This is how we learn

A Best Practice Case of Qualification in SMEs for Work 4.0

Marc Schwarzkopf, Susann Zeiner-Fink, Angelika C. Bullinger-Hoffmann

Digitalization is forcing small and medium-sized enterprises (SMEs) to rethink their work and production processes. Initiated by this process, the organization of production and employees are subject to change. As a result, the job profiles of employees are changing and expanding, as well as the way how knowledge is imparted. Innovative and digitized formats should be integrated into existing training programs and presented in a way that is suitable for use on mobile devices. Therefore, suitable and target group-specific teaching/learning formats are needed that support participative methods and digital collaboration.

For this purpose, a digital teaching and learning format for the application area of automotive engineering in SMEs was designed. This prototypical teaching/learning format was created and evaluated in an iterative process through the participation of the potential users and taking into account existing usability criteria. The two methods used to evaluate the format were Think-Aloud and focus group, the results of this evaluations are presented in this paper. The results show that when evaluating the teaching/learning format, the test subjects mainly refer to the usability criteria of DIN ISO 9241-110, the structure of the course and the information content of the course. Recommendations for the creation of future digital teaching and learning formats for SMEs are derived from these findings.

1. Reorientation of education and training 4.0 through digitalization

Information technology has permanently changed private life, working and learning. Digitalization is making its way into all occupational fields and defining new industries and business models (acatech 2016; Heim et al. 2016). In particular, the manufacturing industry and its branches of industry as well as their inherent work processes are affected by the digital transformation. Digitalization not only creates new job profiles, but also redefines the requirements for existing occupational fields. Accordingly, the needs of employers and employees are changing with regard to training and further education measures in order to do justice to the technological transformation and its effects (Poschmann 2015). Various studies see the top priority of the digitally transformation in the context of work in the ability of lifelong learning (acatech 2016; Ingenics / Fraunhofer IAO 2014). As a result, ex-

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isting training and further education content must be adapted to meet the requirements of digitization for both the learners and the teaching/learning content (Lichtblau et al. 2015). Work-process-integrated and highly flexible forms of learning are focused and should be able to be dynamically and efficiently adapted to changing work processes, requirements and learning needs (Kuhlmann/Sauter 2008; Hofert 2016; Melzer/Bullinger 2017). In order to make work conducive to learning, classic teaching/learning formats are no longer sufficient since they can only be adapted to changing processes with great effort and cannot be used interactively on mobile devices (Dombrowski/Wulbrandt/Fochler 2019). The focus of corporate educational work is the question of how and in which framework work can be designed to promote learning and skills, taking into account the personal dimension (Dehnbostel 2018). This offers the possibility to design teaching/learning content in an individualized way: Learners are in the focus and the process of imparting knowledge is simultaneously understood as a process of social exchange and interaction between learners. Following this development, learners take more responsibility for the learning process and knowledge is constructed and integrated based on existing experiences (Wegener et al. 2011; Meissner/Stenger 2014). The adaptation of appropriate delivery methods and teaching/learning content can be enabled by digital learning and contribute to developing professional skills such as situational, critically reflective, creative, and productive learning and teaching (Arnold et al. 2018). The focus here is primarily on content transfer through the use of digital tools or teaching/learning concepts (Aust et al. 2019; Dombrowski et al. 2019).

Taking these possibilities and the needs of the teachers and learners into account, two factors critical to success can be identified: The user-centered development of the teaching/learning format with the involvement of the teachers and learners and, building on the findings of the user-centered development process, the usability with regard to the presentation and operation of the teaching/learning format (Zeiner-Fink et al. 2018). Both of these factors require an approach that i) captures the needs and wants of learners and ii) an iterative evaluation process ensures that these needs have been realized (Feldhoff et al. 2019). This paper presents a digital teaching/learning format that was evaluated and created following the process described by Feldhoff et al. (2019). Furthermore, recommendations for the creation of future teaching/learning formats are derived from the evaluation.

