COLLABORATIVE DEVELOPMENT OF OPEN EDUCATIONAL RESOURCES FOR BUILDING COMPETENCIES IN THE USE OF DIGITAL TOOLS IN CHEMISTRY

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Abstract

The requirements placed on today's generation of students are becoming increasingly diverse. They are expected to develop a wide range of skills and competencies outside their specialist knowledge, not only during their university studies, but also when they enter the professional world. Particular focus is placed on the handling of various subject-related and non-subject-related software products.

In a collaboration, the Heinrich Heine University Düsseldorf, the University of Wuppertal and the TH Köln (University of Applied Sciences) are creating open educational resources (OER) for students and developing new materials in the project OER.DigiChem.nrw to support intentional learning in the early stages of university studies. Due to the development in recent years, freely accessible educational resources enable diverse ways of learning, but are associated with further quality requirements. Basic requirements for media didactic learning offers are analysis, design, development, implementation and evaluation. The phase-based quality assurance system integrated in the project enables reflection and, if necessary, adjustment of the process at different points in time. Furthermore, a long-term implementation of the created educational resources can be ensured through a nationwide OER platform.

How can educational resources for the target group of students, with focus on Bachelor students in the first and second semester, be prepared to promote learning? Which conditions can encourage intentional learning? What social and technical challenges during learning with those materials do students face? And what constitutes good educational materials? These kinds of questions are fundamental in order to prepare educational resources of quality, so that pedagogical and psychological effects on learning are made possible.

Standardised methodological results are obtained by quantitative online surveys (n>50). Complementary qualitative guided interviews (n>15) allow a methodological triangulation and increase the validity of the research results.

By conducting an initial online pre-evaluation, we were able to better understand the students' needs for video tutorials. Central results pointed towards didactic elements that enhance motivation and learning by providing an avatar (60%), the desire for a physical person in the video (74%), and a gender-independent commenting voice (68%). Based on the results, didactic preparation of the scripts, taking into consideration the theory of multimedia learning according to Mayer, and the learning management system (LMS) are undertaken.

Theoretical and methodological elements of media didactics are used for long-term autodidactic learning support and competence development. Interactive LMS are used to implement the video tutorials, and learning behaviour is supported on a visual and auditory level by practice exercises, forums, and learning plan elements.

As the project continues, the pre-results will be used as basis for further video production and be compared with a post-evaluation and guideline interviews after one semester of video use. The objective is to meet the changes in professional qualification requirements by means of the socio-technological learning approach. By means of the phase-oriented quality management, a common standard is to be achieved so that the production of videos and learning tasks is didactic, methodical and enhances learning, while supporting the students' social, professional and personal competences.

Keywords: OER, media didactics, quality management, chemistry, natural sciences, video production, research methodology, intentional learning.

1 INTRODUCTION

Today's generation of students is often referred to as "digital natives", and it is assumed that students either learned how to use software programmes at some point in school or that they "manage it somehow". In fact, many students show a considerable deficit in competences when it comes to dealing with digital tools, so that in addition to the student associations of the participating universities, some students themselves also approached the university lecturers. These were simple questions, such as how to use Office programmes including the embedding of chemical formulae, corresponding chemical drawing programmes or special evaluation programmes for data analysis, or the students asked what needs to be taken into account when writing a thesis with Office software.

These competences play a central role in chemistry. If students lack these competences, it not only affects subject-specific software but also the effective use of typical standard software. Closing these competence gaps can be seen not only as a university-wide but also as a cross-national task, since the creation of Open Educational Resources makes a particularly resource-efficient re-use of teaching materials possible, and additional learning materials are made available to students while relieving teachers. The materials contribute to the expansion of students' competences in the areas of "information and data literacy" and especially in the area of "problem-solving competence" [1]. From a DigCompEdu A2 quality level [2], teachers can be recommended to look at such materials and to take them into account in their courses.

