Request for group production - verify effectiveness of collaborative work
6. Request for individual essays at the end of course modules - verify the extent of content acquisition
7. Request for final project - verify the capacity to apply all the knowledge imparted within the course
8. Submission of a final questionnaire - request for views on:

8.1. Interest in course contents;
8.2. Educational approach adopted;
8.3. Correspondence between expectations and results achieved;
8.4. Learning material used;
8.5. Organisation of activities;
8.6. Individual students' participation modalities (logistics);
8.7. Technical aspects related to networking and use of the suggested technologies;
8.8. Performance of both tutors and area experts in their various roles

9. Observation of placement phase - verify the capacity to transfer knowledge and skills acquired in the course within one's own professional field.

An online course evaluation should be comprehensive and include valuation from content quality to interactivity to participant satisfaction. By taking all these aspects into account, it is possible to effectively identify the strengths and weaknesses of the course and take measures to improve and optimize it in the future. Evaluating is an integral part of ensuring online course quality and effectiveness. It helps not only to evaluate the success of the course but also to identify areas for improvement. The basic structure of online course evaluation should be comprehensive and cover several key aspects. ErgoDesign proposal for such a structure in the form of ten areas:

1. Course objectives and outcomes
   - ✓ **Evaluation of the clarity of the course objectives:** Were the course objectives clearly defined and understandable to the participants?
   - ✓ **Achieving learning outcomes:** Were students able to achieve the desired learning outcomes based on the course? What is the evidence of this (tests, practical tasks, projects)?

2. Quality of course content
   - ✓ **Relevance and timeliness of the content:** Was the course content up-to-date and tailored to the needs of the participants?
   - ✓ **Content structure and organization:** Has the course been well-structured and organized into logical units that make it easy to understand the topic?
   - ✓ **Multimedia content:** What was the quality of the videos, presentations, textual materials, and other forms of content? Were they clear and informative?

3. Interactivity and engagement
   - ✓ **Interaction options:** Did the course offer enough opportunities for interaction between participants and instructors (discussion forums, webinars, Q&A)?
   - ✓ **Interactive elements:** Were interactive tools such as quizzes, simulations, or gamification included to encourage participant engagement?

4. Platform Design and Usability

- ✓ **Ease of Use:** Was the platform user-friendly? Was it easy to navigate between modules, tasks and materials?
- ✓ **Accessibility and compatibility**: Was the course available on different devices (mobile, tablet, computer)? Have access features been provided for participants with special needs?

5. Support and feedback
   - ✓ **Quality of instructor support**: How quickly and efficiently did instructors or support respond to participants' questions?
   - ✓ **Feedback on assignments and tests**: Was regular and constructive feedback provided on assignments? Was the feedback clear and useful for the further development of the participants?

6. Success rate of participants
   - ✓ **Course completion rate**: What proportion of participants successfully completed the course? What could have caused any high levels of incompletion (e.g. complexity, time requirements)?
   - ✓ **Level of mastery of skills**: To what extent have students mastered new skills or knowledge? This can be measured through tests, projects or self-assessment questionnaires.

7. Success of technical solutions
   - ✓ **Reliability of technologies**: Were there any technical problems (outages, slow loading, access problems) during the course?
   - ✓ **Technical support**: Was technical support available and effective in resolving problems?

8. Participant satisfaction
   - ✓ **Satisfaction questionnaires**: At the end of the course, it is advisable to collect feedback from participants through questionnaires. This is where their overall satisfaction with the course, instructors, materials, and platform is evaluated.
   - ✓ **Recommendations and ideas for improvement**: Did the participants have specific suggestions or comments on how to improve the course?

9. Economic efficiency
   - ✓ **Cost vs. benefit**: What were the costs of developing and implementing the course compared to the benefits? This aspect is especially important for organizers or companies that administer the course.

10. Long-term impact
    - ✓ **Skills acquired and put into practice**: Where possible, the evaluation should also include monitoring how participants use the acquired skills in practice. This can be measured through surveys after some time after the end of the course.

3.2 Basic metrics of online course monitoring

In order to obtain a reliable and objective overview of the online course in the required structure, it is necessary to set appropriate evaluation criteria - metrics. The combination of these metrics provides a holistic picture of the online course's performance and effectiveness. Each metric offers a different view of the quality of the course, whether in terms of participant satisfaction, performance, or technical support. Quality evaluation based on these metrics allows you to improve courses, optimize the learning process, and increase student satisfaction and success.

