Higher Education in Mathematics with Interactive Media

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ABSTRACT

Interactive media are increasingly used more often than conventional print media at universities. This also causes a change in classical mathematics education. Therefore, interactive learning media, such as online memory games, video assessments and spoken answers are used at Brandenburg University of Technology Cottbus-Senftenberg (BTU). These materials present new requirements for teachers, students as well as technical infrastructure. In this article, the didactic added value is shown. At the same time, error sources and possible solutions are shown.

Keywords: interactive media, education, mathematics, higher education, assessment, video, multimedia, online courses, moodle

1. PREMISE

The gap between necessary and actual abilities is extraordinary large in the mathematics knowledge of many engineering study beginners. [1] In addition, it is important to emphasize the fact that it is increasingly difficult to motivate students to use classical teaching material such as print media. [2] As an equivalent teaching form, various digital media are possible to offer. These are more oriented towards the multimedia centered worlds (e.g. YouTube) of students. [3][4] The time available in mathematics lectures to compensate for the knowledge deficits is often not present in the first semester due to the abundance of mathematical content. Particularly in the first study semesters at the BTU, courses in engineering (mechanical engineering, electrical engineering, and industrial engineering) are taught in which, due to the further course of studies, deepened mathematical knowledge is required. The lecture in the first semester for mechanical engineers and industrial engineers includes:

- 1. Principles (quantities, statements, numbers, complex numbers, equations and inequalities)
- 2. Linear algebra (vectors, matrices, operations with matrices, scalar and vector products, solving linear equations, determinants, eigenvectors and values, principal axis transformation)
- 3. Analysis I (sequences and series, functions of a variable, limit values and continuity, differential and integral calculus of functions of a variable, Fourier transformation)
- 4. Differential calculus I (ordinary differential equations of first and second order) [5]

For mathematics-based learning events in the student entrance phase, a concept was developed within the BMBF-funded project "Exzellenz von Studium und Lehre - individueller Studieneinstieg, innovative Studienmodelle, Forschendes Lernen" (Exuellenz von Studium [...]) which is based on hybrid teaching forms, which is described in more detail in the following chapters. The concept of hybrid forms of teaching is in this paper a synonym for the word pair "blended learning". In addition to self-assessments in the learning platform moodle of the BTU and learning platform-independent applications (self-developed learning APPs for tablets and smartphones), interactive materials were also developed as digital learning offers. They aim to identify the students' existing knowledge gaps. Students should then be able to complete the gaps by means of an individual exercise plan. The Projekt Exuellenz von Studium [...]is currently in the second funding phase. This phase will run until the end of 2020. The funding guidelines are part of the Qualitätspakt Lehre (QPL). This guideline is intended to improve the quality of study at German universities. Various universities are supported throughout Germany.

2. TECHNICAL BACKGROUND

In addition to the didactic scenarios, an easy-to-use technical solution plays an important role in the development of interactive learning media. Therefore, in this section, the technical characteristics of the learning platform, used modular extensions and solutions for video streaming and development will be presented.

2.1 Learning platform at BTU

A large part of the interactive media is offered within the BTU learning platform moodle. Moodle is supervised by employees of the multimedia center. The technical infrastructure of the learning management system is operated in BTU's data center. Currently, moodle at the BTU is running in version 3.3. Various adjustments were made within the platform. This includes the graphic representation Landing Page, but also modules developed at the BTU, such as the course category finder.

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Figure 1. Start Page of the BTU moodle System

The moodle platform of the BTU was especially adapted for mathematical applications. For example, question types such as "Stack" [6] and "Question type Formulas" [7] were implemented. The moodle text module "Mathslate" [8] has been installed for the better representation of mathematical expressions in textual form. Another moodle module within the platform is H5P. It was developed directly for the creation of interactive media and is briefly presented below.

2.2 H5P module

H5P is a free and open source software for creating interactive (learning) content for the web. Joubel, a company cofounded by the open source companies Amendor AS and Cerpus AS, is currently the main developer of the project. Nevertheless, H5P is a community driven development. So other companies and volunteers are also free to further develop the project. In addition to moodle, an H5P plugin can be integrated into "WordPress" and "Drupal" pages. [9]

Within the moodle platform, the H5P module is listed as an activity. H5P offers content types differentiated according to "Games", "Multimedia", "Questions" and "Social Media". 36 different content types are currently supported by H5P. (Figure 2) H5P and the associated interactive media were put into production this year at the BTU.



Figure 2. Adding H5P activity into the BTU moodle platform (left); different H5P Content types within the activity (right)

The H5P modules "memory game", "speak the word" and "interactive video" are described in chapter interactive media.

2.3 Video streaming and production

The streaming server bases on the free system Kaltura Community Edition Video Platform (Kaltura CE). [10] [11] The administration of the virtual servers occurs about Virtual Machine Monitor (VMM) with the open source virtualization platform XEN. [12] The administrator is able to control, start and stop the virtual servers. The streaming service based on the HTTP protocol. Adaptive streaming based on HTTP enables the client to dynamically adapt the quality of requested video according to the available bandwidth, thus providing a better user experience and quality of service. [13]

During the upload the videos are converted equally automatically into the desired formats. According to size of the video, the number of videos converting at the same time, number of the formats to be converted and server capacity, the process lasts some minutes up to hours. The users who watch videos notice nothing of the process because the conversion is independent of the streaming process. [14]

Teaching videos used to create interactive media have been created by the software Camtasia Studio (Camtasia). The videos use a consistent background image. This is a checkered note book. The booklet is placed on a wooden table. There is a yellow "Post It" on the right upper edge of the notebook. At the bottom corners of the booklet is the BMBF logo. This background does not change during the video except by zooming in and out. The fixed background was selected in such a way that the otherwise dynamic form of the videos would place increased demands on the learner because of the volatility of the information. [15]

The videos have a maximum length of five minutes to ensure the best possible attention of the learners. [16] Various animations can be integrated using Camtasia. The texts within the video are animations that are displayed using Camtasia. The texts were sounded after the production and synchronized with the texts with the video processing software. Within the animated texts, a predefined navigation on the notebook took place through different zooming and panning functions along the appearing textual units. These additional animations were chosen to keep the text size similar to the font size. In addition, more content could be placed on a page. The proximity to the learner's own reading and writing was thus maintained.

