TEASER

Teacher as Avatar

Teaching and learning scenario

Biomaterials and 3D Bioprinting in Cell Culture

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I. Master Data and Context

- **Scenario Title and Abstract:** The scenario is titled **"Biomaterials and 3D Bioprinting in Cell Culture".** It serves as an advanced learning unit that builds on the foundations of classical 2D cell culture and builds a bridge to modern **3D applications and innovative research approaches**. The core content includes the theoretical introduction and practical application of **tissue engineering**. Learners will learn how hydrogels are modified to optimally support cells and how cell cultures are prepared for the process of **3D bioprinting** to create the first three-dimensional cell constructs (e.g., alginate structures). As usual in the TEASER scenarios, knowledge transfer is hybrid through **AI-supported learning videos** that can be accessed directly at the laboratory stations via QR codes.

- **Occupational field and target group:** This scenario is located in the field of **biology, chemistry and bioprocess engineering** .

    - **Target group:** The scenario is primarily aimed at **trainees (VET apprentices) from the 2nd year of apprenticeship**.

    - **Occupational profiles:** Prospective biology laboratory assistants **and** chemical laboratory assistants **who already have basic knowledge of aseptic work and are now to acquire specialized skills in regenerative medicine and additive manufacturing** are particularly addressed.

- **Learning objectives:** Competence development is divided into three categories:

    - **Knowledge:** Participants understand the physicochemical basics of **hydrogel modification** as well as the technical principles of **3D bioprinting**. You will acquire knowledge about the relationship between material properties (e.g. viscosity, biocompatibility), cell compatibility and the structural design of tissue constructs. They also know the specific health and safety regulations for the operation of bioprinters in the laboratory.

    - **Skills:** Learners are able to modify hydrogels according to exact specifications and safely embed cells in them. You will be proficient in **setting up and operating a 3D bioprinter** as well as controlling the printing parameters. In addition, they learn the skills to assess the printed 3D constructs microscopically and to document them in terms of cell health, structural integrity and freedom from contamination.

    - **Competencies:** Trainees develop the ability to critically evaluate the practical relevance of 3D bioprinting methods for research and clinical application. They can independently develop transfer ideas for future projects and systematically compare their results with target values in order to identify optimization potential in the printing process.

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II. Educational Design

- **The "Educational Question":** The central pedagogical challenge of this scenario lies in the complexity of the transition from classical 2D cell culture to modern **3D applications such as tissue engineering**. Trainees must not only master highly sensitive biological techniques, but also understand the physicochemical parameters of new tools such as **3D bioprinters** . The specific "educational question" is: **"How can AI-powered avatars and adaptive media be used to make the teaching of complex, technologically sophisticated process flows (such as hydrogel modification) more consistent, task-related and individual?"**. The use of AI media solves the problem of **cognitive overload** in the simultaneous handling of biological material and digital machine technology by providing asynchronous support directly at the point of action.
- **Didactic setting:** The scenario is theoretically embedded in the **SAMR model** and reaches the level of **"modification" (redesign),** as the use of QR code-based avatar instructions and AI-generated tasks functionally changes the learning process and enables individualization that would not be feasible without this technique. In addition, the European competence framework **DigComp 2.2** (or DigCompEdu) is applied by promoting the **digital sovereignty** of learners in dealing with AI systems and process control. Station-based learning is used as a teaching method : Learners move independently or in small groups between different workstations (e.g. sterile workbench for cell preparation and station of the 3D bioprinter), linking theory and practice through interaction with the avatar and digital work instructions.
- **Role of the trainer/teacher:** In this scenario, the teacher undergoes a change from pure knowledge imparter to **moderator, coach and pedagogical advisor**. While the avatar takes over the standardized, repetitive instructions (e.g. on device safety or hydrogel production), the instructor focuses on the following tasks:
    - **Safety monitoring:** Monitoring compliance with health and safety rules (H&S) during the operation of the bioprinter.
    - **Technical expertise:** Answering in-depth scientific questions about cell compatibility and material properties that go beyond the standard instructions.
    - **Quality assurance and feedback:** Carrying out plausibility checks of the AI results and individual support in the analysis of the microscopic images of the 3D constructs.
    - **Reflection support:** Moderation of the final discussion on the ethical aspects and the future of bioprinting in research and clinical application.