As part of the solution of the ErgoDesign project, suitable metrics were determined, from which the course designer can choose the appropriate ones:

Learner Performance and Progress

Metric 1: Learning Progress

Measuring how participants' outcomes improve throughout the course. It may involve comparing the results of the initial and final tests. It provides a picture of whether participants are really progressing in learning and how their knowledge or skills are evolving. On a basic level, students who progress through your course at a good pace are most likely engaged and invested. That could indicate a strong course design that you can replicate or demonstrate to others. For course progression monitoring are the most appropriate questions:

- ✓ How long does it take a learner to complete a lesson?
- ✓ How quickly do they advance through each topic and lesson?
- ✓ What concepts seem easy, and which seem too difficult?
- ✓ If learners consistently drag, how can I make it clearer?

Learner Satisfaction and Approval

Metric 2: Exit surveys

Just because a learner finished a course doesn’t mean they loved it. Consider sending out a survey after a course finishes (and once learners know their feedback won’t affect the outcome of their grade.) A quick exit survey can capture initial impressions.

Metric 3: Course reviews

Learners may not openly tell you how they’re feeling, but they may leave a review if you ask. You can also ask them how likely they would be to recommend your course to a friend. Reviews are the perfect way to gather feedback and find room for improvement

Metric 4: Instructor effectiveness

Even the best instructors might waver when presenting an online course. Check-in on how instructors are responding to learner requests and how they're communicating with your learners. This is especially important to track if instructors change but not the course material. Is there a difference in engagement?

Metric 5: Discussions and comments

Online discussion threads are a great way for learners to work through material together and feel a sense of community. Monitor group discussions to examine how learners are talking about and interacting with the material. A certain level of engagement in the discussion board can be validating!

Metric 6: Learner Satisfaction

Evaluation of the course by participants using questionnaires or surveys after its completion. Measures how satisfied participants were with the content, instructor, platform, and overall organization of the course. High satisfaction means a positive experience, while low satisfaction points to problems.

Learner Competency and Proficiency

Metric 7: Test Scores / Quiz performance

Results achieved by participants in tests, quizzes and assignments during the course. It provides a picture of how participants understand and master the course content. A low score can mean that the content is too challenging, unclear, or not explained enough. If learners seem to be struggling with a quiz, make sure the quiz reflects the lesson material properly. On the other hand, too many perfect tests/ quiz scores might mean your course (or test/quiz) is too easy!

Metric 8: Quality of assignment submissions

The depth and quality of assignments help course creator get a sense for how learners are engaging with the course. If possible, give learners personal feedback on each assignment (or check the feedback an instructor is leaving). This helps you understand how students are overcoming roadblocks. It can also lead to higher success rates (and reviews!) for individual learners.

Metric 9: Certifications vs Retakes

How long do learners stay enrolled in the course, and do they come back for more? How many finish the course with a certification, or how many need to retake the final test? A strong completion rate is an easy statistic you can track without needing your learners to give you an explicit review.

Course Designer Particulars

Metric 10: Course Completion Rate

The percentage of participants who successfully completed the course compared to those who enrolled. A high completion rate indicates that participants find the course interesting and valuable, while a low completion rate may indicate problems with the content, its complexity, or the motivation of the participants.

Metric 11: Engagement Rate

The degree of active participation of participants in various activities such as discussion forums, quizzes, assignments, and webinars. A high level of participation means that participants are engaged, which is important for deep learning. A low level of participation can signal a lack of interest or problems with the course design.

Metric 12: Dropout Rate

The percentage of participants who left the course before it was completed. A high dropout rate can indicate problems with the course content, its difficulty, technical issues, or unclear goals.

Metric 13: Average time spent in the course

The average amount of time participants spend watching lessons, completing assignments, and interacting with course content. This metric shows whether participants are dedicating enough time to the course and whether the course modules are set up correctly in terms of time demand. Too short a time may indicate a lack of interest or tasks that are too easy.

Metric 14: Net Promoter Score - NPS

The percentage of participants who would recommend the course to their friends (promoters) minus the percentage who would not recommend it (critics). NPS is an indicator of how much participants appreciate the course and whether they find it valuable. A high NPS means that participants would recommend the course, which is a sign of its quality.

Metric 15: Feedback and Reviews

The number of participants who have provided feedback or review and the quality of that feedback. More feedback increases the possibility of improving the course and its individual aspects. The quality of this feedback is important for identifying specific strengths and weaknesses.