With a view to competences and the bundling of resources, the Ministry of Culture and Science (MKW) of the Federal State of North Rhine-Westphalia (NRW) has decided to set up a new state-wide online portal for studying and teaching (Open Resources Campus, ORCA.nrw) in order to make the use of existing and future offers of digital teaching as well as learning content and tools more attractive and to expand the integration of digital forms of teaching. Video tutorials on the correct, i.e. effective and efficient, use of software relevant to chemistry can not only benefit students in self-study, but can also be used by lecturers as part of their teaching.

The project "OER.DigiChem: Development of OER in the form of e-tutorials for competence development in the use of digital tools in chemistry" is a joint project within the framework of the funding line "OERContent.nrw" of the MKW. As part of the joint project of Heinrich Heine University Düsseldorf, the University of Wuppertal and the TH Köln (University of Applied Sciences), the digital needs of chemistry students were first identified in order to then specifically promote the corresponding competences of students in their basic studies. A central aspect here is the creation of target group specific video tutorials, which are made available on the respective learning platforms (ILIAS, Moodle) and can be introduced in flanking, curricular integrated courses and then used across modules.

Different quality assurance mechanisms are taken into account for the project phases of planning and conception, creation and evaluation of the materials and their application. Technical quality assurance is provided by the IT and Media Centres (ZIM) of the respective universities and universities of applied sciences.

The first step was initially to compile the various software products used by the collaborative partners in teaching and student projects and to classify the corresponding digital learning needs of chemistry students.

Generally used software:

- Office programmes (e.g. Word, Excel, Powerpoint).
- Image editing programmes (e.g. Gimp, Darktable)
- Drawing programmes (e.g. Inkscape)
- Literature management programmes (e.g. Endnote, Citavi)
- Applications for photography in the lab
- Literature research in databases

Special chemistry-related software:

- Electronic laboratory journals
- Spectra evaluation programmes (e.g. Mestrenova)
- Chemical drawing programmes (e.g. ChemOffice, ChemSketch)
- A learning platform (scheLM)

In addition, digital skills are necessary for taking photographs in the laboratory, for example, for pictures of laboratory apparatus for publications. Since no software can extract important details from poorly taken pictures, in addition to the handling of software, the photo documentation of experimental results and set-ups has to be practised. So pictures need to be taken in the laboratory and then processed or developed. Apart from safety aspects, the principles of Gestalt psychology for demonstration experiments according to Schmidkunz must be considered [3][4]. Another challenge is a proper illumination without shadows or reflections. When creating digital content [5] with a camera, digital competences come into play when using a camera or smartphone. Learners have to transfer the content presented in our tutorials to their individual end device, as these devices can be quite different in their operating concept.

Central media-didactic questions were, among other things, how do which tutorials best help the target group, and how must these be structured in order to cover deficits in a targeted manner? Which software products are used at the respective locations, where are overlaps, which focus should be set? These and other questions will be answered in the next chapters.

2 METHODOLOGY

The goal of our project is to increase the competences of students regarding the use of (chemistry related) software. A central aspect of our project is the production of video tutorials for self-study courses, which integrate the videos in an e-learning environment, such as Moodle or ILIAS. In order to maintain the same quality, all videos should follow common layout guidelines and standardised technical and didactical guidelines. Prior to our first regular video production, we produced video prototypes in order to evaluate several didactic aspects.

The considerations go hand in hand with standardised quality management. Quality assurance within the project occurs on different, corresponding, and mutually influencing levels. On the pedagogical-didactical level, the theory of multimedia learning according to Mayer [6] forms the groundwork and is complemented by the design-oriented media pedagogy according to Kerres [7]. A special focus is on the cross-location quality standard of the scripts (same intro/outro, tip and hint design in each script, see Fig. 1) and the video tutorials. For this purpose, templates for DaVinci Resolve were created. As a result, a uniform standard is ensured.

Figure 1. Standardised templates: Here tip.

On the user interface dimension, the focus is on usability, especially accessibility, as well as the design of the LMS content with a very similar design at all locations. Quality assurance on the part of the ORCA platform of the state of NRW is ensured by a specially created quality assurance instrument, which is implemented on the basis of the 22 scales (15 pedagogical-didactical and seven technical dimensions) of the Hamburg model [8] as well as by peer review procedures and peer feedback on the platform itself. However, the final operationalization of ORCA.nrw is still in progress. The successful implementation on both described levels was already shown in the pre-evaluation. 44 students indicated that the graphical elements and examples of use were sufficient/appropriate and that there were no elements that interfered with learning (see Fig. 2).