III. Technological implementation

- **AI and avatar solution:** In this scenario, **linear 2D AI-generated avatars** are primarily used to act as **digital tutors and demonstrators**. In the learning process, the avatar takes on the role of a specialized laboratory companion who introduces the complex theoretical foundations of **tissue engineering** and guides the learners step by step through the phases of hydrogel modification. A central function is its use as a **demonstrator for machine safety**, whereby the avatar visually explains the correct setup and operation of the **3D bioprinter** and asks specific comprehension questions at the end of video sequences that must be answered in the system. Although the project also experiments with 3D environments and avatars, the visual embodiment here deliberately remains low-threshold in order to ensure easy practicality in everyday laboratory life.

- **Technical tools:** The technological infrastructure for this scenario combines real laboratory hardware with specialized AI software:

    - **AI software: ChatGPT** (GPT-4) is used for didactic script optimization and for the automated creation of knowledge quizzes from video transcripts.

    - **Avatar and speech generation:** HeyGen **is used for the visual animation of the avatars** , while the natural speech output is generated by **Eleven Labs** (11 Labs).

    - **Interactive media: H5P** and **Hedra** are used to create complementary 360-degree learning environments where trainees can interact with lab objects.

    - **Hardware triggers:** Physical **QR codes** are attached directly to the laboratory stations (e.g. on the bioprinter) and enable mobile access to the instruction videos via **tablets or smartphones**.

    - **Subject-specific hardware:** The practical implementation is carried out on a **3D bioprinter** (e.g. for the creation of alginate structures) and using a **reversible microscope** for quality control.

- **Software-hopping approach:** The content is created via a technical chain established in the TEASER project **(software hopping),** which enables teachers to produce professional media without programming knowledge:

1. **Content capture:** The teacher first creates a technical guide or a raw script based on real laboratory processes.

2. **Text optimization:** This transcript is linguistically refined by **ChatGPT** and converted into a didactically structured avatar script.

3. **Media synthesis:** The optimized text is voiced in **Eleven Labs** and then imported into **HeyGen** to lip-sync the avatar.

4. **Distribution:** The finished video is uploaded to **YouTube** and linked via a **QR code** . This process ensures a high level of consistency of the instructions while at the same time minimizing the creation effort.

IV. Detailed Lesson Plan

This lesson plan is designed to combine the fundamentals of classical cell culture with state-of-the-art additive manufacturing and is hybridly supported by AI media.

1. Introduction and orientation

- **Duration:** 30–45 minutes.
- **Content:** Learners will receive an introduction to the **basics of hydrogel modification** and the technical principles of **3D bioprinting**. The critical relationship between material properties (e.g. viscosity), **cell compatibility** and the structural design of tissue constructs is taught. In addition, the specific **health and safety regulations** for working with bioprinters in the laboratory are explained.
- **Activities:**
  - **Learners:** Follow the **AI-supported learning video via QR code**, take notes on the complex processes and plan the practical work steps for the subsequent hydrogel modification. They also prepare their laboratory station and the required materials independently.
  - **Lecturers:** moderate the introduction, clarify technical questions of understanding and check compliance with safety regulations as well as the correct provision of the starting materials.
- **Media: AI avatar videos** (combined with AI speakers), digital work instructions, safety data sheets, hydrogel materials, and cell cultures.

2. Execution of the task

- **Duration:** 90–120 minutes.
- **Contents:** Practical modification of hydrogels, **preparation of cells** (e.g. L929) and their embedding in the biomaterial as well as the **creation of first 3D cell constructs**. The focus is on precise control of printing parameters and monitoring of material integrity.
- **Activities:**
  - **Apprentices:** Modify hydrogels according to exact specifications, embed the cells aseptically and set up the **3D bioprinter** . During the printing process, they continuously check the constructs for structure, cell health and potential contamination.
  - **Instructors:** Monitor sterile **work** under the workbench as well as the technical parameters of the printer; they provide immediate technical feedback in case of problems.
- **Media:** 3D bioprinter, sterile workbench, reversible microscope, pipettes, special AI learning videos on printer operation and hydrogel modification.