2. Focus on learners: user-centered approach to evaluating a teaching/learning format

Based on the user-centered design process following DIN EN ISO 9241-210 (ISO 9241-110: 2020) and the service design process according to Leimeister (2012), a digital teaching/learning format of an automotive manufacturer in the field of high-voltage awareness is evaluated (Feldhoff et al. 2019). This digital course included various media such as audio content, animated videos, animated and interactive diagrams as well as learning assessments. It is planned to integrate this course into future teaching activities of universities of cooperative education in the field of automotive engineering. The teaching/learning format which gets evaluated was initially created by an IT service provider without involving the learners. It should be used in training and further education. The original analog course, on the other hand, included occasional videos and relied largely on face-to-face instruction. The evaluation was carried out in two evaluation phases (see Figure 1) using the methods "thinking aloud" and "focus group".

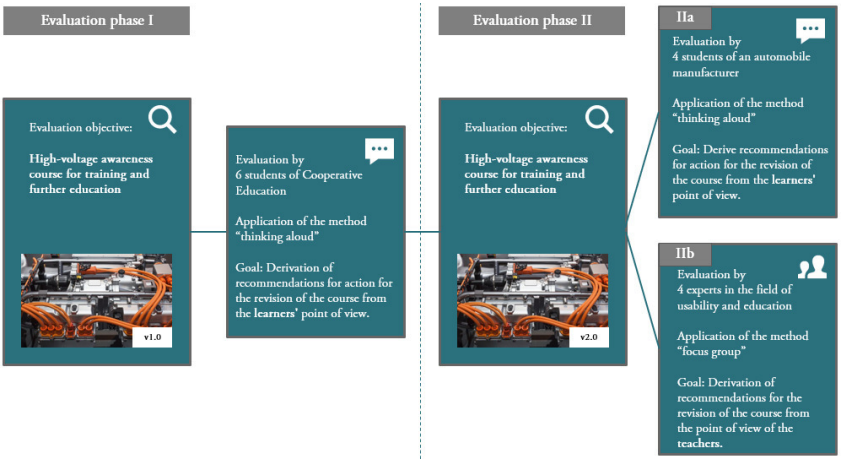

Figure 1: Representation of the evaluation phases

2.1. Methods

In order to evaluate the high-voltage awareness course in terms of usability and the quality of the learning content, the qualitative methods "thinking aloud" and "focus group" were used in an iterative procedure. By using the method of thinking aloud, a test person verbalizes his or her thoughts during the execution of the experiment (Jääskeläinen 2010). The "focus group" method, on the other hand, represents a moderated group discussion. Based on a guideline, the experimenter moderates the discussion, which is usually led by experts on a predefined topic

(Steward et al. 1990). The methods were chosen because, in addition to problem detection from the user's point of view, they also enable a diagnosis of potential causes, from which specific recommendations for action to correct the identified problems can be derived. In addition, the technology affinity of all participants who used the method of thinking aloud was assessed and compared using the ATI scale, to ensure that the participants' skills in using digital devices were comparable. (Franke et al. 2019).

2.2. Test procedure

The test procedure included two iterative evaluation phases (Figure 1). Evaluation phase I included the method of thinking aloud. Six students from the course of vehicle technology (w = 0, m = 6) from a university of cooperative education were selected randomly. All students did not yet have an academic degree, completed their studies as a dual system and studied vehicle technology in two different years, whereby the course content for high-voltage awareness was completed by all students. All test subjects showed a comparable affinity for technology and experience in dealing with digital end devices. The processing time for the digital teaching/ teaching format was set at 45-60 minutes. Each student was assigned an experimenter. The entire test run was recorded and then transcribed with MAXQDA. The problems identified by the subjects were then compared by a small group of four usability experts (over four years of experience in usability testing) from the field of education to eliminate duplications and misconceptions. The revision of the teaching/learning format based on the knowledge gained from the first test run was tested in evaluation phase II. This phase contained both an evaluation using the method of thinking aloud (evaluation phase IIa) and a focus group (evaluation phase IIb). Phase IIa included four test subjects (w = 2, m = 2) from a German automobile manufacturer. It was ensured that the education and technical affinity of the test subjects was comparable with the cohort from the first evaluation phase. The test procedure and the learning task to be completed were identical to evaluation phase I.