The videos are not adjusted by a professional speaker or by a constant voice produced by the computer. Students and mathematic lecturers act as speakers. They have developed a textual script with their own vocabulary, which is also used in teaching units, on the basis of their experience gained during lectures. Particularly through the student tutors, a low-threshold access was achieved via the language. These often avoid too many technical terms and explain facts in their own simplified language. [17][18]

3. INTERACTIVE MEDIA

After explaining the technical infrastructure at the BTU for the creation of interactive materials in the previous chapter, three examples will now be presented.

3.1 Memory Game

Memory games are not a novelty in the field of didactics. This game is a popular card game played by children and adults around the world. [19] Due to the general familiarity and the easy-to-learn game principle, uncomplicated access can be achieved. The game offers itself in the search for 2 identical picture or word pairs to strengthen the factual knowledge. If, on the other hand, word or image pairs are sought which represent connections, the game can also be used to consolidate process or conceptual knowledge. Using H5P, interactive memory games were developed in the field of higher education mathematics at BTU. This is an exercise that interrogates the relationships in derivation rules. (Figure below) In another exercise, functional equations and their associated graphs are queried.



Figure 3. Interactive memory game for derivation rules

In addition to specific feedback when selecting pairs correctly, H5P will display the time and all attempts within a game. Since the question and answer options in this assessment are consistent, the required trials and the time can give the students a feedback regarding an improvement. A lower processing time and fewer attempts can indicate a safer handling of the topic. If this other form of assessment is to be used as a pre-examination or admission, a maximum time and attempts in a game could be defined. A combination of both criteria appears to be meaningful, since otherwise the concept is lost by rapid guessing or the recording of the deposited cards.

This form of exercise is particularly useful to explain mathematical terminology and facts. We are increasingly struck by the fact that students do not master the mathematically correct language. Logical expressions should be considered here as an example. In classroom teaching, the problem cannot be addressed because students are not required to speak. This is partly due to the lack of time. For this reason, this kind of compulsory exercise in a playful form is particularly appropriate.

3.2 Interactive Videos

The developed teaching videos were more appealing to students through various enrichments of interactions (such as interactive tests). Thus the learners leave the role of the recipient by their own actions. With the help of the H5P editing software, the interactions can be easily implemented through prior planning. The interactions are on the one hand involved questions (also called video assessments). On the other hand, there are hyper textual references. Camtasia offers similar interactions.

The project team, however, decided on the initial benefits of the integrated Camtasia actions for the H5P solution. H5P provides easier integration of the results into the moodle assessment overview. In addition, the editing of the interactions is from our point of view in the H5P editor easier than in Camtasia. Application examples for this form of quiz were shown in the context of the penultimate InnoEducaTIC. [20] In addition to uploading videos, the H5P editor allows to link a source URL. In addition to YouTube resources, videos from BTU's Kaltura Streaming Server can also be used (as seen in the Figure below).

Upload video file	or	Paste YouTube link or other video source URL Inter video source URL or YouTube link H5P supports all external video sources formatted as mp4, webm or ogy, like Vimeo Pro, and has support for YouTube links.
		Insert Cancel

Figure 4. Integrating a source URL in the H5P editor to the BTU's Kaltura server

The following types of questions can be integrated with the editor:

- Single Choice Set
- Multiple Choice
- True/False Question
- Fill in the Blanks
- Drag and Drop
- Mark the Words



Figure 5 Example of H5P Video Assessments

3.3 Speak the word

H5P provides a test form in which the results have to be reproduced verbally. In this test form, a microphone (Smartphone, tablet, PC or laptop) is accessed. Via this happens after a prompt the input. The software compares the spoken word with the sample solution. Different languages can be pre-defined during the creation process. If the answer is correct the progress bar is filled in the test. If the answer is incorrect, the learner can enter an input again or see a sample solution. H5P shows how the speech input is interpreted. The flow diagram below is intended to visualize the described process.



Figure 6 Flow Chart "speak the word"

Such test and input forms are certainly particularly suitable for language learning. However, it is also used at the BTU in the field of mathematics. In the home learning phase, students can thus verbally reflect results and partial solutions. Thus the oral, correct mathematical expression of the learners is trained. Due to the high number of students, these competences are generally not taught at the lectures and exercises at BTU.

4. OUTLOOK

In general, it should be noted that the relatively rigid digital structures of a learning management system can be used to handle heterogeneous and dynamic learning groups. [21] Through a media mix, the highest possible access to the entire student group can be achieved. It should also be noted that the structures should not be fixed, so that each student can choose the most appropriate entry. The interactive theory described in detail in this text can only be a part of a holistic concept. The pure teaching through media can thus only partially cover the students' learning needs at presence-universities. In this context it is still necessary to discuss the form that these materials will take in the future. If the interactive media are operated not only formatively (accompanying), but also diagnostically or summative (as an examination service), the usage criteria could be given a different weighting because of the different claims of the respective examination form.

All interactive media will be evaluated this year by student surveys and standardized questionnaires at the BTU. The detailed results are expected to be presented in 2018.

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