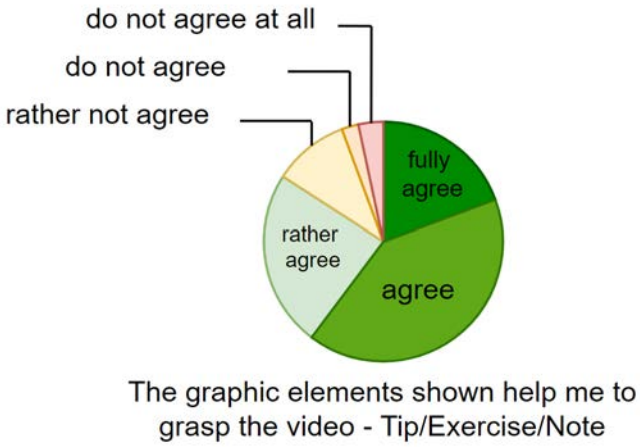

Figure 2. Satisfaction with the graphic design.

Quality assurance is realized and ensured across locations in the evaluation design for both quantitative and qualitative research. The use of LimeSurvey as online questionnaire software was able to guarantee the randomisation of the videos, anonymity, fairness, objectivity as well as other quality criteria of psychological research by evaluating the questions from Tab. 1. After the post-evaluation, transcripts of the interviews (>15) can be generated using MAXQDA software, independent of location and time. The evaluation method (grounded theory) can be immediately selected and used. A major advantage is the integration of the categorizations and the analyses of the online questionnaires using SPSS, so that a comparison of thematic overlaps is automatically taken over by the software. Online questionnaires fulfill various quality dimensions as an evaluation tool, including usability, since accessibility is independent of location and time and does not present any visual hindrances in terms of font size and type.

Table 1. Questions of the conducted survey of the students.

Question type	***Question***
Socidemographic data	1. How old are you?
	2. What gender are you?
	3. What is your native language?
	4. What is your highest degree to date?
	5. What degree are you currently pursuing?
	6. What year of your current degree program are you in?
Didactic elements	1. Tick in the appropriate place for you: The graphic elements shown help me to grasp the video - Tip/Exercise/Note
	2. In the video I prefer: (keyboard/key combination)
	3. In the video I prefer: (spotlight/yellow background)
	4. I find the video design: (appealing yes/no)
Natural person or avatar	1. In the video I prefer: (avatar/speaker)
	2. In the video I prefer: (voice type)

3 RESULTS

Increasing the competence of students by means of e-learning is a growing process that requires continuous monitoring of the LMS in order to be able to adequately map the learning process and success, but also any problems that arise (of a technical and content-related nature). Standardized evaluations (online questionnaires) and qualitative guided interviews are intended for this purpose. In a first pre-evaluation, different dimensions were reproduced, which are partly oriented on the dimensions of LORI [9] (in the post-evaluation, these will be included completely). The focus was on the dimensions Content Quality, Presentation Design, and Accessibility, so that a uniform, cross-locational standard can be defined, which is oriented towards the needs of the students, the technical quality can be guaranteed (technical problems can be solved, presentation on different devices, etc.) and didactic elements can

be used as a learning-supporting medium during the ongoing process. Individual key areas are addressed in the following.

3.1 Speaker

The design of our videos follows strict rules: They always start out with a short introduction, in which the learning outcomes are defined (< 30 s). During this period the speaker is visible in front of a neutral background. The second part teaches the skills to use the specific software. During this time the speaker is not visible. Instead the actual software is shown and the actual problem is solved step by step and is explained by the speaker off-screen. This part is complemented by tips (see Figure 1), hints and tasks in some videos and each video closes with a short summary with the speaker visible once more.