In addition, the revision of the high-voltage awareness course was evaluated by a focus group (evaluation phase IIb). The focus group consisted of four usability experts (different to those from the comparison of the identified problems after phase I and IIa, w = 2, m = 2) from the field of education. The participants were not familiar with the findings from evaluation phases I and IIa. The focus group was conducted in order to additionally address the needs and requirements from the perspective of the teachers and with regard to the usability and technical design of the course. The high-voltage awareness course was completed by all participants prior to the focus group evaluation. In addition, the contents of the guideline were communicated and participants were asked to take notes on potential problems during the course. The moderation of the group was ensured by using a guideline. The recording was transcribed and analyzed using MAXQDA.

3. Results

The respondents' statements from evaluation phase I were assigned to the deductively formed categories "technical implementation," "course content," and "platform design" using qualitative content analysis.

The technical implementation addressed, among other things, quantifiable usability criteria of DIN ISO 9241-110 (ISO 9241-110: 2020), such as suitability for the task, self-descriptiveness, and ease of learning (with respect to the learnability of system operation). In addition, the technical quality of the audio-visual (A/V) content presented was evaluated (volume, resolution, etc.). The topic area "course content" referred to the presentation, linking and interactivity of the teaching/learning content, i.e., whether the content was presented in a comprehensible way and whether there was a perceived benefit for the learners from using the digital course. Identified problems in the area of "platform design", on the other hand, related only to the presentation of the platform's audiovisual content (videos, use of color, design elements, etc.). The distribution of the identified problems can be seen in Figure 2.

A total of 50 problems (multiple responses taken into account and summarized) were identified with an average of 35.6 problems per learner ($s = 8.3$). Problems were, for example, the incomprehensible course structure (course content), missing dialog options (technical implementation – suitability for the task) or poor contrast values (platform design - use of color). These problems were assessed and weighted by usability experts from the field of education. Six problems were removed during the review process or assigned to other problems. For example, two respondents identified the problem "lack of information about the diagram" and "insufficient explanations about the diagram". The two problems were combined to "task-relevant information is not available for diagrams (suitability for the task)".

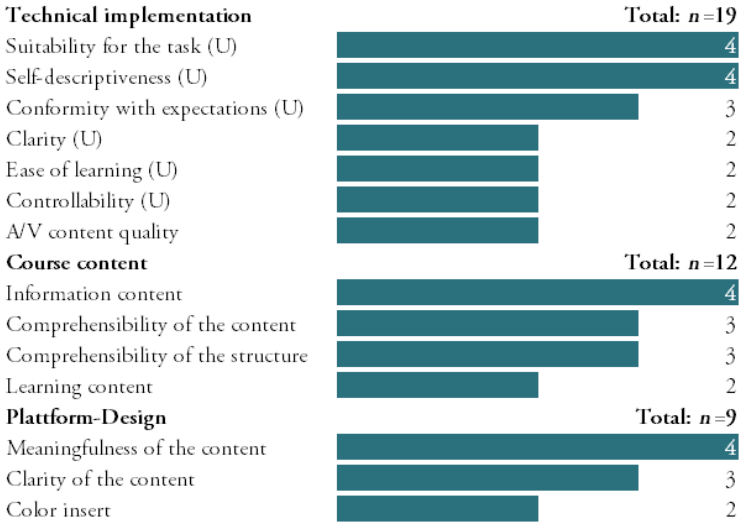

Figure 1: Evaluation phase I - distribution of the absolute numbers of the identified problems in the first evaluation run (only mapping of at least two mentions); (U) represents usability criteria of DIN-ISO 9241-110

Four problems were directly related to the complexity of the learning content and were excluded for further consideration. Most of the problems were identified in the category "technical implementation" with regard to usability. All test persons criticized the self-descriptiveness of the teaching/learning format (interaction buttons without prompt character, unconventional design of the interaction buttons, etc.), the suitability for the task (missing functions, dialog steps do not fit the task) and conformity with expectations (incomprehensible or unknown abbreviations, inconsistent design). The application of the method of thinking aloud enabled not only the identification of the problems from the learners' point of view, but also a diagnosis of the causes, which was used to derive specific proposals for solutions or recommendations for action for the revision of the tested teaching/learning format. A revision of the system by the IT service provider was based on 37 recommendations for action.

