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An AI-based lesson planning software to support competency-based learning

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Abstract
Teaching is a complex and cognitively demanding process and a very creative task. A lesson must be carefully prepared to ensure effective, purposeful teaching. Nowadays, lesson plans are also often created using standard software, such as learning or content management systems. It is obvious that this complex process of lesson planning can be supported by specialized software systems that not only facilitate routine tasks but also encourage reflection. This paper explains the idea and concept of a lesson planning software based on artificial intelligence technologies to support competency-based learning. Through the software, teachers should be able to generate individualized learning content easily and intuitively without losing their pedagogical freedoms. Through various user scenarios, the possibilities of the software are demonstrated and explained. Finally, this paper aims to raise awareness of such intelligent learning environments and how they enable an automated development of learning content along the lifelong education chain.

Keywords: *Digital education; Lesson planning; Artificial intelligence; Competency-based learning.*

1. Introduction and problem definition

The requirements for competency-based and student-centered teaching are enormously high and diverse, which is reflected in a high workload when planning lessons. Together with various non-teaching commitments of teachers, this means that the actual workload of the majority of teachers is significantly above their target. A study by the University of Göttingen (Mußmann, 2020) found that teachers work an average of 48.5 hours/week. However, the share of actual teaching activity is only 35%. According to the study, 27% of teachers' working time is spent preparing for and following up on lessons, 7% on travel and 31% on other non-teaching activities. The abundance of non-teaching activities in particular means that the preparation and follow-up of lessons suffers, which has a negative impact on the quality of lessons and is in clear contrast to the high-quality standards expected from teachers. According to the study, this divergence between demands and reality is reflected in a very high level of stress for teachers, for whom significantly higher staff burnout values were recorded than in other occupational groups (Mußmann, 2020).

The abrupt switch to distance learning in March 2020 due to the COVID19 pandemic once again highlighted existing deficiencies and the need for action with regard to digitalization and the use of digital media and formats in teaching, not only in Germany. The pandemic years have shown that digital education and in particular good quality learning materials and digital teaching strategies are very important (Daniel, 2020). The quality of the teachers' classroom delivery and consequently the students' learning opportunities depend on the quality of the lesson planning (Li et al., 2009). Therefore, planning is considered an essential component of teacher education (Kang, 2016). However, several studies have examined the difficulties teachers face in lesson planning: they have been found to be unable to design tasks that are valid and satisfying for students (Ainley, 2012); to be unclear about the different learning objectives (Liyanage and Bartlett, 2010); to have no idea how to begin lesson planning (Schmidt, 2005); and to find it difficult to draw from their knowledge of the subject when planning lessons (Bigelow and Ranney, 2005).

As teachers plan their lessons in advance, they need to be able to access lesson planning tools and implement and review their plans. However, as there are not many such planning tools available to support teachers' work process, the creation of high-quality digital learning resources is very difficult and time-consuming (Strickroth, 2019). This paper gives an overview of the development process and the features of the digital, web-based platform called CLEVER that aims to close this gap by providing teachers and trainers a tool for creating competency-based digital and analog teaching resources with the help of artificial intelligence (AI).

The remainder of this paper is structured as follows: Section 2 explains key terms necessary for further understanding of this paper. Section 3 introduces the AI-based software tool

CLEVER and explains its purpose, architecture and possible user scenarios. The paper ends with conclusions and an outlook on further work in section 4.

2. Key Terminology

2.1 Competency based learning

Competency can be defined as the set of knowledge and skills that the student is expected to master and understand after completing the learning process (González and Wagenaar, 2003). Competency-based learning is a pedagogical approach that focuses on the mastery of measurable learning outcomes. The evaluation of student progress is based on whether students demonstrate mastery of predetermined competencies (Albanese et al., 2008). Although competency-based learning has its roots in the early 20th century and mastery learning, it became more widely spread in the 1970's (Henri et al., 2017). The instructional approach set itself apart from others by allowing the students to progress in their own pace and ensuring that the students mastered all the predetermined learning outcomes before moving on to the next level. Competency based learning approach aims to create flexibility and allow students to progress as they demonstrate mastery of learning content, regardless of time, place, or pace of learning. It emphasizes student-centered strategies that highlight the need for personalization of the learning process (Henri et al., 2017).