Metric 16: Learner Retention Rate

The percentage of participants who enroll in the next course after completing one course. High retention indicates that participants see value in the courses and are willing to further their education within the programs offered. Low retention can signal low motivation or insufficient fulfillment of expectations.

Metric 17: Level of Learner-to-Learner Interaction

The degree of communication and collaboration between participants through discussion forums, group projects, or online discussions. Strong interaction between participants promotes deeper learning and the development of social learning. Low interaction may indicate a lack of opportunities for collaboration.

Metric 18: Instructor Engagement

The degree of involvement of the instructor in answering questions, providing feedback, and supporting participants. The active participation of the instructor increases the success and satisfaction of the participants, as they feel supported and guided.

Metric 19: Material utilization rate

How many participants use different educational materials (e.g. videos, articles, worksheets) and how often. The rate of use of materials shows which resources are most or least useful to participants. Based on this, it is possible to adjust the content and formatting of materials.

Metric 20: ROI (Return on Investment) rate

It measures how much value a course will bring compared to the investment it took to create and execute it. This metric is important from a business perspective, as organizations need to know if a course provides an adequate return on investment.

Metric 21: Number of technical issues

The number of technical issues reported by participants during the course, such as problems logging in, playing videos, or accessing materials. It shows the quality of the technical support of the course. Frequent problems can reduce the quality of the learning experience and lead to dissatisfaction.

4 European Credit Transfer System (ECTS) Recognition Process

Basic rules applicable to the recognition of evaluation achieved by students at different universities in Europe are described in the chapter. The European Credit Transfer and Accumulation System (**ECTS**) is a standard means for comparing academic credits, i.e., the "volume of learning based on the defined learning outcomes and their associated workload" for higher education across the European Union and other collaborating European countries.

ECTS is a Student-Centred Learning (SCL) (in some authors work as “learner-centred system”) for credit accumulation and transfer, based on the principle of transparency of the learning, teaching and assessment processes. Its objective is to facilitate the planning, delivery and evaluation of study programs and student mobility by recognizing learning achievements, qualifications and periods of learning. SCL is a process of qualitative transformation for students and other learners in a learning environment, aimed at enhancing their autonomy and critical ability through an outcome-based approach. The SCL concept can be summarised into the following elements [4]:

- Reliance on active rather than passive learning;
- Emphasis on critical and analytical learning and understanding;
- Increased responsibility and accountability on the part of the student;
- Increased autonomy of the student;
- A reflective approach to the learning and teaching process on the part of both the student and the teacher.

ECTS key features [4]:

1. **ECTS credits** express the volume of learning based on the defined learning outcomes and their associated workload. 60 ECTS credits are allocated to the learning outcomes and associated workload of a full-time academic year or its equivalent, which normally comprises a number of educational components to which credits (on the basis of the learning outcomes and workload) are allocated. ECTS credits are generally expressed in whole numbers.
2. **Learning outcomes** are statements of what the individual knows, understands and is able to do on completion of a learning process. The achievement of learning outcomes has to be assessed through procedures based on clear and transparent criteria. Learning outcomes are attributed to individual educational components and to programmes at a whole. They are also used in European and national qualifications frameworks to describe the level of the individual qualification.
3. **Workload** is an estimation of the time the individual typically needs to complete all learning activities such as lectures, seminars, projects, practical work, work placements1 and individual study required to achieve the defined learning outcomes in formal learning environments. The correspondence of the full-time workload of an academic year to 60 credits is often formalized by national legal provisions. In most cases, workload ranges from 1,500 to 1,800 hours for an academic year, which means that one credit corresponds to 25 to 30 hours of work. It should be recognized that this represents the typical workload and that for individual students the actual time to achieve the learning outcomes will vary.