The revision of the teaching/learning format was tested in evaluation phase II. The overview of the identified problems in evaluation phase IIa can be seen in Figure 3.

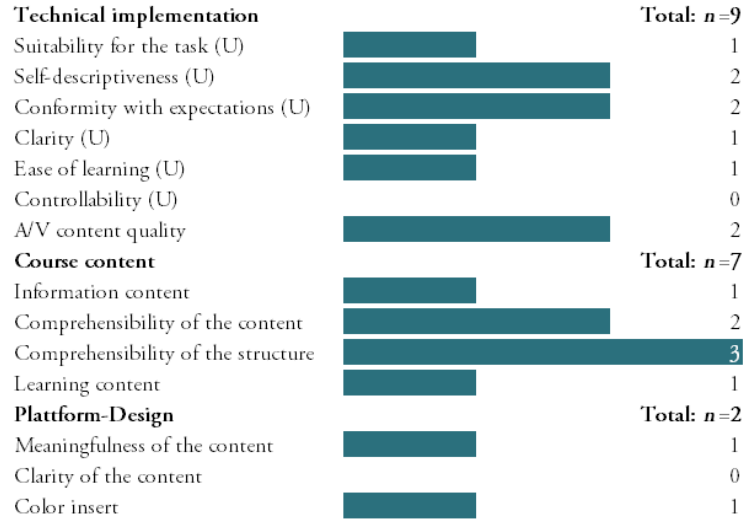

Figure 2: Evaluation phase IIa - distribution of the absolute frequencies of the identified problems in the second evaluation run; (U) represents usability criteria of DIN ISO 9241-110

A total of 18 problems (multiple responses considered and summarized) were identified, an average of 16.7 problems per learner (s = 2.8). After the review by the team of usability experts from the field of education, 17 problems remained in the revision of the teaching/learning format. Four of these problems were not considered further because they were directly related to the complexity of the learning content (identical problems as in the first phase). Eight of the problems identified related to changes made during the revision, and six of the problems identified in the second phase were not identified by the first cohort (e.g., lack of interactivity of the tabular presentations, arrangement of course content, etc.).

The problems identified by the focus group were assigned to the same categories as the problems from evaluation passes I and IIa. Figure 4 shows the problems identified.

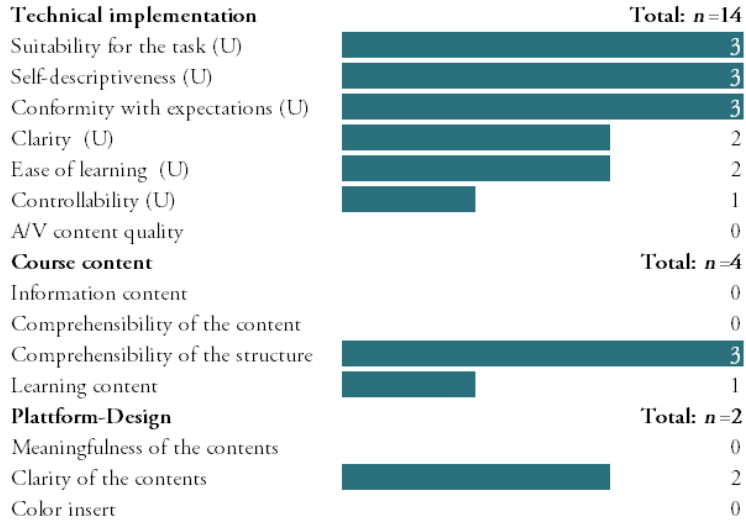

Figure 4: Evaluation phase IIb - distribution of the absolute frequencies of the identified problems of the focus group; (U) represents usability criteria of DIN ISO 9241-110

The focus group of four participants identified a total of 20 problems. These problems were not verified by another group of experts.