2.2 Artificial intelligence in education

Nowadays, AI has become omnipresent and AI systems are already being used in many areas such as the automotive industry, banking, medicine and social media (Popenici and Kerr, 2017). Consequently, the lives of many people are already directly or indirectly affected by AI technologies. The growing availability of data due to the constant connection to the Internet, as well as the constantly increasing processing power of computers to handle the large amounts of data, offer new opportunities for the development of AI systems (Fukas et al., 2021). The situation is similiar in the education sector. Schools are using more digital devices and learning platforms to simplify organization. Companies are striving to develop AI systems that support teachers and learners in various educational situations. The potential applications of AI systems are also stimulating a discourse on different forms of teaching and learning. In particular, new possibilities in the personalization of learning content through AI increasingly raise questions about the choice of the form of instruction (Popenci and Kerr, 2017). Student and school assessment, grading and scoring of papers and exams, and personalized intelligent teaching represent just a few exemplary scenarios for AI in education. In summary, AI-enhanced education includes smart education, innovative virtual learning, and data analytics and prediction (Chen et al., 2020).

3. Towards an AI-based software tool for creating competency-based learning content

As mentioned in the introduction, there is a remarkable gap between the very high expectations towards teachers regarding the quality of their competency-based digital learning scenarios and the level of available support provided to them in the planning and conducting of lessons in the context of the abruptly changed circumstances due to the ongoing COVID19 pandemic. The authors are proposing an AI-driven software tool to scaffold the work process of teachers and trainers and make it less time consuming, so that they could focus on the important parts of the teaching process while the software takes over the time consuming but mundane tasks in the material creation phase.

3.1 The design process of the platform

The user research and design process started with a desk research followed by participatory design workshops where teachers and university lecturers helped the design team to map the main pain points in the usal process of preparing learning content. This was done in several collaborative design sessions where the designers moderated the mapping of user journeys and ideation for finding better solutions to the identified bottlenecks.

Based on the participatory design sessions, the designers drafted the first wireframes that were introduced to the stakeholders. This started a cyclical design process where the prototypes were specified and improved over several months in many design-proposal-feedback iterations. As soon as the prototype was mature enough, first user testing sessions were carried out to validate the design ideas and get feedback regarding general usability from target group representatives who were not involved in the design process.

3.2 Development and software architecture

At the same time, the development team started to choose the tools for the technology stack and to set up the initial services. The software architecture of the platform composes of four levels: (1) Didactic Guidance, (2) Content Management, (3) Platform Services and (4) Data and Services. Figure 1 provides a graphical overview of the software architecture. The individual levels are explained in more detail below.

Didactic Guidance

The didactic guidance layer contains the support that the platform offers to the user in two different ways. On the one hand, the platform provides a structure that guides the user through the preparation process of the learning materials. The content creation in the authoring tool enables the user to structure the lesson into different phases. The lesson phases include the five E-s: engage, explore, explain, elaborate and evaluate (Bybee et al., 2006). Each lesson planning also starts with the selection or definition of the competencies that the teacher would like to foster with this material. The platform already includes the curricula that are relevant for the users work as part of the setup for a specific institution or user. However, it is also possible to flexibly define new competencies, if needed. These steps ensure that the user pays attention to the lesson structure and is guided by a competency-based approach.

The AI based recommendation system builds on the structural elements of the platform, taking into account the lesson phase and the selected competencies as well as user preferences and previous activities on the platform. This way, the CLEVER platform provides an AI-based recommendation system that helps the user choosing existing content from the platform library or creating new content. The content can be added to a lesson in three different ways: (1) by uploading or embedding existing external content; (2) by selecting previously created content from the CLEVER platform library; or (3) by creating new content with the help of the platform authoring tool, that provides a number of different format-templates (e.g. a timeline, hotspot image, word-puzzle, interactive story etc).

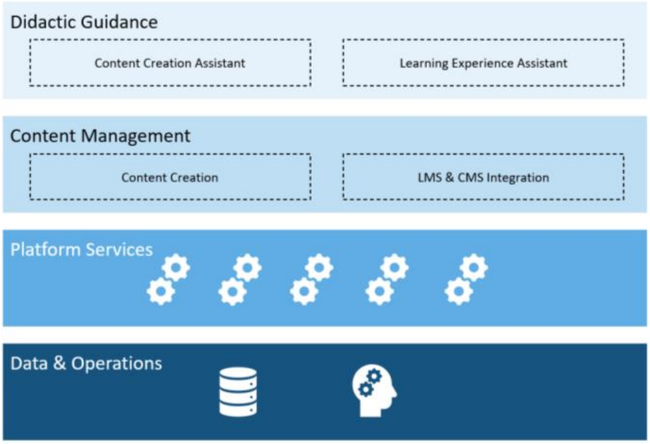

Figure 1. Overview of the CLEVER software architecture. Source: Own illustration.

Content management

Level two contains the functions for creating, managing and using content, which are also offered by conventional Learning or Content Management Systems (LMS/CMS).

Platform Services

This level provides the necessary basic services that are required to develop the functionalities. These include, for example, authentication, user profiles, roles & rights or persistence. The services are organised in a service architecture and operated as Docker containers.

Data & Operations

This level contains all the technical functions necessary for a trouble-free and scalable operation of the platform. In the context of high availability and system reliability as well as load distribution, a containerisation concept is used.

