U.EDU

Unified Education –
Medienbildung entlang der Lehrerbildungskette

BIOPROCESS ENGINEERING MEETS AUGMENTED REALITY
– Research-Based Experimentation in the Digital World of STEM Education

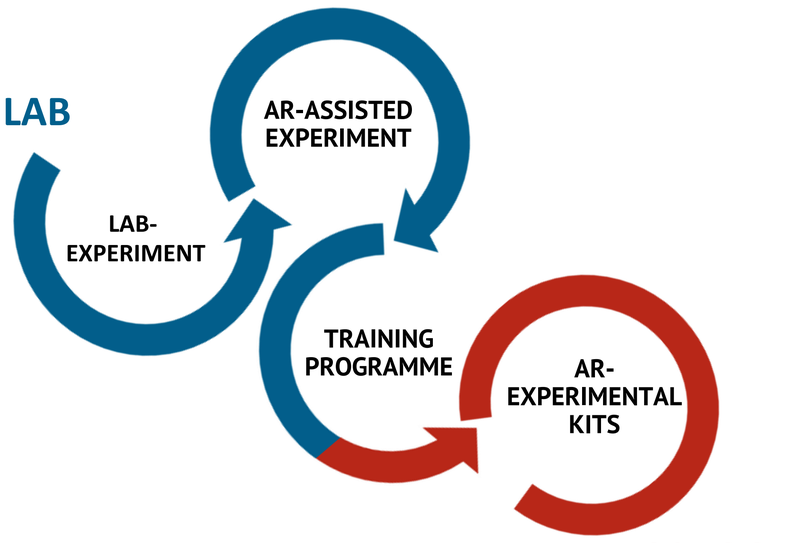
Introduction and Motivation

Augmented reality (AR) is a 3D technology which supplements reality. AR allows the user to see the real world, with virtual objects superimposed upon or composited with the real world [1]. AR has become a popular topic in educational research in the last few years [2].

The media qualities of AR and the combination of real and virtual elements aim to **enhance learning** and **reduce cognitive load** [3]. The potential **educational benefits** of AR are particularly relevant to the fields of natural science and engineering science. This is shown by studies which describe **positive effects** of AR on the development of spatial skills, practical skills, conceptual understanding and scientific inquiry learning [4].

In the **ARWIN** project, laboratory experiments in bioprocess engineering are supplemented by AR applications. The experiments focus on biorefinery, biocatalysis, process engineering and bioprocess engineering and are implemented in the education fields of **S**cience, **T**echnology, **E**ngineering and **M**athematics (**STEM-Education**).

In order to integrate the augmented laboratory experiments into the experimental phases of science lessons, the materials are integrated into **experimental kits**. Teachers can rent these experimental kits. In addition, training programme is offered.



Conceptual Framework

A specific idea of combining the real experiment with AR applications allows achieving the research projects purposes.

AR applications as:

- **additional further information**,
- **assistance to the learning content** and
- **guidance on the experimental procedure**.

The AR applications provide the intelligent guidance system or an assistance to the real experimental procedure. The **multimodal augmented learning aids** allow additional access to the learning content and the experimental procedure.

In this way, the students should be able to delve deeper into the natural and engineering sciences.

Study Purpose

The AR-assisted instructional scenario investigates in a field study with high school students and teachers. The aim of this study is to optimize the AR application on selected factors in a school-specific and student-oriented way.

Study variables in quantitative studies with high school students:

Cognitive Load | **Usability of AR Application** | **Interest in subject and topic**

Study variables in quantitative and qualitative studies with teachers:

Willingness to use AR | **Suitability of AR Application** | **Challenges of AR Application**

"Augmented" Experiment in STEM Education

EXAMPLE FOR LEARNING CONTENT:

"BRINGING BIOTECHNOLOGY TO LIFE" - RESEARCHING ALGAE GROWTH WITH A LOW-COST PHOTOMETER

In this experimental kit, students learn about the cultivation of microorganisms in bioreactors and cultivate the microalga *Microchloropsis gaditana* under specified cultivation parameters in a bioreactor they built by themselves (Fig. 1).

In the process, photometric measurements are conducted periodically using the low-cost photometer (desklab gUG; Fig. 2) to measure the growth of the algae. In addition, the experimental kit includes additional experiments concerning factors which affect algae growth, such as cultivation with copper sulfate or different light intensities.

Fig. 1: Cultivation of *Microchloropsis gaditana*

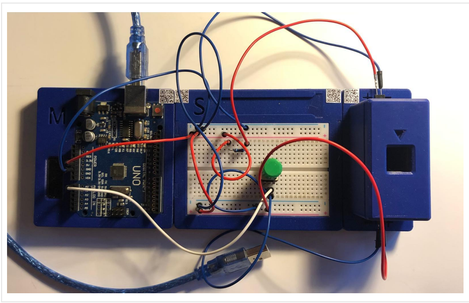


Fig. 2: low-cost photometer (Desklab gUG) / QR-Code: Video for more information

EXAMPLE FOR AR APPLICATION:

"EXPLORING THE COMPONENTS OF THE PHOTOMETER" (Fig. 3)

- All red elements are superimposed on a mobile device (e.g. tablet);
- Text-based and video-based information and further information sources are shown when the respective red buttons are pressed;
- Students individually choose their preferred presentation of the learning aids.

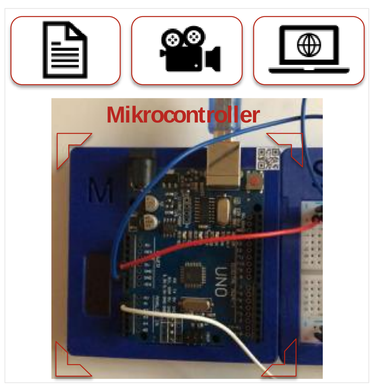


Fig. 3: Plan of the AR application for a component of the photometer

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