3.1. Consolidation of the evaluation results

The identified problems of the focus group were compared with those of the evaluation of evaluation phase IIa by a team of experts from the fields of usability and education. Ten problems with similar causes were identified by both groups (e.g., consistency of pictograms and abbreviations, availability of course content downloads, lack of interaction options). While the remaining four problems of the learner evaluation were mainly related to the information content and the comprehensibility of the course content, the focus group was able to identify further usability problems in particular, but also referred to content-related problems of the course structure. From the identified problems of both groups, 22 specific recommendations for action were derived (e.g., splitting teaching/learning content into two or more modules, revising the course structure, consistency of abbreviations), which served as the basis for the second and final revision of the teaching/learning format.

3.2. Conclusion

The iterative procedure described for evaluating and revising the teaching/learning format has shown that even a small number of test subjects can identify a large number of problems in digital teaching/learning formats. In the first evaluation phase, 50 problems were identified by the test persons with a high dispersion of

the average reported problems ($\bar{x}$ = 38.6; s = 8.3). After the first revision, the number of identified problems was reduced in a second evaluation phase conducted by a comparable cohort (n = 21) and also the dispersion of the average identified problems decreased disproportionately ($\bar{x}$ = 16.7; s = 2.8). The comparison of learner evaluation and focus group revealed that ten of the identified problems of both groups were due to the same cause. A summary of the results can be found in figure 5.

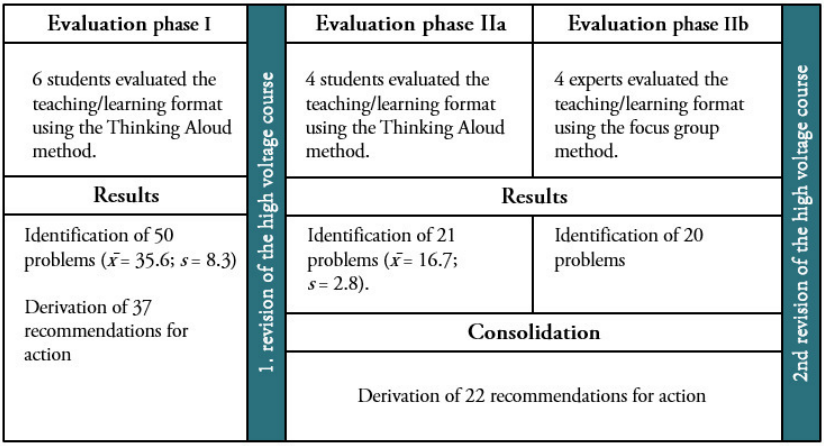

Figure 5: Overview of the number of problems identified and derived recommendations for action

Furthermore, it was shown that the identified technical problems of all cohorts and the focus groups could be assigned to the usability criteria of DIN ISO 9241-110 (ISO 9241-110: 2020). However, the clear assignment was partially problematic: For example, six of the ten participants of the learner evaluation noted that designations or abbreviations were used inconsistently, which represents a problem of conformity to expectations according to DIN ISO 9241-110 (ISO 9241-110: 2020). However, these problems were partly inherent to the teaching/learning content used, so that a separation between technical and didactical problems was not always clearly possible. However, the analysis not only enabled the digital framework of the teaching/learning format to be revised, but also inconsistencies in the (analog) teaching/learning content and materials to be identified and eliminated.

4. Findings

User-centered development and the usability of software systems have been an integral part of sales and corporate strategies for decades (Donahue 2001). Digital teaching/learning formats in which teaching/learning content is embedded, on the

other hand, are rarely subjected to usability testing and placed in the focus of user-centered development. Using the example of the high-voltage awareness course, it was shown that user-centered development with a focus on usability is necessary to enable the process of learning in a digital context to be as free as possible from (technical) disruptive factors and, in addition, to be intuitive and interactive.

In the following, recommendations for action are presented that were derived from the process of creating and evaluating the high-voltage awareness course and can be applied regardless of the topic of the teaching/learning content. The recommendations for action mentioned were extracted from the statements of both learner evaluations and the focus group (see Figure 5).