3.3 The CLEVER platform use-scenario

The platform has two main use scenarios. The first scenario evolves around creating new content. In this case, the user starts with a blank authoring tool, where they first choose or define the competencies that they would like to address with their lesson or learning material. Thereafter they start adding content to each lesson phase by either uploading/embedding external content, choosing content from the recommendations provided from the CLEVER platform library or creating new learning elements by using templates recommended by the AI. In each phase of the lesson, the user can describe the student-teacher interactions, add notes about the materials or technology that they want to use to carry out the planned activities, specify the duration of the activities and the social arrangement (e.g. individual work, group work, etc.).

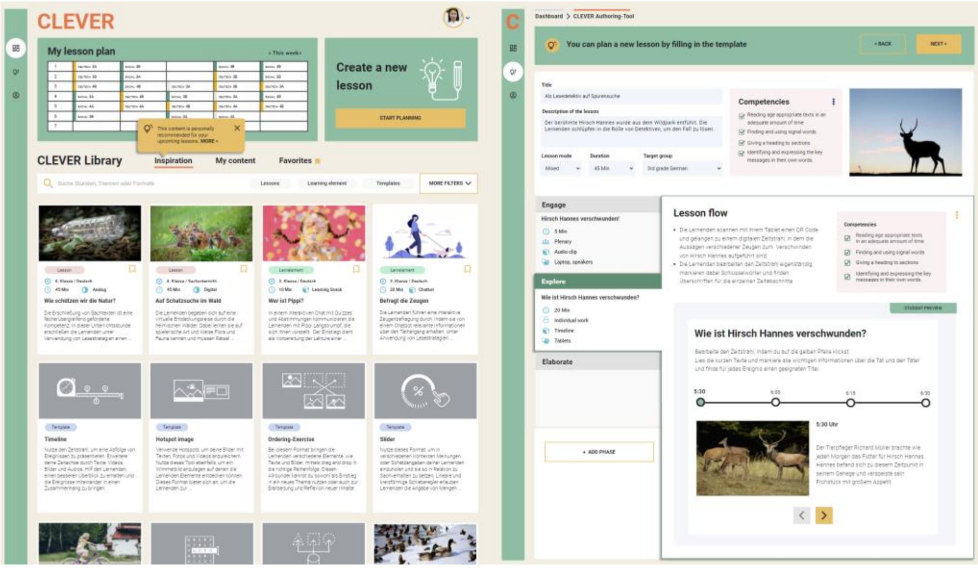

Figure 2. The CLEVER platform dashboard (left) and the authoring tool (right). Source: Own illustration.

When the user has defined the competencies, phases and added content to the corresponding lesson plan, they can finish the lesson planning by getting a summary overview of the lesson plan as well as the preview of the materials that will be later made available for the students. The user can decide, how they make the materials available to the lesson participants – the

CLEVER platform provides options to export the content for both digital or in-classroom lessons.

The second main use scenario evolves around using and editing existing lesson content from the CLEVER platform library. The user can search and filter the library based on keywords, topics, subjects, and curricula or competencies. If the user finds a relevant existing lesson, they can use it straight away or decide to edit it. In the latter case, they might want to change the content of just one of the lesson phases by adding or embedding a custom learning element.

5. Conclusions and further work

The CLEVER software is currently in the last phase of development and will be tested in a final step within the framework of a scientifically accompanied evaluation and piloting process together with teachers from different types of schools in Germany. The evaluation foresees several iterations in which the software pilot is tested by potential end users over a defined period of time. After this test phase, several interviews are to be conducted with the testers to obtain additional, richer and more realistic information about the handling and use of CLEVER. This extensive evaluation process will ensure a successful transfer of the software into school practice.

This paper aims to introduce the idea and concept of the AI-based lesson planning software CLEVER. The focus lies on the specific support of teachers in the planning of didactically valuable lessons. The special innovative character of CLEVER is defined by the use of various AI technologies. These technologies provide teachers with precise recommendations on how their teaching units can be prepared according to didactic principles by taking into account many aspects of lesson planning such as diverse teaching methods, mix of diffenrent social arrangements and media as well as competency orientation. In addition, the AI-supported planning process helps teachers to reflect on their lesson design, evaluate possible options and thus build up self-confidence for the practical implementation of the lesson. Hence, for the first time, the CLEVER software as an intelligent learning environment enables an automated development of learning content along the lifelong education chain - from primary school to in-company training and further education. At the end, teachers always decide for themselves which suggestions from the software they accept. This way, the current possibilities of digitalization are used without restricting the teachers' self-determination and freedom of decision. Thus, CLEVER is not only the name of the software, but also, in a figurative sense, the name for the intelligent interaction of digitalization and education along the lifelong education chain.

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