The role and appearance of the speaker were important design elements, which were intensively discussed and evaluated: (i) Should two speakers (a teacher for the introduction and summary, a teaching assistant (TA) for the main content part) be used or only one, (ii) in case of only one speaker should the TA be on screen, which might be problematic in respect of the right to the own picture, or should an avatar be used instead and (iii) should students be addressed formally or informally (in case of two speakers, with a possible differentiation between teacher and TA)?

3.2 Mouse and Key Combinations

Using software often involves mouse actions and certain key combinations in order to get some work done. For that reason, it is important to accentuate mouse movement, mouse clicks and key down events. In principal any screen recording software allows to follow mouse movement. However, it is often necessary to focus the attention of the spectator to the mouse. For this purpose, there are several options to highlight the mouse for certain periods of time during the videos. The popular screen-recording software Camtasia, for instance, offers the following options to achieve this goal: cursor highlight, cursor magnify and cursor spotlight, as shown in Fig. 3.

Figure 3. Spotlight highlighting cursor actions.

Not only the mouse movements are important, but the mouse clicks are as well. Here professional screen recording software allows to include an artificial sound effect for any click.

Key presses cannot be directly captured during screen recording. However, efficient use of software requires the use of shortcuts. Such shortcuts can be pressing a single key or in some cases two or three keys simultaneously. For efficient teaching a graphic representation of the key combinations used is necessary. For this purpose, either a complete keyboard or the used keys can be superimposed onto the recording.

3.3 Evaluation

For evaluation purposes we produced three videos prototypes depicting the different speaker scenarios. Each student was shown one of the three videos and then, from the other two scenarios, the intros only. The video, and consequently the shortened scenarios shown, were selected at random.

More than 88 students took part in this evaluation, spread over all three partner institutions.

With regard to the design of the video tutorials, the results of the online survey on the developed prototypes were analyzed to answer the above questions and used as a basis for the development of a correspondingly optimized template for follow-up video productions (see Fig. 1). The students of the surveyed cohort (of which 57% were female and 42% male) were in their first (61%) and in their second year (26%) of study, i.e. in the study phase for which the video tutorials are intended. From the responses of the 88 fully completed questionnaires, it can be deduced that the introduction and conclusion of the video tutorial by a real person as a guiding figure is clearly preferred (74% agreement) over an avatar. It is irrelevant for the students whether this person is female or male. 68% of the

respondents did not indicate a preference for a male or a female explanatory voice in the main part of the videos. A talking Erlenmeyer flask used as an avatar was considered too childish, instead it is shown as an image for special hints in the video. It should be noted at this point that the use of an avatar would solve the problem of a possible refusal of the depicted persons to have their images used after the fact. Nevertheless, it cannot take diversity considerations into account. Using only one avatar raises issues of gender, age, ethnicity and other attributes that cannot be reflected equally in one single avatar.

The students voted for the real person appearing in the video´s introduction and conclusion to also provide the explanatory voice for the content presented in the screencast. During preparatory discussions, it was decided to use a student rather than a lecturer as the real person in the screencast and in the opening and closing sequences. This served as the basis of the users' orientation towards their peer group or an identification with the depicted person and meets with humans' preference for social learning among peers. For the same reasons, the more informal German "Du" is used in the videos instead of the more formal German "Sie" for addressing the viewers.

Regarding the use of graphic elements in the videos 77% of the respondents prefer the illustration of a keyboard to a pure key combination (23%), as exemplified in Figure 3. This can make it easier to find the corresponding keys on one's own keyboard. At this point, it should be noted that the illustration in the video can only be exemplary in view of different keyboards when different systems are used by the students.

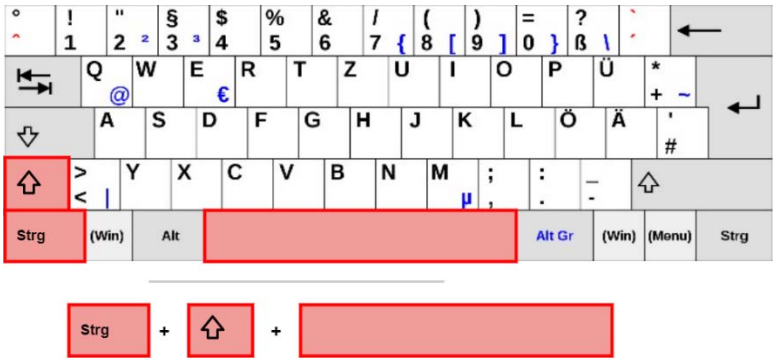

Figure 4. Graphical representations of key combinations.