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3. Evaluation / Review

- **Duration:** 30–45 minutes.
- **Contents:** Systematic **documentation of the print results** and material modification as well as the assessment of cell **morphology** within the printed structures.
- **Activities:**
  - **Learners:** Photograph the printed cell constructs using a **microscope eyepiece camera**. They create a detailed protocol, evaluate print **accuracy and confluence**, and critically compare their results to the specified **set points**.
  - **Lecturers:** Check the documentation for completeness, support the difficult image analysis of the 3D constructs and give feedback on the print quality achieved.
- **Media:** Reversing microscope with eyepiece camera, avatar video for camera operation, digital protocol templates.

4. Completion of the session

- **Duration:** 20–30 minutes.
- **Contents:** Reflection on the **practical relevance** of the methods in research and regenerative medicine as well as discussion on the scalability of the methods.
- **Activities:**
  - **Apprentices:** Take part in a final presentation, observe examples of clinical applications and develop **their own transfer ideas** for future research projects.
  - **Lecturers:** Present further application examples from practice (e.g. tissue engineering), moderate the discussion and evaluate the transfer proposals of the trainees.
- **Media:** Digital presentations or posters, minute sheets for final reflections.

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V. Resources and collateral

1. Videos

The technical mediation is based on AI-optimized **HeyGen avatar videos**:

- **Video 1: Making the Alginate Ink**
    - *Contents: Instructions* for the precise weighing of **sodium alginate (0.2 g)** and **hyaluronic acid (0.02 g).**
    - *Process:* Step-by-step explanation of the addition of deionized water and homogenization by means of a stirring rod and the subsequent storage in the 15 ml Falcon tube.
- **Video 2: Production of the gelatine suspension**
    - *Content:* Presentation of the required laboratory equipment (centrifuge, heating mixing plate, kitchen mixer) and chemicals (**gelatine powder and calcium chloride solution**).
    - *Process:* Focus on removing foaming by repeated centrifugation to achieve printable consistency.
- **Video 3: Preparation and 3D bioprinting**
    - *Contents:* Technical setup of the bioprinter, including filling of the pressure syringe (bubble-free) and fixation of the petri dish by means of vacuum grease.
    - *Software: Instructions for the* Cura Lulzbot **slicer program**, in particular how to adjust the **flow rate from 75% to 100%** for optimal extrusion.
- **Video 4: Hydrogel Modification and Recultivation (L929)**
    - *Content:* Comparison of different coatings (**poly-L-lysine vs. collagen**) to increase cell adherence on the biocompatible surface.
    - *Result:* Optical evaluation of gel stability and recultivation results after addition of the medium.

2. Interactive Components

The scenario integrates various tools for active knowledge verification and support in case of technical problems:

- **Knowledge quizze (questions 37–52):** An extensive catalogue of 16 questions covers all process-relevant details.
    - *Examples:* Why does the gelatine have to be mixed during aliquoting? (Ensuring equal concentration). What happens to uncoated alginate? (It dissolves quickly).
    - *Feedback loops:* Each question provides **immediate pedagogical feedback** that not only confirms the correct answer, but also provides the scientific rationale (e.g., influence of air bubbles on pressure).

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- **360-degree environments (H5P/Hedra):** Interactive visualizations allow learners to virtually interact with laboratory objects and get more in-depth information about material properties.

3. Media Portfolio

- **Avatar Suite:** Linear 2D videos created with **HeyGen** and voiced over **11 labs** that act as structured visual instructions.
- **YouTube archive:** All instructional videos are accessible via the central **TEASER YouTube account** and linked via **QR codes** directly at the laboratory stations (bioprinter, sterile workbench).
- **Visual documentation:**
  - Screenshots of the correct settings in the Slicer program (G-code creation).
  - Graphical representations of cell morphology in 3D constructs to support image analysis using **a microscope eyepiece camera**.
  - Plausibility check templates to detect AI misinformation (hallucinations).