4. **Allocation** of credits in ECTS is the process of assigning a number of credits to qualifications, degree programs or single educational components. Credits are allocated to entire qualifications or programs according to national legislation or practice, where appropriate, and with reference to national and/or European qualifications frameworks. They are allocated to educational components, such as course units, dissertations, work-based learning and work placements, taking as a basis the allocation of 60 credits per full-time academic year, according to the estimated workload required to achieve the defined learning outcomes for each component.
5. **Awarding credits** in ECTS is the act of formally granting students and other learners the credits that are assigned to the qualification and/or its components if they achieve the defined learning outcomes. National authorities should indicate which institutions have the right to award ECTS credits. Credits are awarded to individual students after they have completed the required learning activities and achieved the defined learning outcomes, as evidenced by appropriate assessment. If students and other learners have achieved learning outcomes in other formal, non-formal, or informal learning contexts or timeframes, credits may be awarded through assessment and recognition of these learning outcomes.
6. **Accumulation of credits** in ECTS is the process of collecting credits awarded for achieving the learning outcomes of educational components in formal contexts and for other learning activities carried out in informal and non-formal contexts. A student can accumulate credits in order to:
    a. obtain qualifications, as required by the degree-awarding institution;
    b. - document personal achievements for lifelong learning purposes.
7. **Transfer of credits** is the process of having credits awarded in one context (program, institution) recognized in another formal context to obtain a qualification. Credits awarded to students in one program may be transferred from an institution to be accumulated in another program offered by the same or another institution. Credit transfer is the key to successful study mobility. Institutions, faculties, and departments may make agreements which guarantee automatic recognition and transfer of credits.
8. **ECTS documentation**: The use of ECTS credits is facilitated and quality enhanced by the supporting documents (Course Catalogue, Learning Agreement, Transcript of Records, and Work Placement Certificate). ECTS also contributes to transparency in other documents such as the Diploma Supplement.

ECTS can be practically applied for [4]:

- Programme design, delivery and monitoring;
- Mobility and credit recognition;
- Lifelong learning;
- Quality assurance;
- Supporting documents:
    - Course Catalogue;
    - Documents for credit mobility:
        - Learning Agreement for work placements
        - Transcript of Records
        - Work Placement Certificate

Conclusion

The presented guide presents the results of the ErgoDesign project "Improving Digital Skills for Ergonomics and Bioengineering Innovations for Inclusive Health Care" (Erasmus Plus project 2021-1-PL01-KA220-HED-000031182) in the form of an online course.

The created online course for additive technologies has the potential to help those interested in creating other similar courses to orient themselves in the process of preparation, running and evaluation.

The course in question, created within the ErgoDesign project, was defined and prepared with a view to gaining an overview of the principles of the use of additive technologies in healthcare. Course participants have the opportunity to study the benefits of implantology in the health care system, the use of biocompatible materials and their processing technologies, the principles of additive technologies, anatomy for implantology, the basics of medical imaging and devices for healthcare, 3D scanning and imaging, and the use of information technology.

The course is focused on the knowledge of optimizing processes for the design of implants taking advantage of additive technologies – especially personification, rapid design, testing of digital models and final implant production.

Since additive technologies depend on the use of specific software tools for modeling, simulation and digital production, course participants become familiar with these tools for effective design and optimization of 3D prints.

These parts of the course provide participants with a comprehensive picture of the use of additive technologies in implantology, their advantages and limitations. The project partners gathered experience and implementation and created this guide as a basic support material for creating similar courses.

References

[1] Rhim H. C., Han H.: Teaching online: Foundational concepts of online learning and practical guidelines, In: KJME, 2020, https://www.researchgate.net/publication/344037329

[2] I-TECH Technical Implementation Guide # 4 – Writing Good Learning Objectives, 2010, I-TECH

[3] Hew K.F. et al: Online Education Evaluation: What Should We Evaluate?, University of South Carolina, 2004

[4] ECTS Users´ Guide, Publication Office of the European Union, 2015, ec.europa.eu/education/tools/ ects_en.htm

[5] An approach developed to help people and organizations perform at the speed of business, https://702010institute.com/702010-model/ (as on May 10th 2024)

[6] Learn Foundational Knowledge, https://ablconnect.harvard.edu/learn-foundational-knowledge (as on May 10th 2024)

[7] How to plan an Online Course. /www.thinkific.com/blog/online-course-planning-templates/. (as on May 10th 2024)

[8] How to Write a Course Description https://www.learnworlds.com/best-course-description-examples (as on May 10th 2024)

[9] LearnDash Academy https://academy.learndash.com/ (as on May 10th 2024)

[10] Suny Oneonta courses.lumenlearning.com/suny-oneonta-education106/chapter/6-1-assessment-and-evaluation (as on May 10th 2024)

[11] The UDL Guidelines, https://udlguidelines.cast.org/#content (as on May 10th 2024)

[12] Universal design for learning, https://opentextbooks.uregina.ca/universaldesignforlearninguofs, (as on May 10th 2024)

[13] 10 Instructional Design Models For Creating A Winning Online Course, https://www.thinkific.com/blog/instructional-design-models/ (as on May 10th 2024)