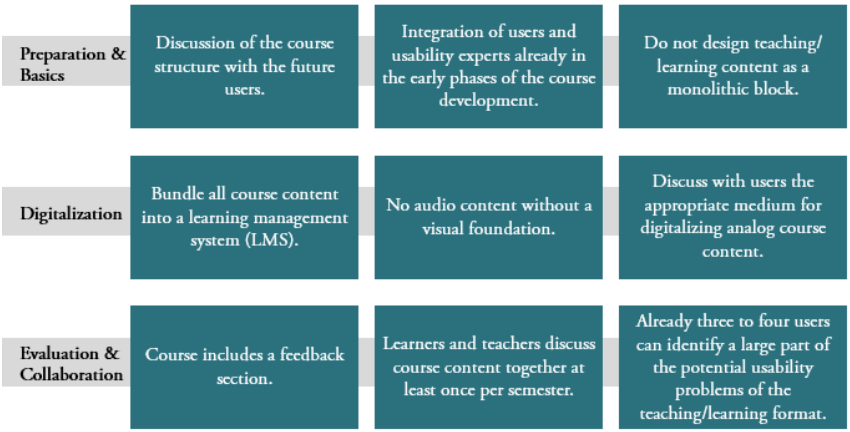

Figure 6: Recommended actions for creating a digital teaching/learning format

5. Limitations

The applied method has various limitations. For example, only passing the course of high-voltage awareness was assumed as a basic requirement for participation in the experiment, but the exact level of knowledge was not checked. This can lead to the fact that course contents were evaluated by test persons depending only on their own level of knowledge or that insufficiently explained contents were not recognized as such by test persons with good knowledge. Furthermore, the test took place under laboratory conditions and each subject was supervised by an experimental supervisor. The presence of the experimental supervisor could limit the ecological validity of the results, as the subjects were constrained in their typical learning process by the observation. Additionally, the learning process could be further limited by using the thinking aloud method, as verbalizing thoughts could make it more difficult to understand and evaluate content.

6. Outlook & preview

The iterative design process described above shows the relevance of developing (digital) teaching/learning formats together with the learners or potential users. The initial prototype of the teaching/learning format was created without involving the learners and contained a large number of technical and content-related problems. However, this article shows that the future users, in this case the learners, should be included early in the didactic development process in order to meet their needs and requirements. By this way, possible technical, content-related or design-related problems can be addressed in advance, thus facilitating the transfer of the content to be conveyed.

By using the method of thinking aloud, it was possible to identify a large number of the problems that arose and their causes in the first evaluation phase with a small number of six test persons. In the second evaluation phase, the number of identified problems decreased significantly, even though the teaching/learning format was evaluated both by the learners and by a focus group consisting of experts from the fields of usability and education. This suggests that the integration of learners and teachers should take place early in the development process in order to make digital teaching/learning formats as intuitive to use as possible and thus support the learning process. In addition, this participatory process creates further advantages: Existing teaching/learning content can be checked in parallel for content-related problems, its structure can be scrutinized and optimized, and learners have the opportunity to actively influence the process of teaching/learning. Ideally, learners not only become consumers of knowledge, but can also help drive the digital transformation in education and training.

The identified technical problems in all evaluation phases could be assigned to the usability criteria of DIN ISO 9241-110 (ISO 9241-110: 2020). However, it has been shown that it is not always possible to clearly separate content-related problems that affect the teaching/learning content from technical problems. In some cases, content-related and technical problems are mutually dependent or potentiated. Furthermore, there is currently no evaluation method that combines usability and content evaluation of digital teaching/learning formats. As a rule, these evaluations are carried out separately from each other, which makes it difficult to identify common problems as well as common potentials. Therefore, the goal is the conception of a hybrid combination of usability and evaluation methods in order to be able to capture synergy effects in a structured way.

Furthermore, the user-centered method for the creation and evaluation of digital teaching/learning formats outlined in this paper is to be iteratively further developed and used in other educational institutions in the field of training and further education. The goal is the development of a generic procedure that makes it possible to create learning formats that optimally support and promote the learning process, taking into account the needs and requirements of learners and teachers.

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