Although real people are preferred for framing the videos, 60% of the respondents like the use of an avatar as an additional graphic element, e.g. for marking tips, exercises and mnemonics. To highlight important control fields in the software presented in the videos, a spotlight and a half-transparent yellow background were tested. 86% of the respondents preferred the use of the spotlight, 10% the yellow background. This follows the considerations of accessibility.

64% of the students used a PC or laptop, while 25% used their smartphone to complete the questionnaire, including the videos to be viewed. Since the latter is one quarter of the cohort, it is necessary to show all relevant content in the so-called "safe area" of the video. Otherwise important content could be cut off by the device.

A total length of the videos between two and three minutes was considered favourable. Therefore, more extensive topics in the self-study course will be divided into several shorter videos.

The assessment of needs of various software products as well as the classification of general and chemistry-specific digital needs of chemistry students, which was carried out by discussions among the collaborative partners and in exchange with students, led to the decision for the software indicated in chapter 1 Introduction.

4 CONCLUSIONS

The importance of quality assurance is also discussed in the appropriate literature [10]. Particular focus is put on the thematisation of quality during production, peer review, and community feedback. In the OER.DigiChem.NRW project, peer review is realized by distributing the work packages between small groups. In order to achieve a uniform quality standard, the scripts are each edited by members of at least two universities. Thus, professional as well as didactic evaluations can be done uniformly. By means of the community feedback in the LMS, in the form of attended and unattended forums, content-related, organizational as well as student matters and wishes can be expressed and answered by staff

members. The post-evaluation, with a special focus on learning success and usability, will be based on the scales of LORI [9].

At the stakeholder level, cross-site project management is fundamental. Particular focus is placed on continuous communication between the small groups and, as far as possible, all project members in a four-week rhythm. The centralisation of communication and overall coordination to a research assistant is proving to be a central component for an unobstructed process. The use of different professional competences of the actors is a distinct feature, which has been especially apparent in the communication with other projects funded by ORCA. This allows the use of existing resources and competences, which can increase the effectiveness and efficiency in the entire project cycle. Accompanying this is the adherence to current technical standards, which is realized through the collaboration of the ZIM in the project.

Challenges lie mainly in updating and adapting learning content and software. Screencasts are created from the most current versions of the software used. Changes in how the software can be operated are not the responsibility of the project members and cannot be influenced.

Accessibility must be considered not only in terms of the project, but also in relation to the outcome, which is why further considerations regarding the placement of subtitles are already being considered during production. Identification of possible barriers as well as accessibility of video tutorials without knowing the needs of people with disabilities is challenging. Instructions can be obtained from the guidelines of the International Organization for Web Standards, which list barriers such as the use of lower contrast, redundant information, or poor quality of the media [11]). As already described, changes in production and software selection have arisen in the project, so that accessibility must be regarded as a continuous process.

Concluding remarks should be made regarding the transition from school to university: The intended target group of students in their first two years of study, who are enrolled in the subjects of chemistry, teaching chemistry or basic natural sciences, enter university with very different previous knowledge and digitalisation-related competences. Apart from the DigCompEdu [2] reference framework at the European level, there are educational guidelines given out by the ministry of education, that provide clear descriptions, intended as standards, of the digitisation-related competences that students must have at the end of their school career [12]. However, there is a wide gap between reality and the educational policy claim. This is also due to the fact that not all school teachers have the skills for teaching the necessary competences (yet). This is why teacher training plays an important role in the entire educational system. Due to the heterogeneous abilities of the students, the design of self-learning environments intended by the project is fundamental, as individual elements to adapted to the students´ individual needs can be used.

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